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AN EVALUATION OF WATER REUSE FOR MUNICIPAL SUPPLY

A Report Submitted to the
U. S. Army Engineer Institute for Water Resources
Kingman Building
Fort Belvoir, Virginia 22060

by
Southern Illinois University
Carbondale, Ill.

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AN EVALUATION OF WATER REUSE FOR MUNICIPAL SUPPLY

U.S. Army Engineer
Institute for Water Resources

IWR
Contract Report
74-11

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Reuse can be an alternative source of water for municipal water supply systems. While the demand for water continues to increase in the United States, especially in our burgeoning urban areas, the traditional alternatives for water supply planning, while useful in the past, are either inappropriate today or may no longer be practicable. Recycling renovated waste water has been shown, under specific qualifications, to be a socially

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acceptable and economically efficient alternative for municipal water supply planning. Two problems may be related to the low community adoption of water reuse: the unavailability of a methodology to access the relative value of reuse and the professional biases of consulting engineers and public health officials. In this report a simulation model for evaluating the economic efficiency of water reuse is formulated and applied to a single community and the nature and role of professional bias in the decision making process in water reuse planning is described.

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FOR MUNICIPAL SUPPLY

A Report Submitted to the
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by

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CHAPTER I

THE POTENTIAL OF WATER REUSE FOR MUNICIPAL SUPPLY

Introduction

Municipal water supply systems in the United States are sources of potable water for an ever increasing metropolitan population. The amount of water delivered has nearly doubled in the period from 1950 to 1970.[1] Even though, by some estimates, the rate of increase has decreased,[2] projections of use for the year 2020, assuming the "medium" population figures, are over four times the present use (Table 1).[3]

The practicability of recycling renovated waste water is being widely discussed today as a promising alternative for supplying water for the increasing urban demands. In response to the increase in demand, cities have usually opted to adopt those alternatives that increase the available supply. And, except under emergency conditions, such as drought, alternatives that would lower demand have been ignored. Although metering has been shown to curb per capita utilization of municipal water, meters were usually installed

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[1] U.S. Bureau of the Census, Statistical Abstract of the United States, 1972 (93d edition) Washington, D.C., 1972, p. 173.

[2] Ibid.

[3] Nathaniel Wollman and Gilbert W. Bonen, The Outlook for Water, Baltimore: The Johns Hopkins Press for Resources for the Future, 1971, p. 60.

TABLE 1

U.S. MUNICIPAL WATER SUPPLY USE AND SOURCE:
1950 TO 1970 AND PROJECTIONS TO 1980
(in billion gallons daily average)

Year	Surface Water	Ground Water	Total
1950	10.32	3.78	14.10
1960	16.32	5.68	22.00
1965	17.78	5.96	23.74
1970	20.47	6.56	27.03
1975	23.04	7.27	30.31
1980	25.87	7.73	33.60

Source: U.S. Bureau of the Census, Statistical Abstract of the United States: 1972. (93d edition) Washington, D. C., 1972, p. 173.

for an entirely different reason--as a mechanism for an equitable system of pricing.

Following a review of the alternatives for balancing supply of and demand for municipal water supply, reuse of renovated waste water will be appraised and two important research problems identified (Table 2).

MODIFY WATER SUPPLY

The major source for municipal water supply, accounting for 75 percent of total capacity, is water from the diversion of rivers and streams. Recent estimates are for surface water flows to increase slightly as a proportion of total demand in the future. As urban areas have grown, streams nearest to the cities have been developed and future opportunities for diversion are becoming more scarce. Three regions in the United States are generally short of

TABLE 2

ALTERNATIVES FOR BALANCING SUPPLY AND DEMAND FOR MUNICIPAL WATER SUPPLY

Do Nothing	Modify Supply	Modify Demand
1) Accept Shortage	1) Increase Supply a. Divert New Streams b. Provide Increased Storage c. Use Ground Water 2) Increase Efficiency a. Reduce Reservoir Evaporation b. Eliminate Leaks c. Increase Runoff d. Reduce Evapotranspiration 3) Weather Modification 4) Desalinization 5) Renovated Wastewater a. Non-potable Uses b. Potable Uses	1) Restrictions 2) Price Elasticity a. Peak Pricing, i.e. Peak Summer Pricing b. Marginal Cost Pricing 3) Meters 4) Publicity Campaign Emphasizing Water Use Conservation 5) Technological Innovations and Application, e.g. Changes from water cooling to air cooling

water and interbasin transfers are required.[1]

Transfer of water can be expensive, especially if the location is a distant basin; the difficulties, both economic, political, environmental, and technological increase. The area in which the water originates, the donor region, is usually rural and often with a higher incidence of individual well users. There is a tendency to regard the water as belonging to the region and to view its transfer as necessary only because of unreasonable use by profligate urban water users.[2]

Groundwater, which presently represents 25 percent of total municipal supply, is expected to decrease slightly in proportion to the use of surface water.[3] Sources capable of sustaining high withdrawal rates are limited to distribution and while groundwater is the predominant source of self-supplied individual users, most major cities using groundwater do so as a supplement rather than as a sole source of supply.

Desalinization and weather modification are other potential sources which may, in selected circumstances, serve to augment conventional supplies. In general, weather modification is highly variable but in some instances has considerable potential, such as increasing snow pack and subsequently spring runoff during years

---

[1]Wollman and Bonen, op. cit., p. 18.

[2]This is an attitude expressed commonly by groups such as S.O.S. (Save Our Streams) in Western Massachusetts fighting the diversion to the Quabbin system; also, see: Marion Clawson, Suburban Land Conversion in the United States, Baltimore: The Johns Hopkins Press for Resources for the Future, 1973, p. 130.

[3]U.S. Bureau of the Census, op. cit.

when winter reservoir storage is low. Desalinization, on the other hand, is comparatively expensive and requires large amounts of energy.

Although efforts to reduce seepage and evaporation have not been highly successful, reduction of water loss by identifying undetected leaks can be substantial: in some cases as much as 15 percent of the water withdrawn may be unaccounted for because of leakage.[1]

MODIFY DEMAND

Although other alternatives are available and practicable, planners traditionally have seen supply as the variable in the supply-demand equation. Price has been shown to be a significant variable which is usually disregarded as a method of controlling demand.[2] Marginal efficiency theory in Welfare Economics suggests that marginal costs should equal marginal revenues. However, the decreasing block-rate pricing system, which is common to most cities, encourages high water-use and prices the last gallon of flow, which has most often been the most costly, at the lowest price. Increasing block rates, peak-rate summer pricing, yearly-rate changes based on the supply in storage, have all been proposed as methods of reflecting marginal cost in the pricing of water.

---

[1] John Simmons, "Economic Signifiance of Unaccounted for Water," Journal of the American Water Works Association, LVIII (1966), pp. 639-641.

[2] The literature is extensive. See Charles W. Howe, "Municipal Water Demand," in Forecasting the Demands for Water, ed., by W. R. Derrick Sewell et al. (Ottawa: Dept. of Energy, Mines, and Resources, 1968), p. 48.

Rationing and restricting uses have been used as a management tool only during drought periods. It is an attractive method of planning for supply: the costs to the consumers of water restriction have been low.[1] In one city, the prohibition of once-through cooling water was an economic benefit to industries which installed cooling towers and consequently saved in water bills more than the costs of the investment in recirculating equipment even when a discount rate of 20 percent was used.[2]

Little evidence is available to evaluate the effects of encouraging the public to reduce the amount of water consumed. However, during the drought of the early sixties in the Northeast, the available evidence suggests that such pleas were largely not heeded.[3]

REUSE AND PLANNING

Renovation and reuse of municipal water is neither a new concept, nor is it an inherently efficient method which should be employed to supply water. Water reuse is a broad term which is applied to any additional application of waste water. It can be inadvertent and unplanned as the withdrawal and use of water from a river with an upstream discharger, or direct and planned, as in a factory where water from one process is directed with or without

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[1] Clifford S. Russell, David G. Arey and Robert W. Kates, Drought and Water Supply, Baltimore: The Johns Hopkins Press for the Future, 1970.

[2] Ibid.

[3] Ibid.

treatment to a second in a series of cascading uses. In the municipal system, planned reuse involves the collection and treatment of sewage and the use of the effluent for irrigation, recreation, industry or for return directly or through an intervening body of water or aquifer for general municipal use.[1]

Although physical conditions in water-short areas will dictate increased water reuse, it has already been recognized by innovative water managers in all areas of the country as a source for industry, recreation, and irrigation of public and private lawn areas and parklands. Water reuse is also being encouraged by federal legislation which, under the Water Resource Planning Act of 1965, requires that reuse be considered as one of the alternative methods of meeting future demands for water.[2] In a study of the nation's water needs by the National Water Commission, reuse has been recognized as an attractive potential source of water which merits careful and serious consideration.[3] It is a source available to all municipal systems which holds promise at least as an alternative to conventional sources of supply and especially in the future because of the recent federal legislation requiring standards for

---

[1]Examples of reuse applications are: Irrigation, Lubbock and San Angelo, Texas; recreation, Santee and South Lake Tahoe, California; aquifer recharge, Whittier Narrows, California; direct reuse, Windhoek, S. E. Africa.

[2]Water Resources Planning Act of 1965 (P.L. 85-90). Sec. 102; also Water Resources Council "Principles and Standards for Planning Water and Related Land Resources," Federal Register, XXXVIII, No. 175, Sept. 10, 1973, 24778-24869.

[3]National Water Commission. New Directions in U.S. Water Policy, (Washington, D.C.: Government Printing Office, 1973), p. 126.

discharge into navigable waterways.[1]

In practice, however, reuse is not usually being considered as an alternative, but as an additional source, adopted by communities for reasons not connected with the status of the water supply system. This adds unneeded capacity and as a result increases costs without necessarily increasing benefits. In a preliminary analysis carried out as a part of this study, the costs and benefits of reuse in Santee and Whittier Narrows, California; Lubbock, Texas; and Colorado Springs, Colorado, showed that only Lubbock had a net benefit from reuse.[2] Each of these cities have at present an adequate or abundant water supply. Whittier Narrows and Santee draw water from the recently completed Feather River Project. Lubbock has surface and ground water reserves which will be adequate for over thirty years. Colorado Springs has been provided with major interbasin transfers along with the development of the capability for reuse.

Although reuse represents excess capacity for Whittier Narrows and Colorado Springs, both consider that reuse provides net benefits. Both cities use average rather than marginal costs in their analysis. The former compares the cost of water provided by the MWD for aquifer recharge with the cost of water from the reuse plant, the latter with the average cost of water from the municipal system.

---

[1]The scheduled deadlines are established by the Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500; 92nd Congress, S. 2770, Oct. 18, 1972.

[2]Daniel M. Dworkin, "Economic Considerations of Reuse--Prologue to a Model" in Community Adoption of Water Reuse Systems in the United States, Roger Kasperson et al. (Worcester: A Report to the Office of Water Resources Research, 1973), p. 4.

Marginal costs comparisons, however, might lead to different conclusions.

Renovation and reuse of municipal water is neither a new concept, nor an inherently efficient method which should be employed to supply water. It is, however, a potentially attractive alternative which should be investigated to determine if it is safe, acceptable, and efficient. To make a valid judgment of the efficiency of reuse, a plan is required for examining the supply, demand, and treatment of water with alternatives for increasing the system capacity by providing reuse or conventional additions to supply.

RATIONALE FOR REUSE

Reuse provides a source of water which could delay or obviate the need for conventional additions to supply. In addition to supplying water, the presence of a standby source can increase system yield and provide planning flexibility. The benefits would result from its application in three areas: 1) as a substitute for high levels of assurance or reliability of supply; 2) as a method of mobilizing over-supply resulting from understatement of system yield; 3) as a method of shortening the planning cycle which would allow pragmatic evaluations of change in demand to replace present long term projections.

System Capacity: The Supply of Water.

The yield of a water supply system based on storage of flows is usually expressed as a quantity of water available for a stated

percentage of the time or expected probability of occurrence. The availability is of some high-order, typically 95 percent or more of the time. This concept of safe yeild is simple and while it is often regarded as a deterministic quantity, it is not. The streamflow records which would be required for a statistically satisfactory calculation are not available. As a result, the short record available which is assumed to represent the entire population of flows is used. Alternatively, a synthetic trace of streamflows is generated which also may not be representative of the actual population of flows encountered during the life of the system.

The engineer must, using the synthetic trace of flows, select the severity of events which will then determine the yield of the system. Engineering texts and the standard reference handbooks urge a conservative calculation.[1] Social Scientists, on the other hand, claim yields are often, if not always, understated.[2] As an alternative to this sometime academic debate, renovation and reuse can provide a standby source which allow the use of present facilities until pragmatic evaluations of the behavior of the physical system to the demands placed upon it can replace the engineering estimates of yield. If the system yield has been understated, reservoir levels will fail to drop at the rated yield

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[1]Gordon Maskew Fair, John Charles Geyer, and Daniel Alexander Okun, Water and Wastewater Engineering, Vol. 1, Water Supply and Wastewater Removal (2 vols., New York: John Wiley and Sons, Inc., 1966 (p. 6-8).

[2]Clifford S. Russell, David G. Arey, and Robert W. Kates, Drought and Water Supply (Baltimore: The Johns Hopkins Press for Resources for the Future, Inc., 1970), pp. 100-101.

during low-flow years. Standby capacity would allow the operation of the system under conditions of increasing demand until excess yield, if any, was used.

Substitution for High Assurance Levels

There is a relationship between levels of assurance and yield in which a given stream and reservoir combination will produce higher yields as the required assurance is relaxed. The amount of increase is a function of the distribution of flows and the level of development of the stream. Table 3 is the calculated relationship between assurance and flow in the Colorado River Basin.

TABLE 3

STORAGE AND FLOW RELATIONSHIPS IN THE COLORADO RIVER BASIN

(Flow in billions of gallons daily, storage in millions of acre-feet)
(No deduction for reservoir losses)

Percent Mean Annual Flow	Billions of Gallons Daily	Levels of Assurance and Required Storage		
		98%	95%	90%
90	12.20	25.50	19.30	13.95
95	12.80	55.00	40.40	18.33
100	13.50	*	*	31.16

*100 percent of mean annual flow is not possible at these levels of assurance.

Source: George O. G. Löf and Clayton H. Hardison, "Storage Requirements for Water in the United States," Water Resources Research, Vol. 2, No. 3 (Third Quarter 1966), Table p. 340 also same authors unreported data as published in Nathaniel Wollman and Gilbert W. Bonen, The Outlook for Water (Baltimore: The Johns Hopkins Press for Resources for the Future, 1971), Table p. 256.

The normal level of assurance is 95 percent or higher. To achieve this, investments must be scheduled to be in place when water-use equals the assured-yield. Since the investment is indivisible for a unit of capacity, there is a period of over-investment, when capacity exceeds water use (Figure 1). At such time, the chance of system failure is less than 5 percent.

In practice, capacity is often added before need eliminating even the 5 percent chance that the system will not produce the full-rated yield. This is done even though allowing shortages that could be ameliorated by rationing might be an efficient method of management. In a study of the effect of drought in 48 Massachusetts communities in which rationing was used to allocate supply, the net costs incurred were low.[1]

Planned shortage, however, of even 5 percent is usually not perceived as a viable alternative.[2] Consequently, investment is made in facilities that will be utilized only 5 percent of the time; but, an alternative to the expansion of water supply systems by conventional additions to supply is to allow system-capacity to rise by relaxing the requirements for high-levels of assurance (Figure 2). The water required to augment the supply could then

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[1]Russell, Arey and Kates, Drought, p. 58.

[2]"The safe yield provided by a reservoir is usually defined as the annual flow delivered by the project; without causing intolerable shortages under recurrence of historical droughts. In the case of municipal and industrial supplies, it is the usual practice to permit no shortage, and in some cases even to provide a reserve storage in the event of droughts that exceed the worst of record." Leo R. Beard, Methods for Determination of Safe Yield and Compensation Water from Storage Reservoirs. Technical Paper #3, U.S. Army Corps of Engineers, Hydrologic Engineering Center, 1965 (underlining added).

Figure 1

WATER USE / SAFE YIELD

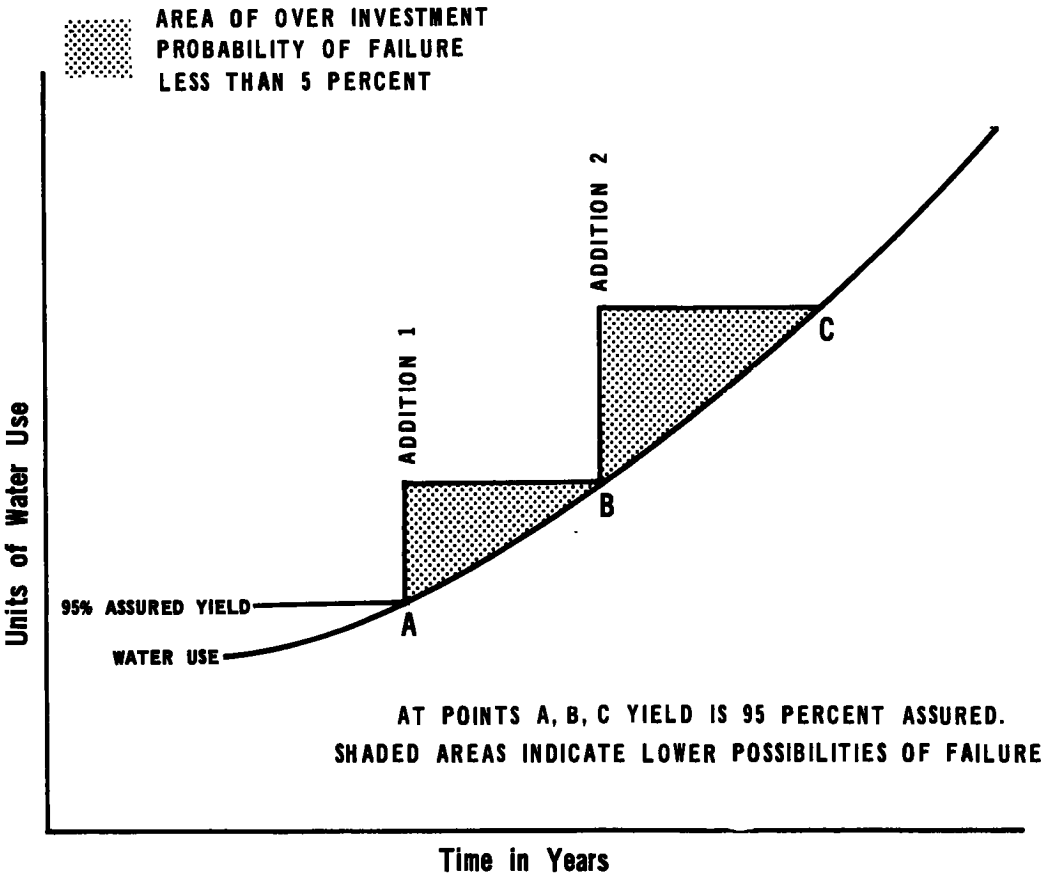
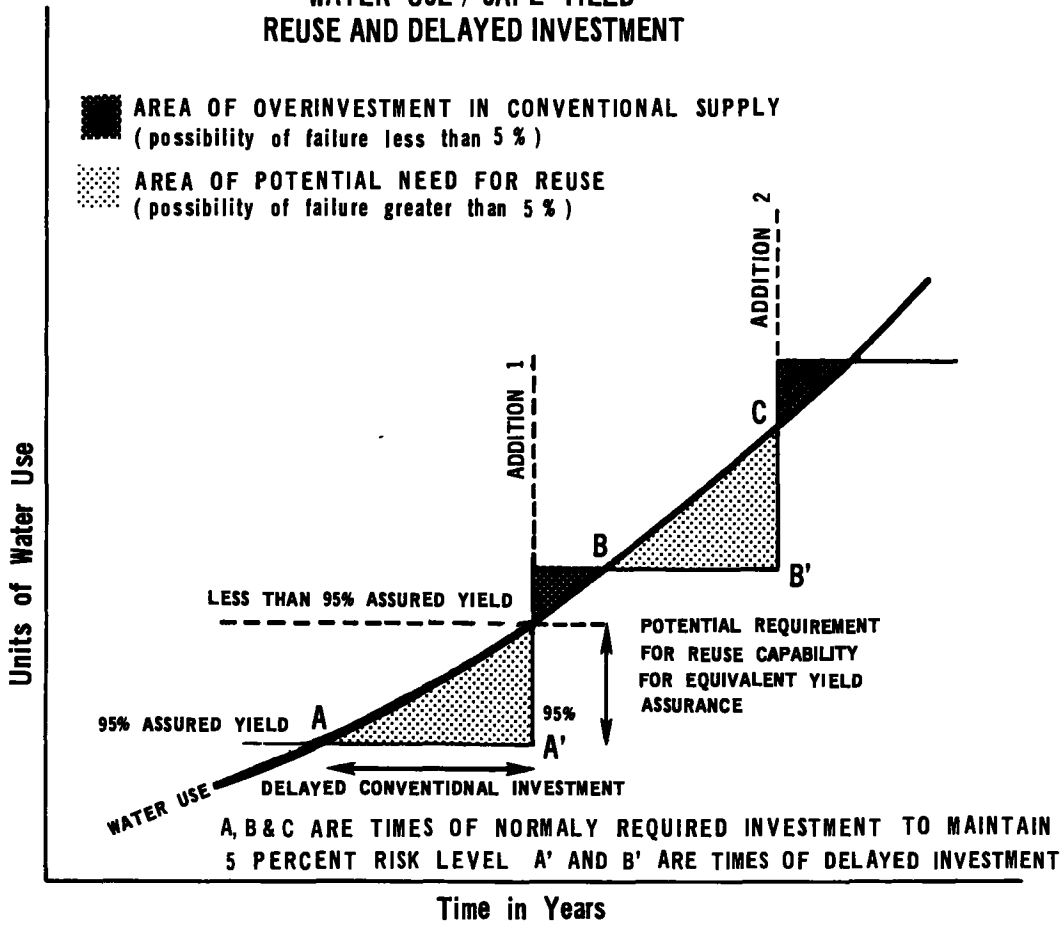


Figure 2

WATER USE / SAFE YIELD
REUSE AND DELAYED INVESTMENT



be furnished by reuse of renovated waste water either by processing it to potable quality and adding it to present flows or by displacing a present use of potable water which could then be supplied by treated effluent. In the latter instance, the required effluent quality might be available as a normal output of the waste treatment plan or might require additional treatment. An additional cost would be incurred in the distribution of the non-potable water directly to the user.

The Demand for Water

The projection of demand for water is the other variable of concern to the municipal water planner. The long time required for development of new water sources requires long term estimation of the future "need" for water. In the past, the growth in demand for water has rapidly utilized excess capacity based upon overestimation of municipal water requirements. However, the rapid growth of water systems nationwide has slowed. There are factors that would indicate that the slowdown will continue as the present low-rate of births affects the average family size. The single house with its requirements for lawn and garden water may give way to cluster homes and apartment type living units with lower per capita water requirements. If the rate of increase in use is slowed, a longer period will be required for the system to use any excess capacity provided. This will increase the costs since the system will have an investment in idle capacity for a longer period of time!

If the water system included the capacity to renovate and reuse

water, the planning cycle could be shortened. The need for water could be judged by noting the increased use over recent periods rather than projecting long term trends. The reuse component would provide the assurance to the water manager that the capacity of the system could be increased quickly if the conventional additions to supply were delayed too long.

REUSE: SAFETY, EFFICIENCY, ACCEPTABILITY

Water reuse is a potentially attractive alternative that should be investigated to determine whether it is safe, economically efficient, and socially acceptable. In a two-year study of water reuse, the safety, acceptability and efficiency of water reuse were investigated by a team of researchers based at Clark University and Southern Illinois University at Carbondale.[1] The group studied reuse applications in ten cities located in the East, the Southwest, Midwest and far Western United States. This study resulted, in part, from that research effort.

Safety: A Question of Public Health

Public health concerns are, for the most part, restricted to the uses in which drinking or bodily-contact is planned. There are at present no cities in the United States processing effluent for direct potable reuse. Windhoek, South West Africa, has provided the only long-term example of direct introduction of effluent into the municipal supply. The sewage is treated to a tertiary level

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[1] Roger Kasperson et al., Community Adoption of Water Reuse Systems in the United States (Worcester: A Report to the Office of Water Resources Research, 1973).

and includes a final filtration through carbon before being mixed with the conventional surface flow. The water produced meets all the standards set by the World Health Organization.[1]

Santee, California has been experimenting with the recreational use of renovated wastewater. Lakes containing treated effluent served as a scenic background for picknicking. Boating, fishing, and swimming activities were added in successive stages. The swimming experiment was closely investigated and even though viruses were commonly isolated from the raw sewage, none were ever found in the input to a final contact chlorination process.[2]

There is a concern by public health officials and other water management professionals, that while the sewage treatment plants might produce effluent suitable for any desired level of use, the operating personnel and the plant equipment are not capable of maintaining the degree of reliability required for potable use. Without minimizing these concerns, they should be examined in the context of the present state of the system and the alternative for augmentation. While most people are served by water supplies of acceptable safety, there continue to be incidents reported of acute or incipient health hazards because of the presence of potentially dangerous substances or organisms. A study of waste

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[1]G. C. Cillie, et al., "The Reclamation of Sewage Effluents to Domestic Use," Third International Conference on Water Pollution Research (Washington, D.C.: WPCF, 1966); also G. J. Stander, "Water Reclamation in Windhoek, Scientiae, X (January, 1969), pp. 3-14.

[2]John C. Merrill, et al., The Santee Recreation Project, Santee, California (Cincinnati, Ohio: U.S. Department of the Interior, FWPCA, 1967, pp. 108-116.

treatment, covering over one-third of the population served by surface water supplies in the United States, estimated municipal effluent in the water supply to vary from 0 to 18 percent with a median of 3.5 percent.[1] Daniel Okun estimates that half the users of public water supplies are receiving water, part of which was discharged only hours before from a municipal or industrial sewer.[2] The public health problems associated with unplanned reuse of effluent arises from the lack of treatment provided for the water from sources which had been considered safe. As a result, only cursory chlorination had been provided.

U.S. public health standards require polluted water sources to have dependable treatment facilities as well as adequate provisions for chlorination.[3] There is at present no federal legislation which requires adherence to either the criteria of water quality, standards of treatment, or monitoring for water quality furnished by municipal supply systems. There are standards for water used in public carriers engaged in interstate commerce, and under this provision the Environmental Protection Agency has banned 27 water systems for a variety of reasons, some unrelated

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[1]Louis Koenig, Studies Relating to Market Projections for Advanced Waste Treatment (Cincinnati, Ohio: U.S. Department of the Interior, FWPCA, 1966), p. 35.

[2]Gladwin Hill, "Impure Tap Water a Growing Hazard to the Health of Millions Across U.S.," New York Times, Sunday, May 13, 1973, p. 1.

[3]U.S. Department of Health, Education and Welfare, 1962, Public Health Drinking Water Standards, PHS Pub. 956 (Washington, D.C.: Government Printing Office), p. 6; and U.S. Congress, "Safe Drinking Water Act of 1973," S. 433, 93rd Congress, 1st Session, June 25, 1973.

to source of supply or treatment.[1]

The decision not to approve planned reuse for water supply does not preclude it from taking place. Most streams do have a reuse component in the flow. Present concern might be directed toward better controls on treatment and monitoring of both raw water and reuse sources.

Economic Considerations

Renovation and reuse have become a popular concept with the popular emphasis on conservation of resources, concern for the environment, and as an innovative approach to water management. It is not *per se* any of these things, for if unused capacity exists to supply water from storage of surface flow, which would otherwise spill, then the additional treatment may be unnecessary and uneconomical.

The capacity to recycle water is not without costs. The amount of savings from delaying conventional additions to supply would in part be offset by the cost of reuse capacity. There are many systems in use now where the costs of conventional water would be less than the present methods of renovating effluent. To judge the potential benefits of either conventional or reuse systems, a method of analysis must be used which will measure the availability and costs of conventional additions to supply as an alternative to reuse.

While a complete analysis of the system is essential for

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[1] Duane Baumann and Roger E. Kasperson, "Public Acceptance of Renovated Wastewater: Myth and Reality," Water Resources Research, 10 (August 1974), pp. 667-674.

definitive solutions, some generalizations are possible. Reuse systems are less capital intensive, but more costly to operate than diversion and storage of flows. Reuse systems are best for use as standby capacity, while stored surface water tends to be less costly if used at or near capacity. This would suggest reuse as a peak-load facility with storage to provide base loads.

The assessment of the economic costs and benefits from renovating and reusing effluent would require an analysis of the costs of the reuse and of the alternatives in supplying the needs of the system over the planning cycle. The costs of each would be assessed, the benefits would be assumed equal if equal water were supplied. The analysis should include alternate future projections of requirements for water and of streams flows serving as a source of supply.

Reuse capacity would be provided as required, but it would serve as a standby system used intermittently only when the level of water in the reservoir(s) were low. This type of analysis has not been performed. The concentration has been on calculating the costs of producing potable water from sewage even though untreated sewage is not the input, potable water not the only output, and continual use not the most efficient method of employing reuse.

The current literature available on problems of reuse considers only selected parts of the required information. Two questions are necessarily posed: What additional processes are required to treat the municipal effluent and what are the costs of providing and operating a plant to achieve the desired standards? Extensive research has been carried out to provide these data

(Tables 4 and 5). Once the costs and effectiveness of the processes required to treat sewage are known, the calculations become simple. Comparison with the costs of the conventional water supply indicates the relative efficiency of reuse. These investigations have largely focused on the costs of treating sewage by a series of incremental processes to restore the effluent to the original quality of the potable supply. Other investigations have focused on the same questions. Gloyna, in discussing the current status of water renovation, is confident of the technology but estimates costs of 54 to 57 cents per thousand gallons and suggests brackish water as an alternative.[1] Culp presents an analysis of South Lake Tahoe which indicates a cost of 37 cents a thousand gallons in a small plant (7½ MGD).[2] Work carried on by the Taft Research Center has provided cost estimates on waste treatment processes of all types and for different size plants.[3] Operating and investment costs are reported separately. Smith, in 1968,[4] and Eckenfelder, in 1970,[5] have also provided extensive work in the same field. Parkhurst, in 1963, provided an analysis of the

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[1]Earnest F. Gloyna, "Major Research Problems on Water Quality," in Water Research, Allen V. Kneese and Stephan C. Smith, Eds. (Baltimore: The Johns Hopkins Press for Resources for the Future, 1967), p. 485.

[2]Russell L. Culp and Gordon L. Culp, Advanced Wastewater Treatment (New York: Van Nostrand Reinhold Company, 1971), p. 128.

[3]Robert Smith and Walter F. McMichael, Cost and Performance Estimates for Testing Wastewater Treatment Processes (Cincinnati: U.S. Department of the Interior, FWPCA, 1969).

[4]Ibid.

[5]W. Wesley Eckenfelder, Jr., Water Quality Engineering for Practicing Engineers (New York: Barnes and Noble, Inc., 1970).

TABLE 4

COMPARISON OF ESTIMATED COST OF RECLAIMED SEWAGE EFFLUENT AND COST OF ALTERNATE WATER SUPPLY

Location	Type of Use	Cost of reclaimed effluent $/ac-ft.	Cost of alternative water supply $/ac-ft.	Reference
Pomona, Calif.	Irrigation	6-7.50	20	1
San Bernardino, Calif	Irrigation	0.31	10	1
San Francisco, Calif.	Parks, Lakes	23	70	1
Taft, Calif.	Irrigation	6	none available	1
Talbert, Calif.	Irrigation	6	unsatisfactory	1
Abilene, Texas	Irrigation	no cost	80	1
Kingsville, Texas	Irrigation	no cost	65	1
San Antonio, Texas	Irrigation	no cost	25	1
Grand Canyon, Arizona	Lawn irrigation	120	550	2
Santa Fe, New Mexico	Golf course	49	75	2
Las Vegas, Nevada	Golf course	27	30	2
Big Springs, Texas	Oil refinery	16	57	2
Baltimore, Maryland	Steel plant	11	44	1
Amarillo, Texas	Oil refinery	14	45	1
Los Alamos, Texas	Power plant cooling water	24	92	2
Los Angeles, Calif.	Groundwater recharge	18	42	3,4
Whittier Narrows, Calif.	Spreading	16.85	14*	5

*Metropolitan Water District of Southern California rate for groundwater replenishment. Does not represent total cost of imported water. Future additions from the Feather River are estimated to cost from $50-$100/acre-foot.

Reference:

[1] State of California, Water Pollution Control Board, A Summary Direct Utilization of Waste Waters, Publication No. 12, Sacremento, California, 1956.

[2] McGauhey, P. H., "The Why and How of Sewage Effluent Reclamation," Water and Sewage Works, June 1957.

[3] State of California Department of Water Resources, Feasibility of Reclamation of Water from Wastes in the Los Angeles Metropolitan Area, Bulletin No. 80, December 1961.

[4] Orlob, G. T. and M. R. Lindorf, "Cost of Water Treatment in California." J. American Water Works Association, 50(1), January, 1958.

[5] County Sanitation Districts of Los Angeles County, California. A Plan for Water Re-Use, July 1963.

Source: Richard J. Frankel, "Economics of Artificial Recharge for Municipal Water Supply," Symposium of Haifa, 72 Association Internationale I'Hydrologue Scientifique, Gentbrugge, Belgium, 1967, Table 1, p. 291.

TABLE 5

COST AND EFFICIENCY OF ADVANCED WASTE TREATMENT FOR WATER REUSE

Treatment process	Removal characteristics and efficiencies	Estimated cost of treatment process only ($/1000 gals)	Estimated average total cost of reuse ($/1000 gals)[a]	References
Absorption with activated carbon	70-95% removal COD-bearing organic material. Effluent contains 10-15 ppm organics. Inorganic salts not removed.	.05-.10	0.27[b]	1,2,3
Foam separation	85-95% removal ABS, 25-35% removal organic residuals. Effluent ABS less than 0.5 ppm. Inorganic salts not removed.	.02	.27[b]	1,2,4
Coagulation-sedimentation	95% removal phosphates, 40% ABS, 50-70% organic nitrogen	.07-.15	.30[b]	2,5

[a] Total costs to meet drinking water standards, exclusive of distribution and collection.

[b] Limited to 23 cycles of reuse unless dilution or demineralization provided.

Reference:

[1] Middleton, F. M., "Advanced Treatment of Wastewaters for Re-Use." Water and Sewage Works, September 1964.

[2] Stephan, D. G., "Water Renovation, Current Status of the Technology." Paper presented at the Southern Water Resources Conference, Chapel Hill, North Carolina, April 1965.

[3] Joyce, R. S. and V. A. Sukenik, Feasibility of Granular, Activated-Carbon Adsorption for Waste-Water Renovation. Public Health Service Publication, No. 999-WP-12, May 1964.

[4] Rubin, E. et al. Contaminant Removal from Sewage Plant Effluents by Foaming. Public Health Service Publication No. 999-WP-5, December, 1963.

[5] Williamson, J. N. et al. Evaluation of Various Adsorbents and Coagulants for Waste-Water Renovation. Public Health Service Publication No. 999-WP-14, June 1964.

Source: Richard J. Frankel, "Economics of Artifical Recharge for Municipal Water Supply," Symposium of Haifa, 72 Association International I'Hydrologue Scientifique, Gentbrugge, Belgium, 1967, Table 2, p. 292 (adapted).

relative costs and benefits of an imaginative plan for water reuse in the Los Angeles area.[1] The first innovative study of water reuse was by Johnson, 1971, who pointed out that the important consideration was the cost of additional treatment required above that required for control of pollution.[2]

What is required is an integrated analysis of a municipal water system in which the costs of expanding and operating the system without reusing water are compared to the same costs in a system which uses treated effluent as a supplementary source of water. The analysis should be extended to include various methods of integrating renovated water into the system.

Public Acceptance

Although renovated wastewater may be safe to drink and economically attractive, in some situations, a third and important question concerns public accptance, not only the consumers, but the politicians, management personnel, public health officials and consulting engineers. In essence, no program utilizing renovated waste water can be implemented without acceptance by the public.

In memory of the fluoridation debates and coupled with the heightened public participation of the present day, the question of whether the public (consumers) would accept recycled renovated

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[1]John D. Parkhurst, A Plan for Water Reuse (Los Angeles: County Sanitation District of Los Angeles County, 1963).

[2]James F. Johnson, Renovated Waste Water: An Alternative Supply of Municipal Water Supply in the United States. Chicago: University of Chicago, Dept. of Geography Research Paper No. 135, 1971, p. 128.

waste water or opt for a more conventional source of supply is paramount in the minds of water resource planners and managers. From a survey of 300 municipal water managers in the United States, the most common reason cited by the 50 percent who opposed waste water reuse was an anticipated rejection by the public. Similarly, Johnson found that "It would appear that water managers know very little of consumer responses concerning renovated wastewater, but generally consider the public would not accept it."[1]

In a recent research project and literature review, Baumann and Kasperson concluded that "...there is little evidence to support the widespread conviction among those discharged with proposing solutions to the nation's water supply problems that public opposition constitutes the most important obstacle to the adoption of waste water reuse systems."[2] Moreover, there is evidence that the public will accept renovated waste water for potable use provided they are aware of the technological characteristics of water treatment. Based upon survey data in five communities, Sims and Baumann suggest that what the consumers know and feel about drinking renovated waste water is related to the individual's general education level and his knowledge about water treatment and is not related to unconscious threats

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[1]James F. Johnson, Renovated Waste Water: An Alternative Supply of Municipal Water Supply in the United States. Chicago: University of Chicago, Dept. of Geography Research Paper No. 135, 1971, p. 92.

[2]Duane D. Baumann and Roger E. Kasperson, "Public Acceptance of Renovated Waste Water: Myth and Reality," Water Resources Research, 10 (August 1974), p. 673-674.

of specific dimensions such as fear of contamination or beliefs concerning nature, technology, aesthetics, authority, progress, or destiny.[1]

The central question, then, is why do the managers and engineers perceive the public as unwilling to accept recycled renovated waste water when the available evidence suggests that the consumers are not a major obstacle in community adoption or a program of renovated waste water? Could it be that as a result of the process of professional socialization the engineers, water managers and public health officials are reluctant to innovate or change the established procedures of municipal water supply provision? Hence, the public becomes a scapegoat for their reluctance to consider and/or recommend a program of reuse?

A key obstacle in the adoption of alternative strategies of recycling renovated waste water may lie not so much in the minds of the consumer, but in the perceptions of consulting engineers and public health officials--two influential groups in community decision making in planning for municipal water supply. It is to these relatively conservative groups that city officials and water managers rely upon for advice concerning the provision of water supply.

THE FUTURE OF RENOVATED WASTE WATER

The shortage of water will make reuse of effluent a certainty for many municipal systems. As cities move to tap less accessible

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[1]John H. Sims and Duane D. Baumann, "Renovated Waste Water: The Questions of Public Acceptance," Water Resources Research, 10 (August 1974), pp. 659-665.

surface or ground water opportunities, the costs will rise, either as a result of physical distance and subsequent cost of transport, or as the opportunity cost of water transferred from lower order uses to municipal use increase.

While the costs associated with water supply are rising, the costs for providing water for reuse are declining. This is due chiefly to the mandated upgrading of effluent discharged by municipal systems. These costs are properly ascribed to pollution control rather than cost of renovation. Under the 1970 pollution control program objectives, the federal government set standards that require secondary treatment of all municipal sewage and additional treatment in areas of special need. As phosphorous and nitrogen control are defined as falling in the latter category, a product water will be produced which will require, according to the experience at South Lake Tahoe, less than 10 cents per thousand gallons for residual treatment.[1]

The new federal legislation, which asserts that the discharge of pollutants into the nation's navigable waters be eliminated by 1985, will provide water for reuse at decreasing costs of residual treatment.[2]

The purpose of this study is to focus on two problems concerned with the practicability of renovated waste water for municipal water supply. First, an exploratory study was undertaken designed to

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[1]Culp & Culp, Treatment, p. 299.

[2]The scheduled deadlines are established by the Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500; 92nd Congress, S. 2770, October 18, 1972.

identify the judgments of consulting engineers and state public health officials toward the practicability of utilizing renovated waste water for municipal water supply (Chapter 2). Second, the remainder of the study (Chapters 3, 4, and 5) is an analysis of the costs of reuse in the context of the municipal system. Simulation modeling was selected as the mechanism to provide the necessary integrated analysis. A model is presented which was designed as a generalized research tool applicable to any municipal water supply system that depends in part upon storage of streamflows. The model is applied to Colorado Springs, Colorado, a community that has utilized renovated waste water as a supplement to its municipal water supply system.

CHAPTER II

CONSULTING ENGINEERS, PUBLIC HEALTH OFFICIALS, AND RENOVATED WASTEWATER*

Unlike the recent past, a common response to a problem today, whether public or private, is to consult a specialist. Children now are given preschool health examinations by pediatricians, more persons than ever before consult with psychotherapists, and communities and public agencies rely more and more upon the services of consulting firms.

The enormously rapid growth in the production of science and technology since World War II and the concommitant increase in occupational specialists are facts universally acknowledged. Daniel Bell[1] has noted that already in 1970, a majority of persons in the United States made a living by performing services, namely, in those occupations concerned with health, education, research, and government. And, by 1980, it is anticipated that nearly 70 percent of employees will be in the service sector. Although the era of specialized services has resulted in (or, at least, has accompanied) an increase in general welfare, it is the professional class, or in Galbraith's terms,[2] the technocracy, that has become more and more active in problem-solving, and more and more influential in determining public policy.

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*In collaboration with John H. Sims, Department of Counseling Psychology at George Williams College, Downers Grove, Illinois.

[1]Daniel Bell. The Coming of Post-Industrial Society: A Venture in Social Forecasting. New York: Basic Books, 1973.

[2]John K. Galbraith. Economics and Public Purpose. Boston: Houghton-Mifflin Company, 1973.

Two perhaps contradictory and perplexing themes can be clearly identified in the public response to this development. On the one hand, we have recently witnessed a resurgence of a populist movement, an outcry for participatory democracy, a plea for a voice in determining and guiding public policy. However, this response may be representative of but small select groups of educated elites or special interests. Because, on the other hand, there is much evidence that feelings of alienation among the public have never been higher; that among a large segment of the public there is a feeling of inefficaciousness, a conviction that there is virtually nothing one can do to effect change, and a feeling of powerlessness amidst the giants who have a monopoly not only of control but of knowledge. The creation of new institutions representing the consumer may be a promising trend in that the public may find more and more avenues of involvement in the decision-making process. But the problem seems staggering when one ponders the amount of knowledge required in understanding the ever-increasing complexity of our problems. Regardless then, of possible changes in the distribution of socio-political power, the nature of the problems themselves will force reliance on professional experts.

Our focus in this chapter is to examine the roles that two kinds of professional experts--consulting engineers and public health officials--might play in recommending the adoption of recycling renovated wastewater as an alternative in the provision of municipal water supply. Generally, little research has been undertaken concerning the psychology of professionals who are involved with environmental

problems.[1] A noteworthy exception is Sewell's[2] study which demonstrated distinct differences between public health officials and consulting engineers with respect to their perception of environmental problems and solutions. He found that both groups reflected their professional biases: when concerned with water quality, public health officials most frequently emphasized health problems while engineers were usually concerned with increasing costs of production. And, when concerned with solutions to environmental problems, public health officials, relied upon issuance of a warning followed by litigations, whereas engineers emphasized contruction of facilities--a reliance on what some term the "technological fix." But, we know of no research on how these two groups of professional experts perceive the persons and processes involved in a specific community decision concerning a specific environmental issue--in this case, the use of renovated wastewater.

To explore this issue, samples of health officials and engineers[3] were shown a picutre in which seven adult men in business dress were grouped in various attitudes around a conference table (Fig. 3). They were read the following instructions:

> This is a picture of a meeting in a mayor's office which he has called to discuss the possibility of

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[1]Kenneth Craik, "The Environmental Dispositions of Environmental Decision-Makers." Annals of American Academy of Political and Social Science, (May, 1970a), pp.87 - 94.

[2]W.R.D. Sewell, "Environmental Perceptions and Attitudes of Engineers and Public Health Officials." Environment and Behavior, 3(March, 1971), pp. 23 - 59.

[3]The sample of 98 consulting engineers (from 33 firms) and 22 state health officials (from 9 states) was drawn from areas of the eastern, midwestern and western United States.

Figure 3 TAT Picture

> coping with an impending local water shortage through the use of reclaimed wastewater. I would like you to use your imagination and tell me a story about it. Who do you think are the various persons attending the meeting? What is going on at the moment? What are the men thinking and feeling and saying? How do you think this situation will turn out?

The rationale for using such an unstructured, projective technique was the desire to avoid the power of suggestion inherent in more direct questionning. It was thought that such open-ended story-telling would reveal more truly who they thought should participate in such a decision, what might go on at such a meeting, and what course of action would finally be outlined, than would a series of leading questions, such as would lawyers be present, would the press have been invited, would you anticipate conflict at such a meeting.

The first question of interest concerns the persons seen attending the meeting. Who are they, what interests are represented, what professional gorups have been invited--and indeed, who has been left out? Table 6 presents the relevant data.

In general, consulting engineers and state health officials are in agreement as to who would be involved in a community decision about water reuse. Beside the mayor, whose presence is a given in the test instructions, the most frequently named figure is another elected official--almost three-quarters of the total sample identify at least one participant as a city council member. It is clear that both professional groups define the situation as one dominated by the executive branch of the local government.

The next three highest ranking categories of persons hover around the 50 percent mark for the sample as a whole, but some interesting,

TABLE 6

WATER REUSE MEETING: PERSONS ATTENDING

Person	Total (N=120)	Consulting Engineer (N=98)	State Health Offical (N=22)
		percent	
Mayor	93		
City Council Member(s)	72		
City water works superintendent	52*	49	69
Consulting engineer	52*	58	28
Public health official	49*	42	83
Mayor's staff member(s)	29		
City's engineering staff member(s)	27		
City legal counsel	23		
Representative of the public	21		
Representative of business & industry	17		
The press	6		
City public relations	5		

*For interprofessional differences on this variable, $p \leq .10$.

if predictable, interprofessional differences appear. Is it vanity or experience that results in each professional group seeing its own members as being more frequently involved in the meeting than those of the other: 58 percent of consulting engineers identify a consulting engineer in attendance as against only 42 percent who so name a health official. But that ratio is egalitarian compared to the corresponding figures for state health officials: 83 percent of them are sure a health official is present, but only 28 percent identify a consulting engineer as being at hand. However, state health officials are more generous than consulting engineers about the local water talent--69 percent of them identify the water works superintendent as attending the meeting, only 49 percent of engineers do so.

The next series of categories are mentioned by roughly a quarter of the total sample. Two of these--members of the mayor's staff and members of the city's engineering staff, are merely lieutenants of persons already identified, but the third, that of legal counsel, introduces a new area of expertise. Thus, 23 percent of both groups of professionals perceive the question of using renovated wastewater as probably involving legal problems, including the potential threat of damage suits.

Ending with the lawyers, it should be emphasized that the first 8 out of 12 ranked categories are executive-administrators or professional experts. Overwhelmingly, the picture is one restricted to government officials and their professionals consultants. It is only then that the respondents relax somewhat the criteria of admission: 21 percent identify the presence of a non-governmental representative

of the public (civic leaders, heads of community organizations, etc.); 17 percent identify representatives of business and industry (chamber of commerce, industrialist); 6 percent admit a member of the press (reporter, TV commentator, etc.); and finally, 5 percent bring in the services of a public relations man.

It is tempting to interpret this pattern of figures in the light of Sewell's previously noted study on the attitudes of engineers and health officials toward the solution of environmental problems.[1] Essentially, he found them to possess what may be termed a "closed-shop" ethos--a conviction that such questions should be left to them, as experts, and to representatives (elected) of the people. The people themselves, both the general public, and organized public groups, were disdained and feared. The data in Table 6 would appear to fit such a psychology, yet some caution must be exercised in this interpretation. The stories coded here are these men's projections of what they perceive to be the reality of such a decision-making meeting. And who can argue with the acuity of their vision--that such decisions would indeed most probably be restricted to government officials and their experts. At the same time, there is nothing in the stories to suggest that the story-tellers are not in agreement with that conslusion.

Now that the participants have been identified, it is possible to ask what their roles were. Who took what position on the question, who was for and who against, and what were their concerns? Table 7 ranks the participants according to whether they are initially positive, negative, or neutral (undecided) about the possibility of a

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[1]Sewell, op. cit.

TABLE 7

WATER REUSE MEETING: PARTICIPANTS' STANCE TOWARD PROJECT

Positive		Negative		Neutral	
Person	%	Person	%	Person	%
Consulting engineer	54	Health official	58	Mayor	76
City engineering staff	47	City legal counsel	49	Mayor's staff	65
Representative of the public	28	City council member	48	City water works superintendent	54
Representative of bus. & ind.	25	Representative of public	48	City legal counsel	51
City council member	19	Representative of bus. & ind.	40	City engineering staff	50
Mayor	17	City water works superintendent	30	Consulting engineer	36
City water works superintendent	16	Mayor's staff	20	Representative of bus. & ind.	35
Mayor's staff	15	Consulting engineer	10	City council member	33
Public Health official	12	Mayor	7	Public Health offical	30
City legal counsel	0	City engineering staff	3	Representative of public	24
The press	*	The press	*	The press	*
City public rels	*	City public rels	*	City public rels	*

*Numbers too small to be meaningful.

water recycling program. The percentages given are based on the reduced numbers of those who identified a particular category of persons as being present at the meeting.

The figures which form the top row of Table 7 are quite remarkable in their clarity. Both professional groups are in complete agreement in their perceptions of themselves, each other, and politicians. The consulting engineer is seen as being the person most favorably disposed toward the recycling project (54%), the public health official as most against it (58%), and the mayor as most neutral, undecided, or equivocal (76%).

Further, not only is each of the principals in this office drama--the engineer, the health official, and the politician--seen as displaying a different attitude, they are all seen as displaying a preponderant one. This contrasts sharply with the perception of "the public" which is seen as being more evenly distributed between positive, negative, and neutral attitudes. Thus, 25 percent of the sample see public representatives as being favorable toward the use of renovated water, 48 percent see them as against it, and 24 percent view them as neutral. Similarly, representatives of business and industry are perceived as 25 percent for, 40 percent against, and 35 percent undecided. Clearly, both the engineers and health officials are far more certain of themselves and their professional brothers than of the unknown layman--at least insofar as the initial response to the ideas of using renovated wastewater.

The data in Table 7 have shown that the majority of both consulting engineers and health officials perceive themselves to be in opposition to one another. And indeed, 85 percent of the total sample tell stories of conflict rather than of cooperation. But these are general attitudes;

what are the specifics, the causes (or rationalizations) of their positions. The distinguishing concerns of each professional group are presented in Table 8.

It is interesting that the professional sample most favorable to the idea of using reclaimed wastewater, the consulting engineers, is, at the same time, the group which finds it personally most repugnant: 46 percent of them admit to feelings of revulsion, and it is their first-ranked concern. The next problems most frequently see by engineers are three: public reaction (28%), health issues (22%), and technical feasibility (24%). This last figure is surprising; only a fourth of the engineers raise questions concerning their own area of expertise--the technical problems involved in recycling.

On the same logic, public health officials also respond somewhat unexpectedly--the health issues involved in the use of renovated wastewater are not their first concern, that rank goes to their worried interest in what the public reaction will be (55%). And indeed, their anticipation that the public may "cause trouble," is shown again in their concern about such a program's possible political consequences, an idea expressed with equal frequency (46%) to that of their concern for health issues (46%).

In sum, the two professional groups contrast greatly in the issues discussed at the meeting in the mayor's office. Engineers have but a single concern of first magnitude--that of expressing (and controlling) their feelings of revulsion to the use of renovated wastewater. The problems of technical feasibility, public response, and health, while acknowledged, are not emphasized. Public health officials, on the

TABLE 8

WATER REUSE MEETING: EXPRESSED CONCERNS

Concern	Total (N=120)		Consulting Engineers (N=98)		Public Health Officials (N=22)	
	%	Rank	%	Rank	%	Rank
Personal feelings of revulsion	42	1	46*	1	23	4.5
Anticipated negative public reaction	33	2	28**	2	55	1
Health issues	27	3	22*	4	46	2.5
Technical feasibility	23	4	24	3	23	4.5
Political consequences	18	5	12***	6	46	2.5
Cost	17	6	16	5	18	6
Legal ramifications	5	7	4	7	9	7

* For interprofessional difference of this variable, $p \leq .10$.
** For interprofessional difference of this variable, $p \leq .05$.
*** For interprofessional difference of this variable, $p \leq .001$.

other hand, are majorly concerned with three questions, of which health safeguards is but one; first and foremost, is their anxiety over public response and political repercussions. Again, Sewell has anticipated these results:

> "The problem of consulting public opinion poses a somewhat different problem for the public health official than it does for the engineer. The effectiveness of the former in performing his tasks depends very much upon the extent to which his recommendations and regulations are understood and accepted by the public, and the extent to which he is able to overcome opposition (real or imaginary) from various groups."[1]

The data have established how engineers and health officials differ in their over-all response to the projected use of renovated wastewater, and in the specific problems they emphasize. With these opposing attitudes, opinions, and interests, as well as those expressed by other participants, the mayor's conference, as previously mentioned, has been reasonably characterized by the sample as conflict-laden.

Two questions arise: the first concerns the means by which the conflict is handled--the ways in which questions posed are answered, and positions expressed are maintained or modified. And second, there is, of course, the question of how the conflict is finally resolved. Table 9 presents the data on the operations involved in the decision-making process, the coping mechanisms with which conflict is negotiated. And Table 10 shows the stances of the professionals at the close of the meeting.

Table 9 reveals that virtually a third of the entire sample (and there are no interprofessional differences) evidentaly are not

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[1] *Ibid.*

TABLE 9

WATER REUSE MEETING: CONFLICT COPING MECHANISMS

Mechanism	Total (N=120)
	per cent
The proposing of public relations programs; how to sell it to the public	20
Considerations of alternative sources of expanded water supply	18
General examination of the issues and problems	14
The proposing of further study and research	10
The proposing of a slow, cautious, "easing in" of the program	6
Conflict present but no coping mechanism given	31

sanguine about the conflicts being resolved--at any rate, they propose no methods for working them out. The rest of the sample distribute themselves in a rather disheartened and diminishing fashion among five alternatives: 20 percent suggest that the anticipated negative public reaction might be met with a public relations program; 18 percent propose to "avoid" the issue by suggesting a search for other solutions to the impending water shortage (that is, expanding sources of supply other than by recycling wastewater); 14 percent emphasize and intellective approach--all of the issues and problems must be carefully and comprehensively considered; another 10 percent

TABLE 10

WATER REUSE MEETING: RESOLUTIONS

Resolution	Total (N=120)	Consulting Engineers* (N=98)	Public Health Officials (N=22)
		percent	
FOR - no qualifications	20	24	5
FOR - partial, limited for crisis only	15	15	13
	35	39	18
UNDECIDED postpone decision, await further study	22	23	14
AGAINST - use only as a last resort	22	19	36
AGAINST - no qualifications	21	19	32
	43	38	68

* For interprofessional differences, $p \lesssim .10$.

echo this caution but are more specific in their proposals for research; finally, a minimal 6 percent suggest that a program of using renovated water be activated "by inches," slowly, cautiously, so as not to trigger a negative public response and so as to keep careful control over its possible dangers to health. But clearly the sample, over-all, is unenthusiastic about the processes of conflict resolution. The tone of their encounters with opposition is pretty much one of resignation, a feeling that no one's mind is going to be changed much anyway.

Table 10 presents the meetings final accounting--it details how the participants "vote" in regard to the proposed program of water reuse.

These concluding attitudes are much like the initial ones: twice as many consulting engineers (39%) as health officials (18%) are in favor of the idea, and virtually twice as many health officials (68%) as engineers (38%) are against it. What has happened in the course of the meeting is a shift toward a negative view; originally 54 percent of the engineers were favorably disposed toward the water reuse proposal and only 58 percent of the health officials were opposed. This movement is probably best viewed in the light of professional conservatism--the well-known tendency of the invested professional to avoid the risks of change and to preserve the known and controlled status quo in his area of expertise. We quote Sewell's analysis of the psychology of engineers and health officials a third time: "It is clear that experts are not in favor of change, especially if it means that their own role will be altered. Accordingly, they resist suggestions that new solutions should be tried."[1]

Nevertheless, the interprofessional differences that appear here are considerable. More than two-thirds of the health officials (68%) are against the use of renovated water, only 18 percent of them are for it, and then mostly for the "crisis time only." This contrasts sharply with the final attitudes of the consulting engineers--as many of them are for it (39%) as against it (38%). And indeed, a quarter of them are for it without qualification, a position taken by only 5 percent of the health officials.

These differences are surely best understood from the differing perspectives of the two professions' areas of concern. Consulting engineers are not directly involved with questions of public response

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[1] Ibid.

or politics; their primary interest and responsibility is with the technical--its possibility and practicality. On the other hand, the public health official is by definition responsible to the public and for the public. He must be concerned about their response. And further, the potential consequences of his approval of a program to use renovated wastewater are far more threatening. The spectre of a possible widespread disaster must loom large in strengthening the health official's resistance to an unfamiliar system. His risks are far greater than those of the engineer.

In summary, in telling stories about a hypothetical situation in which city authorities invite experts to consult with them on the possibility of a community program using renovated wastewater, consulting engineers and public health officials reveal their initial attitudes toward such a proposal, their perceptions of what problems might be encountered, their own personal concerns, and finally, their considered professional stance. At each point in the time sequence of the stories, health officials hold the more negative position--they begin by not liking the idea, then raise many and major objections to it, and in the end, find their reflection has strengthened their antagonism. Consulting engineers, on the other hand, begin with a far more favorable attitude, raise fewer objections, and conclude with a perfectly even split between endorsement and rejection. To some extent then, this use of a projective technique has illuminated the nature and strength of professional support and resistance to water reuse.

It is all too clear that a major research effort should be directed toward identifying the full range of implications inherent

in the use of professional experts in the formulation and implementation of public policy regarding environmental issues. The past has emphasized their expertise, the future must recognize their bias.

CHAPTER III

SIMULATION, MODELING, AND THE MUNICIPAL SYSTEM

THE USE OF THE MODEL

This chapter will outline a simulation model designed to investigate the reuse of municipal sewerage as a supplement to present sources of water supply. The model will be used to compare alternative plans that include municipal reuse over a fifty year period. The objective will be to provide water for municipal supply at minimum cost for the duration of the projection period. The costs considered include capital, operation, and maintenance costs for both water supply and waste treatment. All costs are incremental, those associated with present installations and use excluded. The simulation will be used to answer the following questions: 1) Can reuse be an economically efficient, i.e., low cost, method of supplementing water supply? 2) Are present reuse practices efficient? 3) can alternatives be formulated which are more efficient than present methods of reuse?

WATER MODELING

Simulation is a standard procedure used in the analysis of a system where the number of variables is large or the system is so complex that deterministic methods might be impractical. One type of simulation is the physical model. River systems in the form of models to scale have been constructed by the U.S. Army Corps of Engineers to simulate river flow conditions. Although it had been

abandoned, a model of the Mississippi River was recently reactivated to simulate the effect of various management alternatives for minimizing the demage of the record high flood levels of 1973.

Once removed from the physical models are the analog models in which electrical elements, resistors, capacitors, and conductors act on the flow of electrical current and simulate the effect of the system being investigated. First of these electrical-analog models of water resource systems was constructed early in 1950 by the U.S. Geological Survey analog modeling unit in Phoenix, Arizona. Since then over 60 simulations have been constructed which represent river and ground water basins in all areas of the United States.[1]

The continual increase in accessibility, capacity, speed and the decrease in cost of the digital computer has made this type of simulation the most flexible, useful, inexpensive, and as a result, the most widely used of the simulation techniques for the solution of water resource problems. It is routinely used to measure the safe yield of reservoirs and steams, predict deltic formations in reservoirs, optimize stream flow routings and predict runoff from snow melt and rainfall. These and other routines have become so widely used that the Hydrologic Engineering Center of the U.S. Army Corps of Engineers has prepared 27 standard programs to be available to do these calculations as well as assist in

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[1]Southern Colorado Water Conservancy District, Scientific Water Management Arkansas Valley, Colorado 1969-2050. Brochure No. 7 (Pueblo, Colorado: Southern Water Conservancy District, n.d.), pp. 3-6.

solving other water related problems.[1]

The first digital simulation model dates back to 1953. The U.S. Army Corps of Engineers, using a Univac 1 Computer simulated the operation of 6 reservoirs on the Missouri River. The objective was to maximize power generation subject to constraints for navigation, flood control, and irrigation. The next year the International Boundary Commission of the United States and Mexico simulated a two reservoir system on the Rio Grande River using an IBM 701 Computer. The Nile River Basin was simulated by Morrice and Allen in 1955. The objective was to maximize irrigation by using a combination of reservoirs, control works, and operating procedures.[2]

None of the above programs made any attempt to optimize the theoretical ratio of benefits to costs. This was first done by the Harvard Water Program, where a hypothetical river basin including four reservoirs was simulated.[3] The objective of the model was economic optimization of the design and operation of four multi-purpose reservoirs.

This was the first of the digital models to use simulated streamflows rather than a historical trace of actual flows. Using

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[1]U.S. Army Corps of Engineers, Hydrologic Engineering Center, "Generalized Computer Programs" List of Programs Available, September 1971.

[2]Ven Te Chow, "Water Resources, Part II. System Design by Operations Research" in Handbook of Applied Hydrology, ed. by Ven Te Chow (New York: McGraw Hill, 1964), pp. 35-36.

[3]Arthur Maass, et al., Design of Water Resource Systems: New Techniques for Relating Economic Objectives, Engineering Analysis, and Government Planning (Boston: Harvard University Press, 1962).

the historical record of streamflows in water resource modeling has some disadvantages. The record may be short or interrupted, but even if a long, uninterrupted flow record exists, only a single sequence can be simulated. The use of a series of synthetic traces of streamflows means that the model can be simulated for a number of alternate sequences. This provides a method of assessing the outcome of a plan over a wide range of possible flows.

THE MUNICIPAL MODEL--THE MAJOR SYSTEMS

The model designed for this study is a digital simulation model of: 1) the supply and storage of water from streamflows, wells; 2) the demands for water by up to 5 different water using sectors; and 3) the treatment of sewage by secondary and advanced waste treatment processes for discharge or reuse.

Sources of Supply

The streamflows, one of the sources of supply in the model, are generated monthly by using a mathematical model partly based on a stochastic process. A simple equation to produce flows is:

$$Q = U + \sigma z$$

Where Q = Simulated value of the monthly flow
u = Expected value of the monthly flow
σ = Standard deviation of the monthly flow
z = Standardized normal random deviate with a mean of zero and a standard deviation of 1. $N(0,1)$.

In the equation u is deterministic and alone would produce the same flow every month. The product of σ and z represents the deviation from the expected value.

There are three problems with this simple model. (1) Flows are not independent, they tend to persist. One low flow month tends to be followed by another and yet another as low water tables caused by low rainfall periods must be raised before normal rainfall produces normal runoff. The reverse is also true, high water tables support runoff during low rainfall periods. (2) Flows are not usually normally distributed, but follow a log-normal or some other distribution variant. (3) Flows of one stream are interrelated with flows from other streams.[1] The simple model would not generate flows which would exhibit these interrelationships.

The three problems--persistence, distribution, and interrelationship are all considered and routines designed to reproduce these effects are contained in the model HEC-4. This program was designed by the Hydrologic Engineering Center of the Corps of Engineers and furnished for use in the simulation.[2] The model first reads and converts the monthly historical data of flows into logarithms of flows. All other operations are carried out on the log values. The arithmetic mean, the standard deviation, and the skew are calculated for each station and each month. Each individual flow is then converted to a deviate by subtracting the monthly mean and dividing by the standard deviation. These are assumed to be Pearson Type III deviates and are transformed to normal

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[1]Myron B. Fiering and Barbara B. Jackson, Synthetic Streamflows, Water Resources Monograph Series, Vol. 1 (Washington, D.C.: American Geophysical Union, 1971), p. 5.

[2]U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-4 Monthly Streamflow Simulation (Davis, California: The Hydrological Engineering Center, 1971).

standard deviates.[1] Using the normal standard deviates, regressions are performed on groups of ten stations in which the simple and multiple correlation coefficients are calculated for the present and preceding month.

The synthetic streamflows are then generated as deviates by using the formula:

$$K_{i,j} = B_1K_{i,1} + B_2K_{i,2} + \ldots + B_{j-1}K_{i,j-1} + B_jK_{i-1,j} + B_{j+1}K_{i-1,j+1} + \ldots + B_nK_{i-1,n} + (\sqrt{1-R^2_{i,j}})\ (Z)$$

K = Monthly flow log expressed as a normal standard deviate

B = Beta coefficient computed from the correlation matrix

i = month

j = station number

n = number of interrelated stations

R = multiple correlation coeffieient

Z = random number from a normal standardized population

The deviates are converted to flows by first converting the standard deviates of flow to a Pearson Type III distribution. These are then multiplied by the standard deviation and the log of the monthly mean flow is added. The antilog of the calculation represents the flow at the stations for the month.

The other sources of water, wells and project flows are specified by month. They can be changed as required during the simulation. In some runs of the model, water supplied from reuse

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[1]The Pearson Type III distribution is a variation of the log normal distribution which will maintain the skew of the streams. When skew = 0, the Pearson Type III is the same as the log normal distribution.

is a fixed monthly quantity; in others it is a function of reservoir levels which are dependent on the source of supply and the demand for water.

Demands for Water

The use of water in a municipal system can be projected, or in the case of historical data explained, by providing either a single model or equation of total municipal use or separate equations for each water using sector. A single model has been used by the Senate in a study of the Nation's water resources and more recently in an update and refinement of that work by Wollman and Bonen.[1] A study of drought in Massachusetts and its effect on the municipal water supply systems also used a single model of total demand. When the model was used to predict water use and the results compared with the historical data by use of a regression, the level of explanation (as measured by the test) was high.[2]

Models of separate water using sectors can be more sensitive to changes in individual uses. They are not used more often because of the problem in most municipal systems of obtaining monthly data on use by sector. Such data were collected and models of water

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[1]U.S. Senate, Select Committee on National Water Resources, Water Resource Activities in the United States: Water Supply and Demand, 86th Cong. Committee Print No. 32 (Washington: U.S. Government Printing Office, August, 1960), pp. 2-3; also Nathaniel Wollman and Gilbert W. Bonen, The Outlook for Water (Baltimore: The Johns Hopkins Press for Resources for the Future, Inc., 1971).

[2]The variables were an index for weather, an index for employment and time. See Russell, Arey, and Kates, Drought, p. 33.

use for residential purposes were prepared in a study of water use by the Department of Environmental Engineering of Johns Hopkins University.

Two sets of models were formulated, one for use within the house and other for garden sprinkling. The variables were price, an index for sprinkling requirements, value of the dwelling and the number of persons living in a dwelling unit.[1] This simulation uses up to five different demand sectors each represented by a maximum of 10 variables. The equations for sector demand are formulated by using the historical monthly water use figures as input to a regression program. The regression will be used to establish the coefficients of the variables and to measure the significance.

The residual value from the regressions, the error term, are used to introduce a stochastic value in the monthly sector demand for water. This is done by calculating the mean and standard deviation of the residuals. The mean, which should be close to zero, is added to the equation for demand while the standard deviation is multiplied by a random normal deviate (0,1) and added monthly to the value of the derived equation.

Treatment

The model uses a simplified simulation of the waste treatment system. Sewage is treated as directed by the input parameters and

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[1] F. P. Linaweaver, Jr., John C. Geyer, and Jerome B. Wolff, Final and Summary Report of the Residential Water Use Research Project (Baltimore: Department of Environmental Engineering Science, The Johns Hopkins University, 1966).

the conditions of the reservoir in the program. Peak flow through each process determines the required capacity while total flow determines the operational costs. The treatment processes represented in the model are activated sludge, coagulation and sedimentation, filtration, and ion exchange. The processes can be rearranged or replaced by other methods of treatment.

The capacity and operating costs associated with each process are based on data developed by the Taft Center.[1]

TECHNICAL DESCRIPTION OF THE MODEL

The three major systems of the model are combined in a simulation consisting of a main routine and thirteen subroutines. The design and testing of the model was carried out over an eight month period. An experienced programmer, Roy A. Wyscarver[2] worked full time in close collaboration with the author for a three month period writing and debugging the model.[3] As previously noted, the model requires a synthetic record of streamflows and rainfall. The record is simulated by the use of the program HEC-4 and stored on tape or disc for use during the simulation. The following section will outline in detail the operation of each of the subroutines.

TINKLE

TINKLE, the main program of the simulation, manages the streams

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[1]Smith and McMichael, Cost and Performance Estimates for Testing Wastewater Treatment Processes.

[2]Roy A. Wyscarver formerly of the Department of Economics, Clark University.

[3]For technical considerations see Appendix A.

and reservoirs, determines when to recycle, calls for the expansion of the system when it is appropriate, and finally collects the statistics on the supply in the storage and the fixed and variable costs for streams, well, reservoirs, and projects (Figure 4). The main routine first receives the data setting the variables from the subroutine INPUT. It next reads one month of rainfall and streamflows. The flow of each stream is reduced to comply with water laws, pipeline constraints, and the seasonal restrictions against diversion. The amount of water which is of local origin and not to be reused because of the limitation imposed by prior appropriations and the imported water which is available for reuse are both calculated. The file on historical streamflows is updated by this month's flows. The program next checks the reservoir levels for this month in comparison to last month to determine if they are falling, staying the same, or rising. Based on this information, a decision is made to keep the present status of the recycling or to turn it on or off. Reservoir leakage and evaporation are calculated. Current water demands are next obtained from subroutine DEMAND. The new reservoir level is calculated. If the reservoir is spilling or is below the level of the conservation poor subroutine INTRPT prints the appropriate message. If the reservoir is dry the simulation ends and information to that point is printed under control of subroutine OUTPUT. If the reservoir is not dry, the program checks the subroutine EXPAND for any stream or reservoir which is scheduled for completion (Figure 5). All schedule expansions are completed. If scheduled, wells, project flows, and recycling amounts are changed. Statistics are

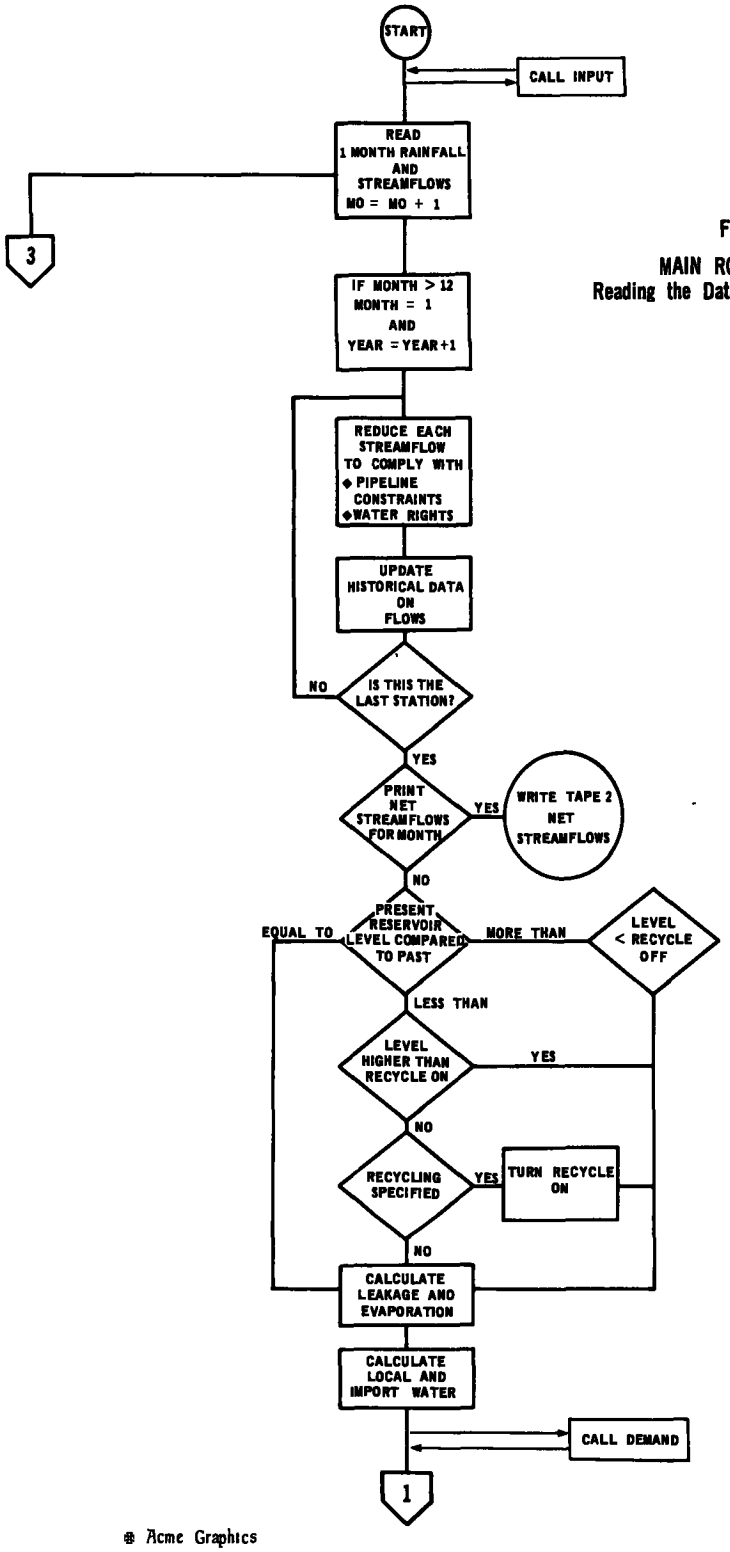

Figure 4

MAIN ROUTINE TINKLE
Reading the Data, Decision on Recycling

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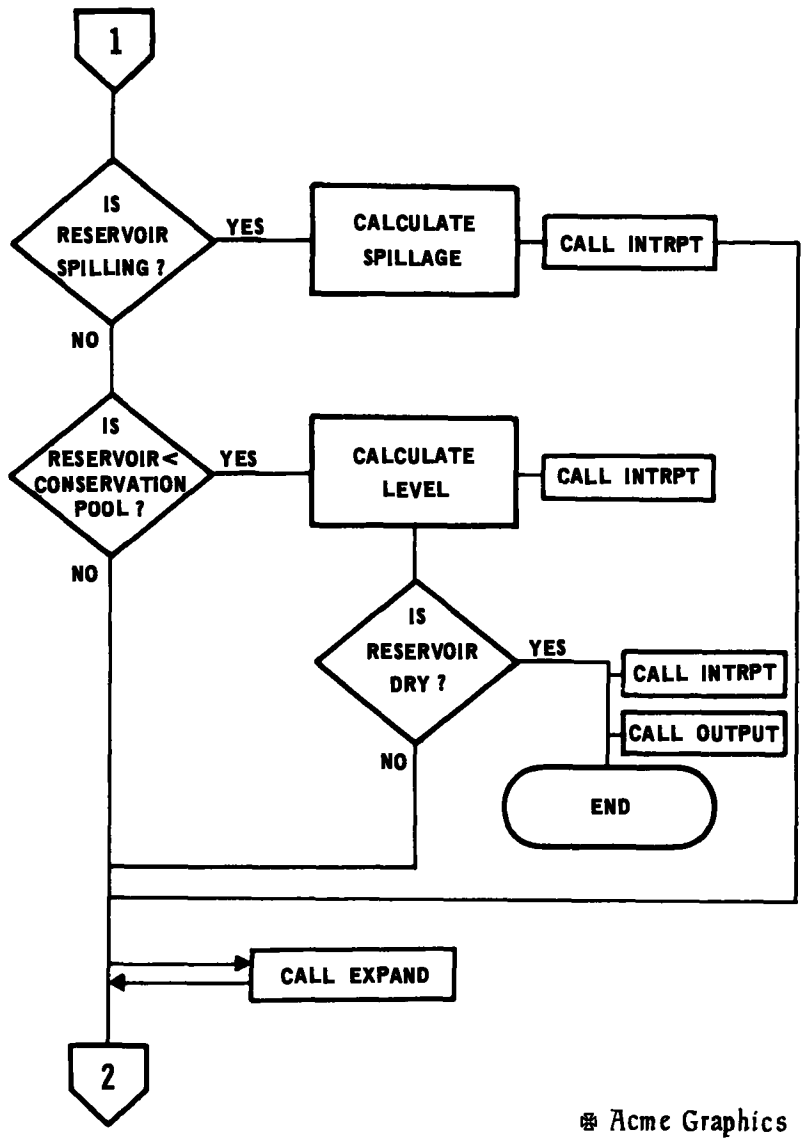
Figure 5
RESERVOIR LEVELS



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collected on streamflow costs. If it is not the twelfth month, the program returns and reads the next month of streamflows. At the end of each year the statistics are collected on the supply in storage.

The Decision Processes for Increasing Capacity

Increases in conventional capacity are made by adding new streams, reservoirs, wells or projects. There are two methods of doing this in the model. The first is the addition of these elements at a scheduled time. A second method relies on a yearly decision process. Before expansion is initiated three checks are made: 1) Is the current reservoir level above an expansion level EXPR? 2) Is the ratio of minimal level to annual use larger than the variable EXPL? 3) Is streamflow rank less than or equal to PROB, a rank of flows from 0 to 1? If all these conditions are negative, have not been fulfilled, the expansion is undertaken unless there is already a plan scheduled for implementation within the next two years. If there are no plans for scheduled additions to the supply for the following two years, the subroutine EXPAND is called and a plan from file 5 is transferred to file 1 and will be implemented in twenty-four months.[1] Finally, the subroutine calculates the variable costs of reservoirs, wells, and projects. Before beginning a new month, the month and year of the simulation

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[1]File 5 contains plans for system expansion which are not dependent on time, but rely on conditions generated within the model. File 1 contains plans which are time dependent.

is checked. If it is the last month, subroutine OUTPUT is called and the simulation ends (Figure 6).

Subroutine DEMAND

Subroutine DEMAND projects the independent variables used in a demand equation, calculates the demand for water and effluent, and in the event of a shortage allocates either reservoir or reused water from a specified level of the treatment plan to meet the demand. If reuse is not specified, then rationing may be used. If so, it allocates water from the reservoir in proportion to the selected allowable shortfall.

In detail the subroutine first projects the independent variable used in the demand models. A check is made with File 4 for any scheduled changes in the price of water or changes in the growth rate of industry or employment.[1] For each month the population and number of employees are re-calculated and changed. A check is then made for seasonal components of water use and summer pricing. The rainfall index, the cumulative departure from the mean rainfall, is set to zero in January. In succeeding months the program continues to accumulate the departure from the mean of rainfall for the year. The industrial demand for water is changed if planning File 2[2] if subroutine EXPAND indicates. This is done by changing the intercept of the demand equation.

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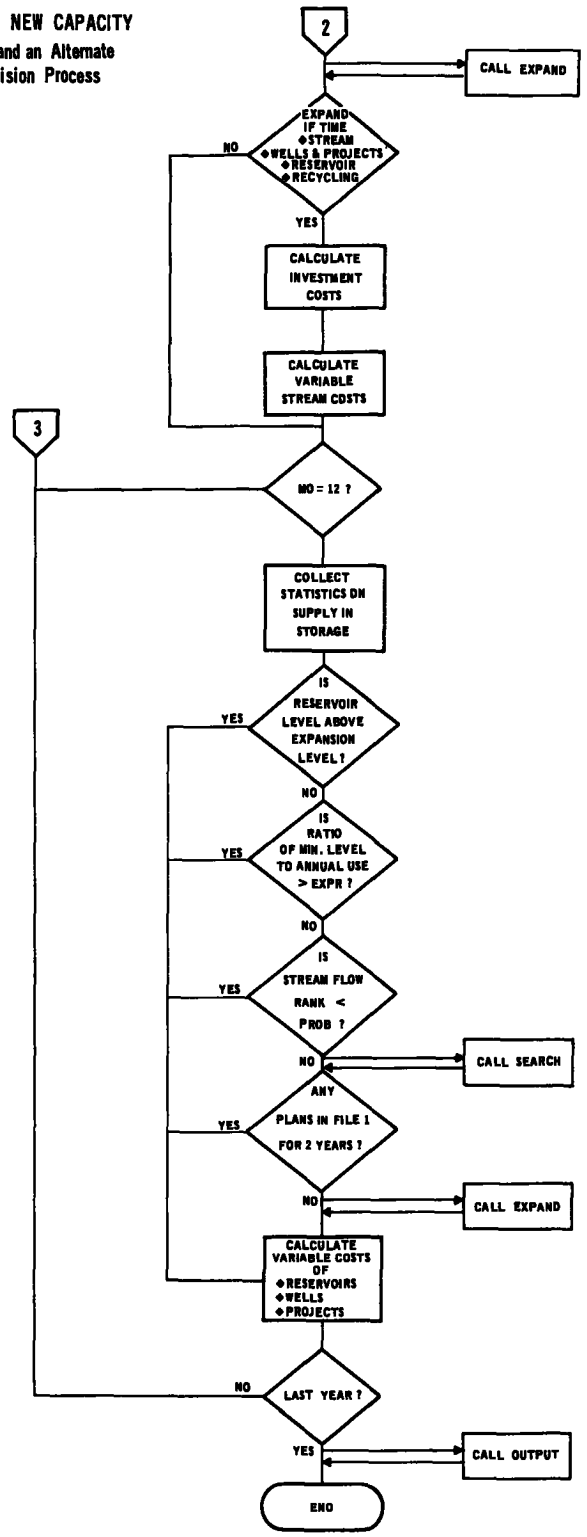
[1]File 4 contains time dependent changes of the independent variables used to project the demand for water.

[2]File 2 contains time dependent plans for a change in industrial use of water.

Figure 6

ADDING NEW CAPACITY

Time and an Alternate Decision Process



⊕ Acme Graphics

If recycling is specified a check is made with planning File 3[1] for any change in the distribution of reused water during periods of shortage. For each change made in the percentage of distribution during the periods of water shortage the INTRPT routine stores the appropriate message. A further check with File 3 is made for any changes in the continuous demands for reused water. If any changes are made these will be noted by the subroutine INTRPT. All the required information is now available to project the demands for water in the reservoir and each level of the treatment process (Figure 7). The demands for water are calculated. The function RNORM provides the required normal random deviate.

The demand for effluent required by the reservoir for the period qs calculated. The level of the reservoir is compared from the level specified by the variable RROFF. If the reservoir is lower, indicating a shortage, either rationing or reuse of water supply will be used to reduce further drain on the reservoir.

Rationing

If rationing is specified, demand (including the reservoir demand) is aggregated and the reservoir shortage is divided by the total demand. If the quotient, the percentage of shortage, is equal ot or less than the rationing limit, set as input, it becomes the percent rationing required. (If the percentage of shortage

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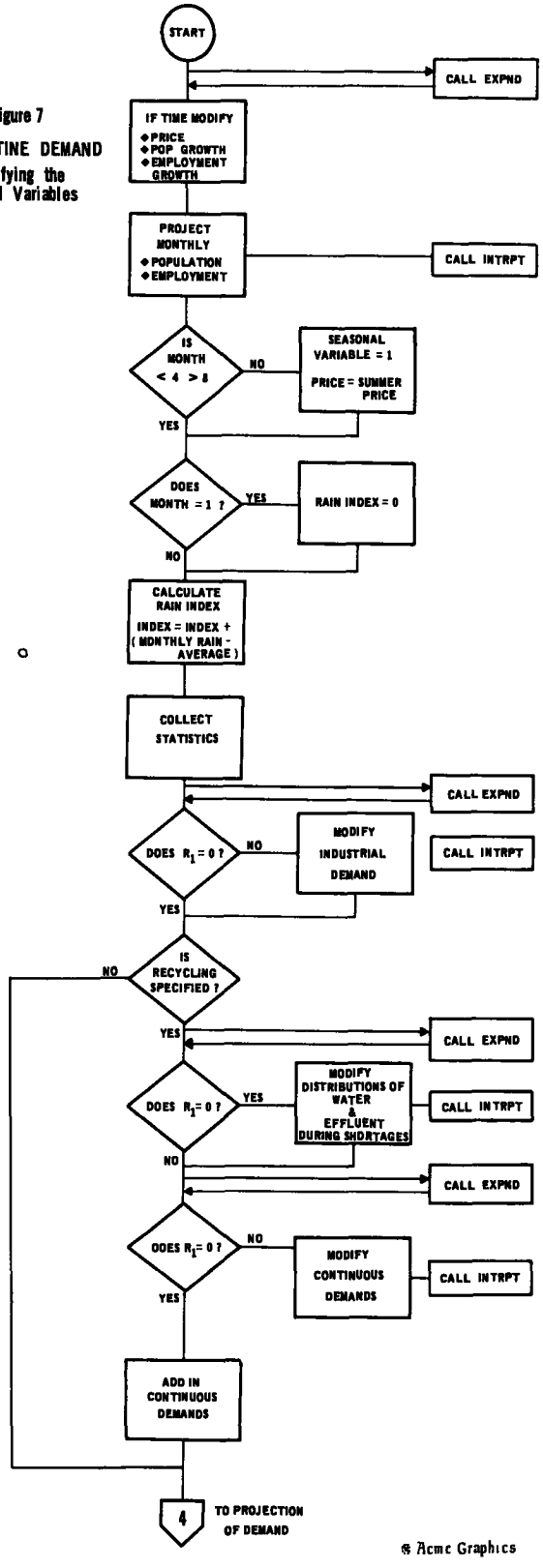
[1]File 3 is used to store time dependent plans for changes in the continuous demands for water and plans for changes in the distribution of effluent during periods of water shortage.

Figure 7

SUBROUTINE DEMAND

Modifying the Demand Variables



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exceeds the limit, it is set at the limit.) Each of these demands is reduced by this amount (Figure 8).

Reuse

When a shortage exists and reuse is specified, the demand projected for each of the five sectors is divided among the various sources of specified by the input distribution. A total demand for any sector of water use can thus be satisfied partly from the reservoir and partly by effluent from any level of the advanced waste treatment process. The quality requirement of the least tolerant user drawing water from a common distribution system will determine the level of treatment required. Each demand for recycled water resulting from the shortage is increased by the continuous demands for that specific level of water. If the amount of reuse provided to relieve the drain on the reservoir does not allow the reservoir level to rise and end the shortage, the reservoir also exerts a demand for effluent.

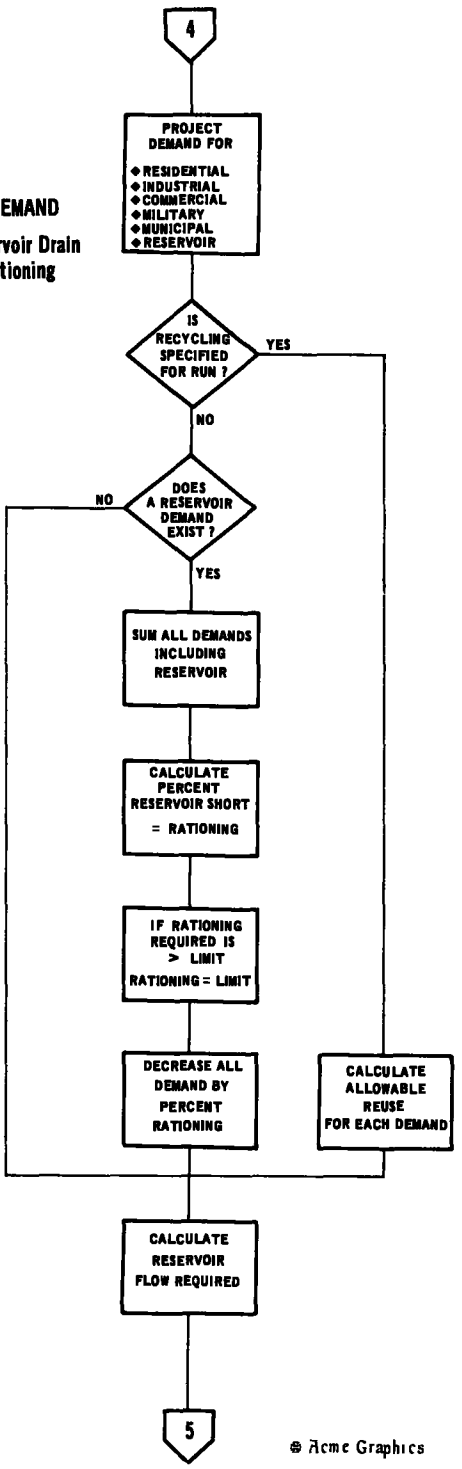
Processing Effluent for Reuse

A calculation is made of the effluent flow available to the advanced waste treatment process. This is the total demand for water from the reservoir less the sum of the locally produced water and the amount for the month not returned as sewage. If the total requirements for reuse, after adding in the system losses in each treatment process, is less than the total effluent flow available, only the amount required is processed. If the demand is just enough or higher, no cut back is made. Effluent is processed at each treatment level until the demand for that level and all

Figure 8

SUBROUTINE DEMAND

Reducing the Reservoir Drain by Reuse or Rationing



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succeeding levels is satisfied. The entire requirement is processed in one pass through the treatment process if enough water is available. If not, the renovated available effluent is distributed and the return flow is collected, treated, and redistributed. The demands of each level are satisfied before water is provided to successively higher levels of treament. The maximum number of passes is specified by the variable RITL. If this is exceeded the subroutine INTRPT is called and the recycling is ended.

The return of water to the reservoir is a special case. The water is processed through all levels of treatment, and before it is added to the reservoir a test is made of the total dissolved solids existing in the reservoir assuming the renovated water is added (Figure 9).[1]

The total flow through each process for a year is accumulated. At the end of each year the routine COST provides an annual cost of treatment by process. The peak flow for each month is compared with past peak flows. A notation is made of the highest monthly peak flow through each process. If a present flow is greater than a past peak, capacity is added. Capacity costs are calculated for each 10-year period by the routine CCOST. All investments in new plant capacity are assumed to be provided in the first year of the current decade.

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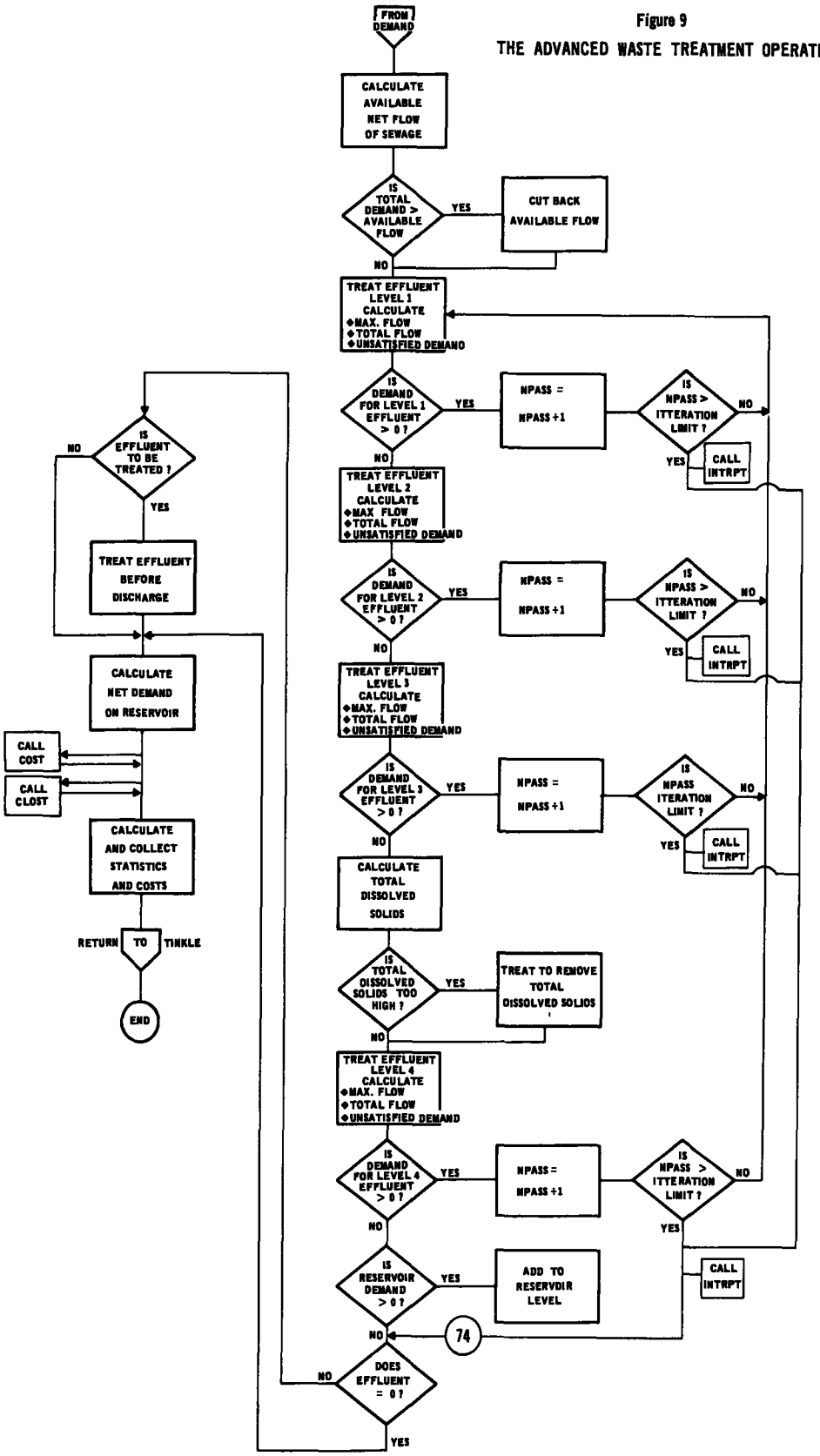
[1]Total dissolved solids of the recycled effluent is increased by 250 parts per million in each pass through the treatment process. When the level of total dissolved solids in the reservoir rises above 500 parts per million, a process to reduce the solids is automatically instituted before the water is added (Figure 9).

Figure 9

THE ADVANCED WASTE TREATMENT OPERATION



* Acme Graphics

Subroutine BLOCK DATA

Subroutine BLOCK DATA serves as a source of data for the variables common to other subroutines in the program. It is used to specify the logical unit numbers of the card reader, printer, punch and tapes of the specific computer being used. This routine also contains the present values for all items in the parameter list. Much of the data in this subroutine would not be changed if the simulation were being applied to another municipal system, such as the number of days in a month. Some could be changed for convenience, such as reservoir levels but if not changed could be overridden by the use of the parameter list. Some should be changed to represent the conditions of the difficult locality, such as the percent of the reservoir flow, by month, returned as sewage.

Subroutine INPUT

Subroutine INPUT read the input data. The subroutine first calls HEADING for the date and time of the simulation, then the title card. These are printed on each page of the output.

Each of the twelve types of data cards starting with data card one, the parameter list is then read. By the use of the parameter list, the user can specify the values for over fifty variables most often changed in different runs of the same basic data. Included in the parameter list is a group of edit options that reduce the full 100-page output to 20 pages of key tables. If specified the subroutine writes Data Cards I through XII.

The Variable List, Data Card I

Data Card I specifies the values of the variables which can be modified by the use of the parameter list.

Streamflow Constraints, Data Card II

The streamflow constraint card records the origin of each stream, whether local or imported water, the maximum flow which can be carried by the pipeline, the minimum flow which must be bypassed because of the prior rights, the amount which may be diverted, and any intervening rights.

Historical Annual Streamflow, Data Card III

The data on past years of streamflow, which had been used to simulate synthetic records of streamflows, are listed on data card III. These provide a historic record by which future years of streamflow data are ranked. All streams which are currently or which may in the future furnish water for the system are included.

Reservoir Losses and Evaporation Data, Data Cards IV and V

The minimum outflows required from a reservoir by month are contained in data card IV. One card is required for each stream specifying by month the amount of flow which must be maintained in the stream.

The evaporation data, Card V, lists by month the percentage of the total water lost by evaporation.

Distribution Data for Recycling, Card VII

The amount of reuse, the percentage of total use which can be supplied, presumably by direct piping, to separate sectors of water use,

is specified by this data card. By use of the card an individual sector will be furnished water during shortage from the reservoir or effluent from any of up to three different levels of treatment in proportion to the total requirement for that month. This will continue every month until the reservoir rises above the specified level to turn off reuse.

Continuous Demand for Reused Water, Data Card VIII

The continuous demands for reused water are controlled by data card VIII. The level of treatment and the amount in millions of gallons a day are specified. The effluent will then be furnished monthly and will be accumulated yearly as nonpotable effluent use.

Data Card IX, X, XI, XII

The next four data cards specify the mean monthly rainfall, the monthly requirements for untreated secondary flow and the water furnished monthly by wells and projects.

Subroutine OUTPUT

Subroutine OUTPUT combines all the data accumulated in the other subroutines of the program into output arrays. After calling and receiving the heading which includes title, date, and time, it prints the page number and appropriate output table. It calls INTRPT for a list of the messages stored and if the edit feature has called for punched output, it punches the data on population, per capita water use, use by sector, total use, reservoir levels, and rank of flows.

Subroutine INTRPT

Subroutine INTRPT stores and prints the list of events called for as the program progresses. These include the presence of invalid data cards, any additions or changes to the system, the reservoir level when spilling, when below the conservation pool, or when empty.

Subroutine EXPAND

Subroutine EXPAND manages the five files which contain the plans for changes in the system.

Subroutine SEARCH

Subroutine SEARCH first calls TINKLE. When called, the subroutine examines file 1. The plans in file 1 are for increases in capacity scheduled at a specific time. If file 1 contains a plan to be implemented within the next twenty-four months the variable IFOUND equals zero. If there are no plans for the next twenty-four months, IFOUND is set to one and the next plan listed in file 5 will be implemented in twenty-four months.

Subroutine SETPLN

Subroutine SETPLN initializes the planning matrix and reads the planning cards. It is called from INPUT and reads all the data cards in the planning files, designating first and last card by attaching a large index number and setting all pointers to initial positions. If a data card does not equal zero then it calls subroutine DUMP which prints the planning matrix.

Subroutine DUMP

Subroutine DUMP prints the planning matrix. It is called from INPUT at the beginning of the program. At the end of the program it is called from SETPLN if data card equals one. This then prints whatever plans are left in the planning matrix at the final part of the OUTPUT. A comparison between the first and last planning matrices will indicate which plans were implemented during the fifty year period and those unused at the end.

Subroutine HEADING

Subroutine HEADING prints a heading and numbers the pages of the output.

Subroutine INFO

Subroutine INFO obtains the date and time of day. It is called from HEADING.

Function COST, CCOST, and RNOM

Two functions, COST and CCOST, provide the operating and the construction costs for the advanced waste treatment operation; they are called from DEMAND. Each contains four equations representing one of the potential advanced waste treatment operations. The final function of the program produces a normal random deviate used in projecting water demands. It is called from DEMAND and is used to compute the stochastic component of the demand equation.

CHAPTER IV

WATER SUPPLY PLANNING: AN ASSESSMENT OF COLORADO SPRINGS, COLORADO

The water supply system of Colorado Springs is a complex network of ground water, surface water from local streams, a federal water project, interbasin transfers, and renovated water from returned sewage (Figure 10).[1] A combination of 20 potable and nonpotable reservoirs provide for the storage and release of flows. Prior appropriation doctrine governs the amount and timing of diversions, storage, and reuse.

The area has been growing rapidly. The growth of El Paso County, the Standard Metropolitan Statistics Area (SMSA) encompassing Colorado Springs, was the sixth highest in the United States. From 1960 to 1970 the population increased 64 percent.[2] To meet the resulting demands the water system has been expanding rapidly.

This chapter will sketch the historical growth of the city, describe the projections of population growth and water use, and review the planning for supply to meet these projections. The yield of a specific element of the system, the Pikes Peak watershed, will be

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[1]Colorado Springs was selected as a site to develop and test the model because of the long experience with water reuse by the city and the completeness of the water system records.

[2]U.S. Department of Commerce, Bureau of the Census. Census of Population and Housing: 1970 Series PHC (2) General Demographic Trends for Metropolitan Areas, 1960 to 1970.

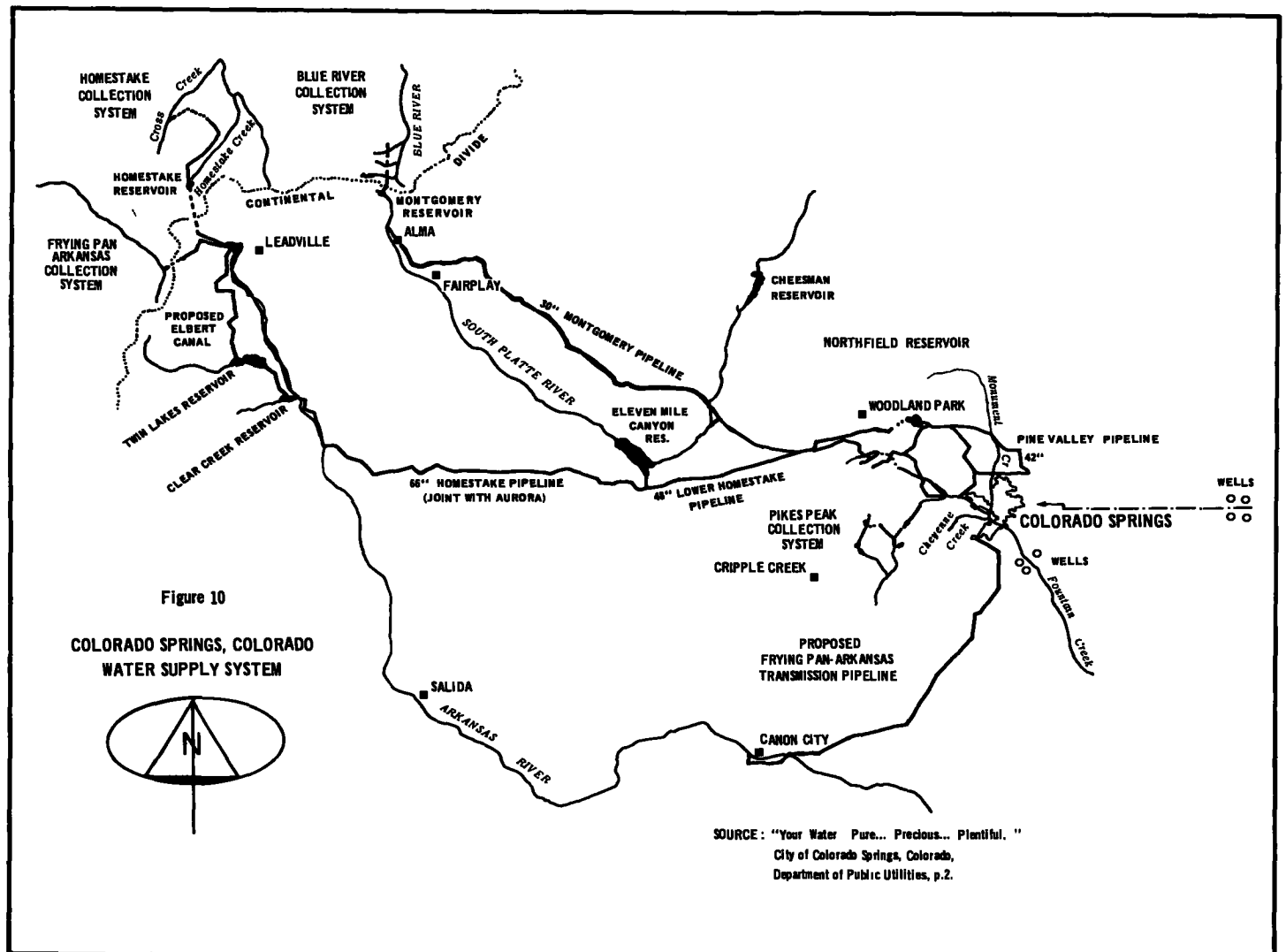

Figure 10

COLORADO SPRINGS, COLORADO WATER SUPPLY SYSTEM

SOURCE: "Your Water Pure... Precious... Plentiful." City of Colorado Springs, Colorado, Department of Public Utilities, p.2.

analyzed as an indication of the conservative engineering estimates of yield. Finally, an alternative to the present planning for the future expansion of the water supply system will be outlined. The present water supply plan and alternatives will be simulated and the results presented in Chapter IV.

COLORADO SPRINGS: A HISTORICAL PERSPECTIVE

The Setting: Environment, People and Government

Colorado Springs, Colorado, is a city of 135,060 persons (1970) located on the eastern slopes of the Southern Rocky Mountains. It is the administrative seat and major city of El Paso county, an area of sunshine, with low amounts of precipitation. Lush green lawns and tree shaded streets are a feature of the older residential areas which are in striking contrast to the surrounding countryside where summer grass cover is mostly brown and sparse. The area was planned as a model city in 1871 by W. J. Palmer, President of the Denver and Rio Grande Railroad. Much of the charm of the city can be credited to his planning including the present park system to which he gave the initial impetus and which now comprises more than 3000 acres.

The Government, the Utilities, and the Chamber of Commerce

There has been a close relationship between the government and the Chamber of Commerce which predates the beginning of the present council manager form of government.[1] In 1919, in response to a petition filed the previous year which asked the city to investigate the

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[1]Historical information in this section is from Department of Public Utilities: An Informal History (1872-1969) compiled by Howard J. Arnberg (Colorado Springs: Department of Public Utilities 1969).

purchase of the public utility franchises, the Mayor and the city attorney returned a report with two points: first, the Chamber of Commerce should appoint a committee of 15 persons to make the recommendations on this issue; and, second, that a special election be held to determine if $20,000 should be appropriated for further study. The special election defeated the appropriation, but the "Committee of 15" was formed and returned a report which became the basis for a successful fight to change the charter to a council manager form of government. In the subsequent election for council seats, the "Committee of 15" supported a slate of nine candidates pledged to "provide the best water system administration and development of the power program in that system." Of the nine candidates elected, five were supported by the committee and pledged implementation of the report while the remainder also became advocates of the program at a later date.

Not only were the elected council members all eventually supporters of the Chamber of Commerce plan, but their tenure was unusually stable, providing continuity in the attitude toward operation of the utilities. Of the nine original members of the council, one served continuously for 22 years. Another served until 1951 with the exception of six years. The long tenure of the city councilman also applied to the city managers. The first served eight years and the second eighteen years.

By 1925, the city owned and was operating the water, gas and electric franchises under the Department of Public Utilities. The department was headed by a manager who exercised administrative

control over four superintendents, two for the electrical system and one for each of the other divisions. Then in 1947, the sewer department also was included and became a division of the utility department.

The close association of the government and the utilities which began with the change to a council manager became city manager in 1930. He maintained executive control of both the government and the utilities for seventeen years until he retired in 1947.

Presently there is a very tangible basis for the close liaison. The utilities contribute money and services to the city in lieu of taxes. In 1970, the total value to the city of money and free services was over 2 million dollars.[1] Had a normal property levy been assessed, it would have raised 200,000 dollars.[2] Not only does the operation of the utilities contribute revenues, but the public and the local government are isolated from the consequences of any expenditures on the system, except as they are reflected in the rates charged for services. The utilities are independent of the financial limitation on municipal borrowing since all monies borrowed by the utilities are secured by bonds guaranteed only by the Department of Utilities revenues.

The combination of a shared vision of growth by the utilities, the Chamber of Commerce and the government provide a climate in which the utilities can grow unchecked by a government that can have public works, not competing for limited municipal funds. The expansionist

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[1]City of Colorado Springs, Department of Public Utilities. 1970 Annual Report, p. 11.

[2]Ibid.

views are reflected in the media where paid advertisements and unpaid documentaries contribute to the general theme that growth of the water system is necessary and may add to your water bill, but water is a bargain. One advertisement ended with the note, "Question is how do we combat the sudden rise in temperature when we get the water bill? How about a swim in Prospect Lake."[1]

Population Growth

The population of Colorado Springs was nearly 37,000 in 1940. Seven years later it had risen to just over 40,000--an annual growth rate of approximately one percent. By 1970, the population had risen to over 135,000. This rate of 6.5 percent is more than double the rate of the previous 11 years (Figure 11). El Paso County, with a 1960 population of 143,742, had grown to 235,972 by the 1970 census. If only the non-city residents of the county were considered, the growth was much slower, 73,548 in 1960 to 100,912 in 1970. The differential growth in the city and the county is causing the gradual domination of the area by the city of Colorado Springs (Table 11).

Employment

Employment in the area largely depends upon tourism and government, both military and non-military sectors. Jobs in manufacturing represents less than 10 percent of the total employment. The single greatest employment category was government. This category accounted for nearly

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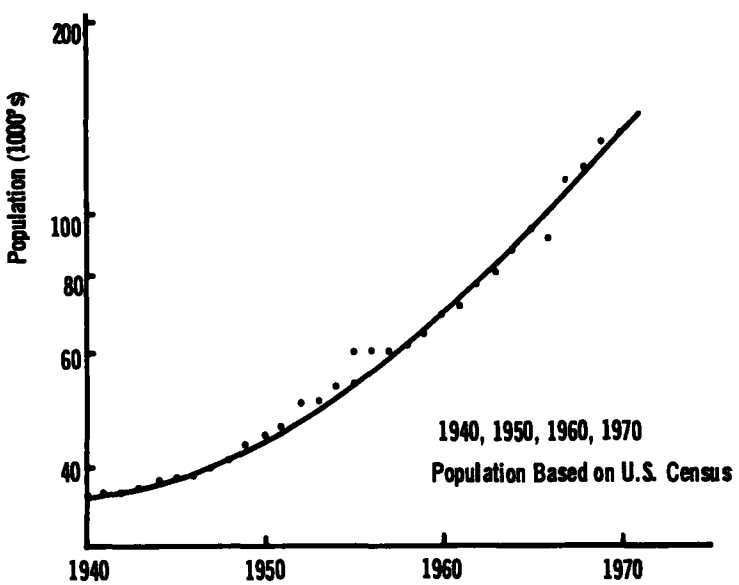
[1]"The Colorado Springs Story Water Cool Clear Costly," an advertisement by the First National Bank of Colorado Springs in the Gazette Telegraph, Aug. 15, 1971, p. 98.

Figure 11

COLORADO SPRINGS
POPULATION GROWTH
1940 - 1970



Source: Colorado Springs Department of Public Utilities

TABLE 11

CHANGE IN POPULATION: COLORADO SPRINGS AND EL PASO COUNTY, COLORADO, 1960-1970

Year	Colorado Springs	El Paso County	County Residents Only
1960	70,194	143,742	73,548
1970	135,060	235,972	100,912
Increase	64,866	92,230	27,364

Source: U.S. Census of Population, 1970.

25 percent of all non-agricultural jobs (Table 12).[1] Many of these workers are employees of the North American Air Defense Command (NORAD), Peterson Field, The United States Army Air Defense Command (ARADCOM), Fort Carson, and the United States Air Force Academy.

The other two large categories, service industries and trade, are in part the result of the presence of a large number of military personnel and the extensive tourist industry. Eight hotels and 159 motels with 4400 rooms serve the region which also has 43 mobil home parks.[2] These accommodate a booming tourist sector, drawn by attraction such as Pikes Peak and the Air Force Academy, as well as an average weekly population of 1680 convention goers.[3]

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[1]Colorado Division of Employment, Work Force Summary, Colorado Springs, Colorado, n.d.

[2]Colorado Springs, Chamber of Commerce, 1972, Statistical Digest, Revised Feb. 8, p. K-7.

[3]Ibid. p. K-4.

TABLE 12

WORK FORCE SUMMARY 1965, 1970: EL PASO COUNTY, COLORADO (ANNUAL AVERAGE 1000's)

Category	1965	1970
Total Work Force	54.0	71.2
Employed	52.2	68.6
A. Non-Agricultural	42.4	58.5
Construction	4.0	3.8
Manufacturing	4.2	6.7
Transportation and Public Utilities	2.5	3.2
Wholesale and Retail Trade	10.0	13.1
Finance Insurance, Real Estate	2.6	2.8
Government (91-93)	10.8	16.4
B. All other Non-Agricultural[a]	8.6	8.7
C. Agricultural	1.2	1.4

[a]Self employed, unpaid family workers, domestics in private households.

Source: Colorado Division of Employment, Colorado Springs, Colorado

WATER RESOURCES: PROBLEMS AND POLICIES

The use of potable water, which was less than 10,000 acre-feet annually from 1940-1947, rose to over 40,000 acre-feet in 1970. Water users are separated into five categories: residential, commercial, industrial, military, and municipal. Municipal use includes system losses as well as actual use.

The separate categories of use vary in the proportion of total use they represent from year to year and also in long term trends (Table 13). The availability of long term records by category of use enables separate models of water use to be formulated for each type of use which is potentially a more rewarding method than present models that are based upon aggregated use.[1]

Residential Use

Residential use is a product of population and per capita use. Changes in either will affect the total amount of water required. Population served by the Colorado Springs system has been increasing as a result of both annexation of other systems and growth within the present area served.

From 1950 to 1970, the average daily per capita use was 100 gallons. Each dwelling unit used 350 gallons per day at a 1960-1970 average cost of 46.5 cents per 1,000 gallons (Table 14).

In a study of municipal use for western areas, with public water supply and sewers, the average daily use was 458 gallons per dwelling

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[1]Charles W. Howe, "Municipal Water Demands," in Forecasting the Demands for Water, ed. by W. R. Derrick Sewall and Blair T. Bower (Ottawa: Policy and Planning Branch, Department of Energy, Mines and Resouces, 1968), p. 77.

TABLE 13

WATER USE BY CATEGORY AS A PERCENTAGE OF TOTAL USE:
COLORADO SPRINGS WATER SUPPLY SYSTEM, 1950, 1960-1970

Year	Residential	Commercial	Industrial	Military	Municipal	Total (Acre-Feet)
1950	32.0	16.6	5.3	7.9	38.2	15529
1960	36.6	12.7	7.1	17.1	27.1	25754
1961	33.8	12.7	7.7	19.0	26.8	20927
1962	36.4	11.6	7.1	19.3	25.6	26937
1963	36.5	11.2	6.8	17.9	27.6	27156
1964	40.8	10.8	7.3	18.1	23.0	30623
1965	33.8	11.6	6.7	17.2	30.7	28528
1966	37.3	14.7	4.0	16.3	27.7	33947
1967	36.3	16.8	4.4	18.0	24.5	37492
1968	39.2	14.2	3.6	17.9	25.1	39240
1969	39.2	16.5	3.9	18.6	21.8	36550
1970	40.3	17.1	3.5	16.0	23.1	44206

Source: Records Colorado Springs Department of Utilities.

unit at a cost of 39 cents per 1,000 gallons. In the East, the comparable figures were 301 gallons and 42 cents.[1] Colorado Springs occupies a medium position between the eastern and western cities in this study.

While per capita use has remained constant over a 20-year period, price has increased more than three fold. On this basis alone, one can suspect countervailing forces acting to maintain the equilibrium.

[1]Charles W. Howe and L.P. Linaweaver, Jr., "The Impact of Price on Residential Water Demand and Its Relation to System Design and Price Structure," Water Resources Research, III No. 1, (1967), p. 18.

TABLE 14

RESIDENTIAL WATER USE, AVERAGE SUMMER RAINFLL AND PRICE OF COLORADO SPRINGS WATER SUPPLY SYSTEM: 1950, 1960-1970

	Rainfall April to October (inches)	Price Received (¢/1000 gals.)	Population Aver./acct.	Daily Use (Gallons) Per Capita	Daily Use (Gallons) Per Acct. total
1950	9.42	16	3.49	101	353
1960	5.36	40	3.32	112	373
1961	17.11	43	3.36	81	273
1962	8.08	42	3.40	107	364
1963	11.13	42	3.44	103	353
1964	5.60	41	3.48	121	421
1965	17.19	44	3.52	88	309
1966	11.78	42	3.56	106	375
1967	13.66	49	3.60	88	316
1968	8.85	55	3.65	100	365
1969	14.59	56	3.70	88	326
1970	11.21	58	3.75	98	367
Average	11.20	46.5[a]	3.50	99.4	349.6

[a]Excluding Year 1950

Source: Records Department of Colorado Springs, Colorado, Public Utilities.

Thus a simple demand model will have limited validity unless all parameters continue to change at the same rate.

Other Use

The other sectors represent the remaining 60 percent of total use. These all exhibit different trends. Commercial use has been rising since 1964. During the same period, industrail use has been declining

not only as a percentage of increased total use, but in absolute terms. Military use was higher as a percentage of total use in 1950, but has accounted for approximately 25 percent of total use since 1960. (Table 13).

Present Water Supply

The present potable water supply system has an estimated capacity of 52,600 acre-feet annually. With the present capability of providing renovated effluent, the total system capacity is estimated to be 56,200 acre-feet. The designation used is firm yield in contrast to yields expressed at a given assumption of risk.[1] Under this definition the sources and amounts are listed in Table 15.

Investment in the Water System

The growth of the water system has resulted in heavy expenditures in new plants and facilities. Three questions are relevant: what is the cost of the investment; what has it bought; and was it needed?

From 1930 to 1950, the total expenditure on water supply projects was less than a million dollars.[2] From 1951 to 1960, over 14 million dollars were expended and by the end of 1970 the total investment in water supply projects was nearly 63 million dollars. If transmission and treatment are included, the total rises to 96 million dollars (Table 16).[3]

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[1]See Footnote 2, page 12 for a definition of safe yield. Firm yield is assumed to agree with that stated concept of no allowable shortage.

[2]Unpublished records, Chief of Operations, Department of Public Utilities, Colorado Springs, Colorado.

[3]Colorado Springs Annual Report, p. 15.

TABLE 15

PRESENT ESTIMATED CAPABILITY OF COLORADO SPRINGS WATER SUPPLY SOURCES

Source	Yield (acre-feet annually)
Pikes Peak	13,000
Northfield	700
Cheyenne Creek	1,600
Wells (ground water)	3,000
Blue River	10,000
Homestake (phase 1)	13,000
Monument Creek	1,300
Fryingpan-Arkansas (first allotment)	10,000
TOTAL	52,600
Reuse	3,600
	56,200

Source: Records, Chief of Operations, Colorado Springs, Department of Utilities

TABLE 16

VALUE OF COLORADO SPRINGS WATER SUPPLY SYSTEM FACILITIES: DECEMBER 31, 1970 (at cost, millions of dollars)

Source of Supply	62.83
Pumping	1.75
Treatment	6.64
Transmission and Distribution	23.72
General Plant	1.14
Total	96.08

The expenditures for the entire water supply and treatment plants for the 1961-1970 period is outlined in Table 17. The investment during the period represents a cost of over 1000 dollars for each additional resident served. Comparable figures for the United States during the period from 1955-1965 averaged 275 dollars which was estimated to rise to 350 dollars by 1970.[1] The costs included supply, treatment, and distribution facilities with their source of supply and transmission requiring the greatest amount (Table 17).

TABLE 17

CAPITAL EXPENDITURES, COLORADO SPRINGS, WATER SUPPLY SYSTEM 1962-1970

Year	Expenditure (Millions of $)	Population (1000's)	Meters in Service (December 31)
1962	2.26	83	28152
1963	2.79	88	29371
1964	7.00	95	31070
1965	16.14	100	32499
1966	10.72	112	36183
1967	3.19	119	37377
1968	8.46	124	39325
1969	8.11	131	40913
1970	2.84	140	43047
Total	61.51		

Source: Records of Department of Utilities, Colorado Springs. Unpublished data.

[1]Howe and Linaweaver, Price, p. 18.

The investment has been used primarily to increase safe yield. The rated capacity of the system in 1961 was 24,000 acre-feet annually, and in 1970, it had increased to 44,000 acre-feet (Figure 12). Each acre foot of capacity costs $3,510 or equivalently $9.38 per 1,000 gallons of flow.

The investment can be related to use rather than capacity. The 1961 use adjusted for average rainfall condition (Figure 12) was 21,200 acre-feet and rose to 38,000 acre-feet in 1970. This would produce an acre-foot capacity cost of $3,640 or $11.17 a thousand gallons.

The investment in capacity has a direct and substantial effect on the cost of water. Interest and depreciation represented over half the expense incurred by the water division for 1970 resulting in a sharp rise in the cost and price of water delivered to the consumer.

The costs increase has been reflected most heavily in the price of water for city and suburban residential users (Figure 13). This class uses less than 40 percent of the water and pays approximately 55 percent of the total bill (Figure 14). New rates, effective January, 1971, will increase the spread between residential and other users because the price of the category of lowest use, 500 acre-feet monthly or less, has increased 35 percent while all higher use categories have increased less (Table 18).

In addition to the direct cost of water supply, an indirect cost in the form of a tax on the assessed value of property has been collected since 1958 by the Southern Water Conservancy District for repayment of the reimbursable portion of the Fryingpan-Arkansas Water Project.

Figure 12

ESTIMATED YIELD and ANNUAL USE:
COLORADO SPRINGS, COLORADO

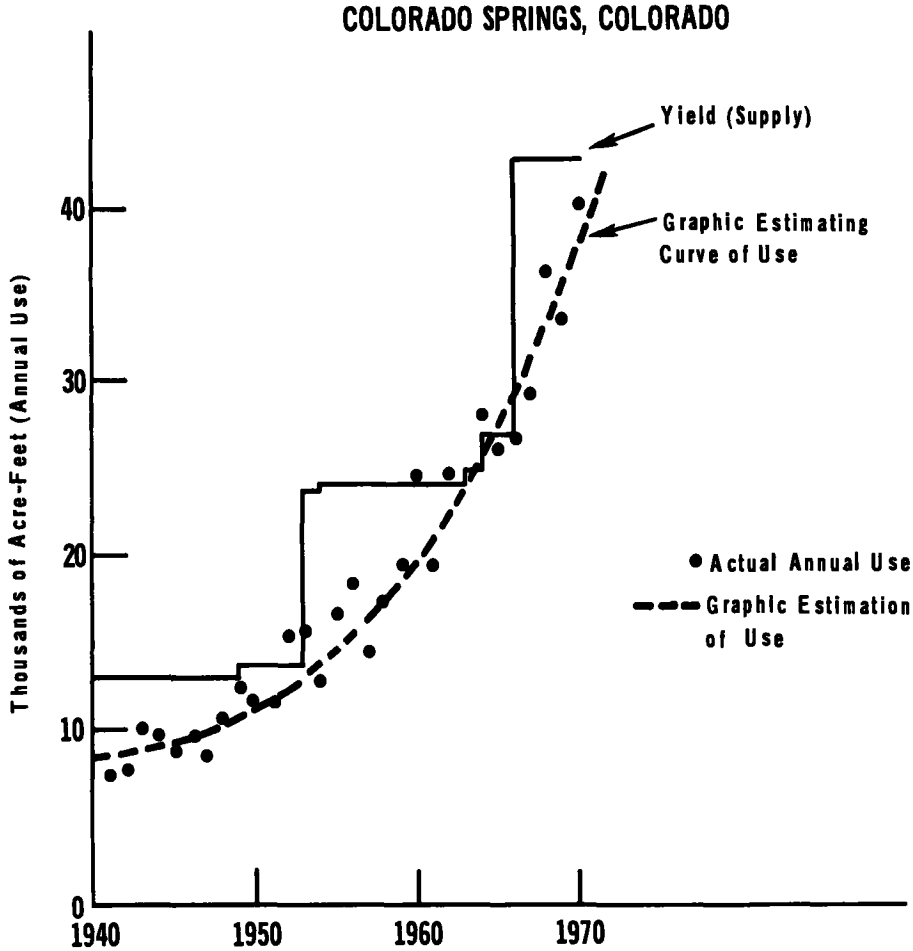


Figure 13

AVERAGE COST OF WATER TO CITY RESIDENTS, SUBURBAN RESIDENTIAL USERS, AND ALL OTHERS

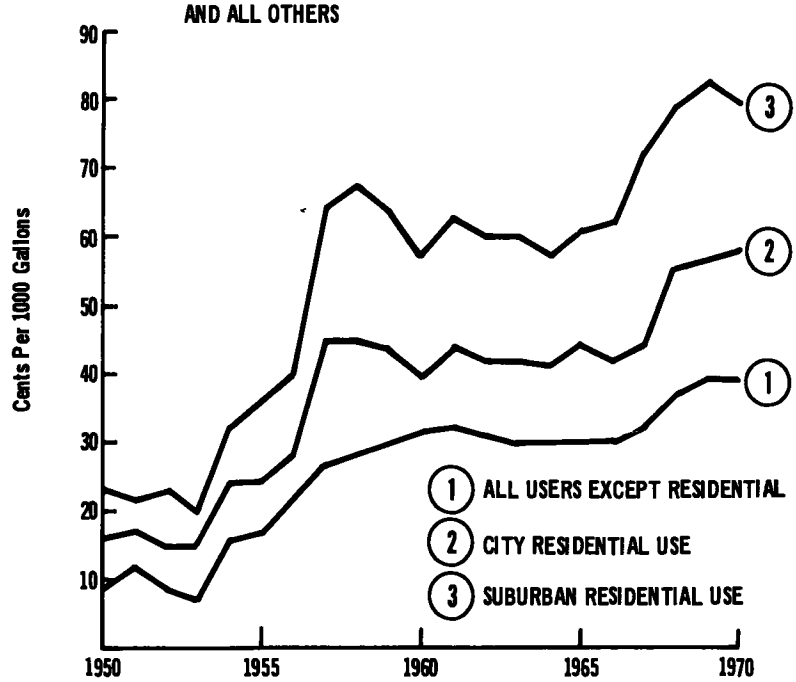


Figure 14

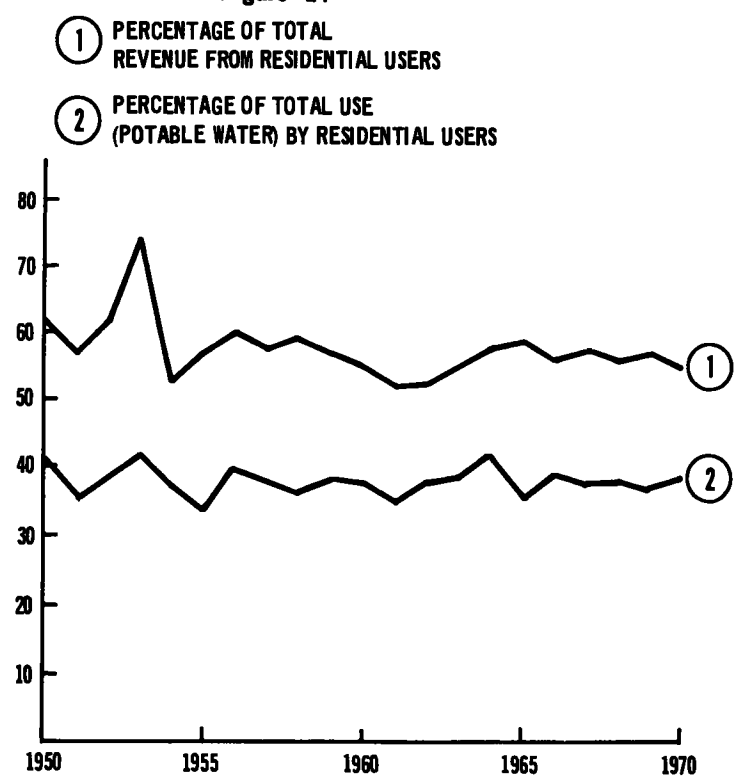


TABLE 18

WATER RATES: COLORADO SPRINGS, COLORADO
(New Rates Effective January 1, 1971)

URBAN (City of Colorado Springs)	New	Old
First 500 cubic feet used per month, per 100 cubic ft.	$.77	$.57
Next 3,500 cubic feet used per month, per 100 cubic feet	.40	.32
Next 46,000 cubic feet used per month, per 100 cubic feet	.37	.29
Over 50,000 cubic feet used per month per 100 cubic feet	.35	.27

MINIMUM CHARGES PER MONTH IN CITY:

The following monthly minimum charges, according to meter sizes shall be made regardless of the quantity of water used per month.

Meter Size	Minimum Monthly Charge	
	New	Old
5/8 inch and 3/4 inch	$3.85	$2.85
1 inch	3.85	2.85
1 1/2 inch	7.75	5.75
2 inches	11.15	8.25
3 inches	25.65	19.00
4 inches	44.90	33.25
6 inches	89.85	66.50
8 inches	128.35	95.00
10 inches	175.60	130.00

SUBURBAN (Territory Located Without the Corporate Limits of the City)	New	Old
First 500 cubic feet used per month per 100 cubic feet	$1.21	$.90
Next 3,500 cubic feet used per month, per 100 cubic feet	.60	.40
Next 46,000 cubic feet used per month, per 100 cubic feet	.56	.36
Over 50,000 cubic feet used per month, per 100 cubic feet	.54	.34

MINIMUM CHARGES PER MONTH OF SUBURBAN USERS SHALL BE AS FOLLOWS:

The following minimum charges according to meter sizes shall be made regardless of the quantity of water used per month.

Meter Size	Minimum Monthly Charge	
	New	Old
5/8 inch and 3/4 inch	$6.05	$4.50
1 inch	6.05	4.50
1 1/2 inch	12.15	8.50
2 inches	17.50	12.50
3 inches	40.25	29.25
4 inches	70.50	40.50
6 inches	141.05	99.00
8 inches	201.50	148.50
10 inches	275.00	202.50

Source: City of Colorado Springs, Colorado, Department of Public Utilities Published Rates Effective January 1, 1971.

Sewage Treatment and Reuse

The sewer division has been a part of the public utility department since 1947. Before it had been a tax supported municipal service, but since 1947 it has received operating revenue from users. The charge is based on water used by the customer in January (Table 19).

The treatment plant had been upgraded in 1959 from primary to secondary treatment by the use of trickling filtration and clarification. Two types of advanced waste treatment exist: one, provides only sand filtration of the secondary effluent and the other, a recently added pilot plant, uses a reactor clarifier and carbon filtration to produce a higher quality effluent (Figure 15).

Reuse renovation and reuse of effluent is controlled by the sewage divisior which has been producing and distributing effluent since 1957. Originally the motivation for reuse was a proposed sale to the highway department for irrigating the median strip. This never materialized, but preparations had been made and a nonpotable line had been installed. Two users, Kissing Camel Golf Course and Colorado College, tapped into the line soon after it was available. Later, two years of low rainfall and a restriction against irrigation (1960 and 1962) encouraged others to use the lower cost available effluent.

Present consumers of reused water, with one exception, are furnished secondary effluent which has been further treated to an advanced level by sand filtration. This has produced a product which has been satisfactory for use in irrigation and which is sold at a third of the cost of potable water. The higher quality product is being produced as cooling water for a city owned electrical generating plant. Other uses are being sought, especially industry not normally able to locate in

TABLE 19

SEWER SERVICE CHARGES: COLORADO SPRINGS, COLORADO
(Effective January 1, 1971)

URBAN (City of Colorado Springs)		SUBURBAN (Territory Located Without the Corporate Limits of the City)	
For the first 500 cubic feet, or any part thereof	$2.25	For the first 500 cubic feet or any part thereof	$3.60
For each 100 cubic feet or fraction thereof from 500 cubic feet to 4,000 cubic feet	.08	For each 100 cubic feet or fraction thereof from 500 cubic feet to 4,000 cubic feet	.12
For each 100 cubic feet or fraction thereof from 4,000 cubic feet to 50,000 cubic feet	.07	For each 100 cubic feet or fraction thereof from 4,000 cubic feet to 50,000 cubic feet	.10
For each 100 cubic feet or fraction thereof in excess of 50,000 cubic feet	.045	For each 100 cubic feet or fraction thereof in excess of 50,000 cubic feet	.07
The minimum monthly charge shall be	$2.25	The minimum monthly charge shall be	$3.60

BASIS OF SEWER CHARGES

Residential: Based on water billed during January each year. Any thirty (30) day period may be used in the case of new users or changing service conditions.

All Other: Base month may be the first calendar month of each calendar quarter and determination so made shall be effective during the quarter including the base month.

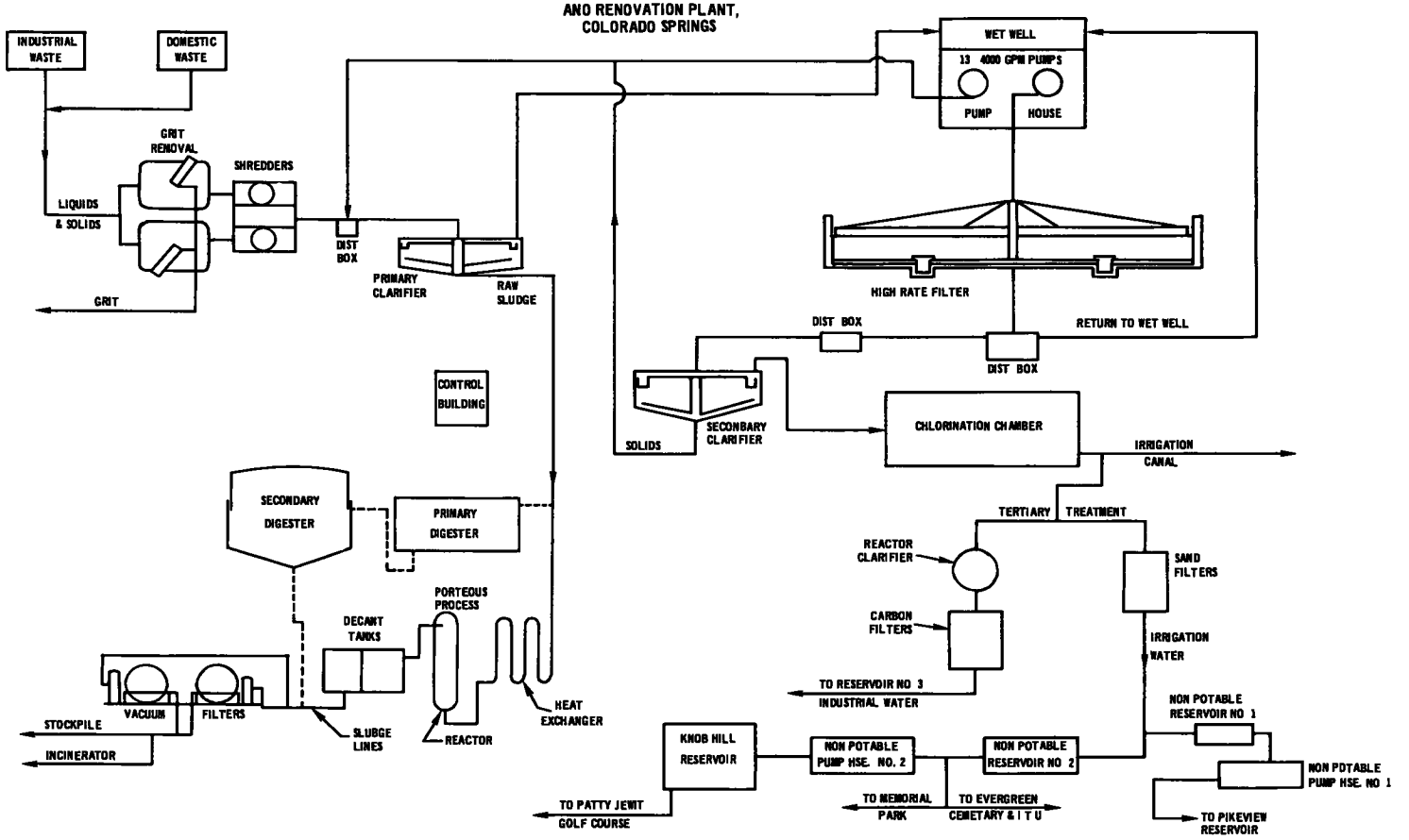
DISCOUNTS AND SURCHARGES

Discounts -- None
Surcharges — For premises located within and without the City of Colorado Springs, who have, upon investigation by the Superintendent of Sewers, difficult or hard-to-treat sewage, a surcharge may be established not to exceed 50 percent of the monthly bill.

Source: City of Colorado Springs, Colorado, Department of Public Utilities, Published Rates Effective January 1, 1971.

Figure 15

WASTE WATER TREATMENT AND RENOVATION PLANT, COLORADO SPRINGS



water short areas. Both irrigation and industrial water will be delivered by separate nonpotable supply lines. The present annual capacity of both systems is 3600 acre-feet.

Limitations on Reuse

As in most states with a doctrine of prior appropriations, the return flows originating in the Colorado Springs drainage basin have been appropriated and are not available for reuse. The only water which is available is imported flow which is diverted from other basins. Even these, as in the case of water from the Fryingpan-Arkansas Project, are sometimes restricted. This prohibition if literally carried out would effectively prevent reuse since the imported and domestic waters are mingled in the supply and the return flows. The method used to make reuse possible is an accounting procedure carried out monthly and the results filed with the irrigation district. In this procedure the waters are separated allowing reuse to proceed. (Table 20).

POPULATION PROJECTIONS AND WATER USE

One of the major determinants of future water use in Colorado Springs is the number of people served by the system. The county population has continued to grow since 1970 from 236,000 to a January 1972, estimate of 263,000, a rate of approximately 5 3/4 percent annually. Population projections for the city and county prepared by both the Pikes Peak Area Council of Governments and the Chamber of Commerce are indicated in Table 21. The consulting engineers to the water division estimate that the system will be serving 273,000

TABLE 20

CALCULATION OF ALLOWABLE REUSE: ACCOUNTING FILED PERIODICALLY, COLORADO SPRINGS, COLORADO

Transmountain Water to Colorado Springs' System	CFS
North Slope at Hydro	19.85
Northfield Plant	26.61
Pine Valley Plant	29.84
Less North Slope Streams	10.07
Less Northfield Local Production	-0-
Less West Monument Creek Local Production	.27
Less USAFA Consumption	7.30
Total Transmountain Water to System	58.66
Total Local Water System	45.74
Total Water to Colorado Springs' System	104.40
Less FCN Consumption	6.12
Less Prospect Lake Inflow	1.08
Tributary to Wastewater Treatment Plant	97.20
Total Wastewater Treated	29.85
Less Contract Areas (15%)	.99
Colorado Springs' Return Flow	28.86
Nonpotable Water Sold or Used	11.87

28.86 ÷ 97.20 = 29.7% Return

29.7 x 58.86 = 17.48 cfs Transmountain Water Return

17.48 - 11.87 = 5.61 cfs Transmountain Water Returned to Stream

Cheyenne Creeks Diversion	4.79
Less South Suburban Consumption	4.74
Required Transmountain Exchange	.05
Exchange Surplus	5.56
	11.1 AF

Source: Water Division, Colorado Springs, Colorado

TABLE 21

POPULATION AND PROJECTIONS: COLORADO SPRINGS AND EL PASO COUNTY, COLORADO
(1,000 Persons)

Year	Chamber of Commerce[a] City	Chamber of Commerce[a] County	Pikes Peak Council of Governments[b] County
1970	135	236	236
1972	155	263	
1973			281
1975	211	340	315
1980			376
1985	342	455	445
1990	403	509	511*

*Presently under revision: a new figure of approximately 475 is expected.

Source: [a]Chamber of Commerce of Colorado Springs, 1972 Statistical Digest, Table of Estimated Population, p. K-9.

[b]Pikes Peak Area Council of Governments population projections.

persons by 1980 and 394,000 by 1990 (Table 22).[1]

Water Use

The projections of water use prepared for Colorado Springs by the consulting engineers are for 52 million gallons daily in 1980 increasing to 64 million gallons in 1990[2] (Figure 16). Estimates by the utilities department are also prepared: Figure 17 shows a growth

[1]Black and Veatch, Report on Cheyenne Canyon Booster District and Templeton Service Area for Colorado Springs, Colorado. (Kansas City: Black and Veatch, 1972), p. 15.

[2]Ibid., p. 12.

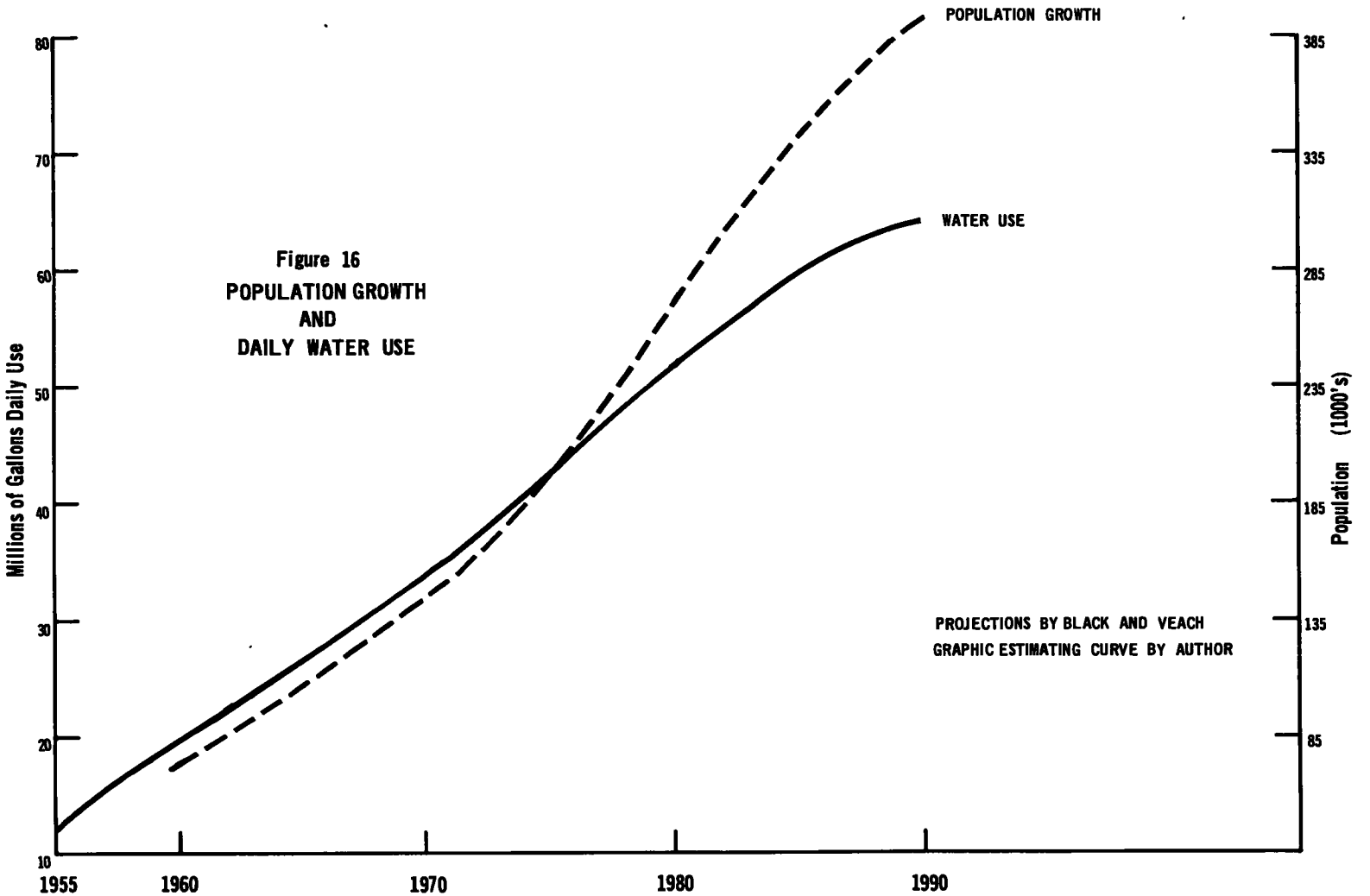


Figure 16
POPULATION GROWTH
AND
DAILY WATER USE

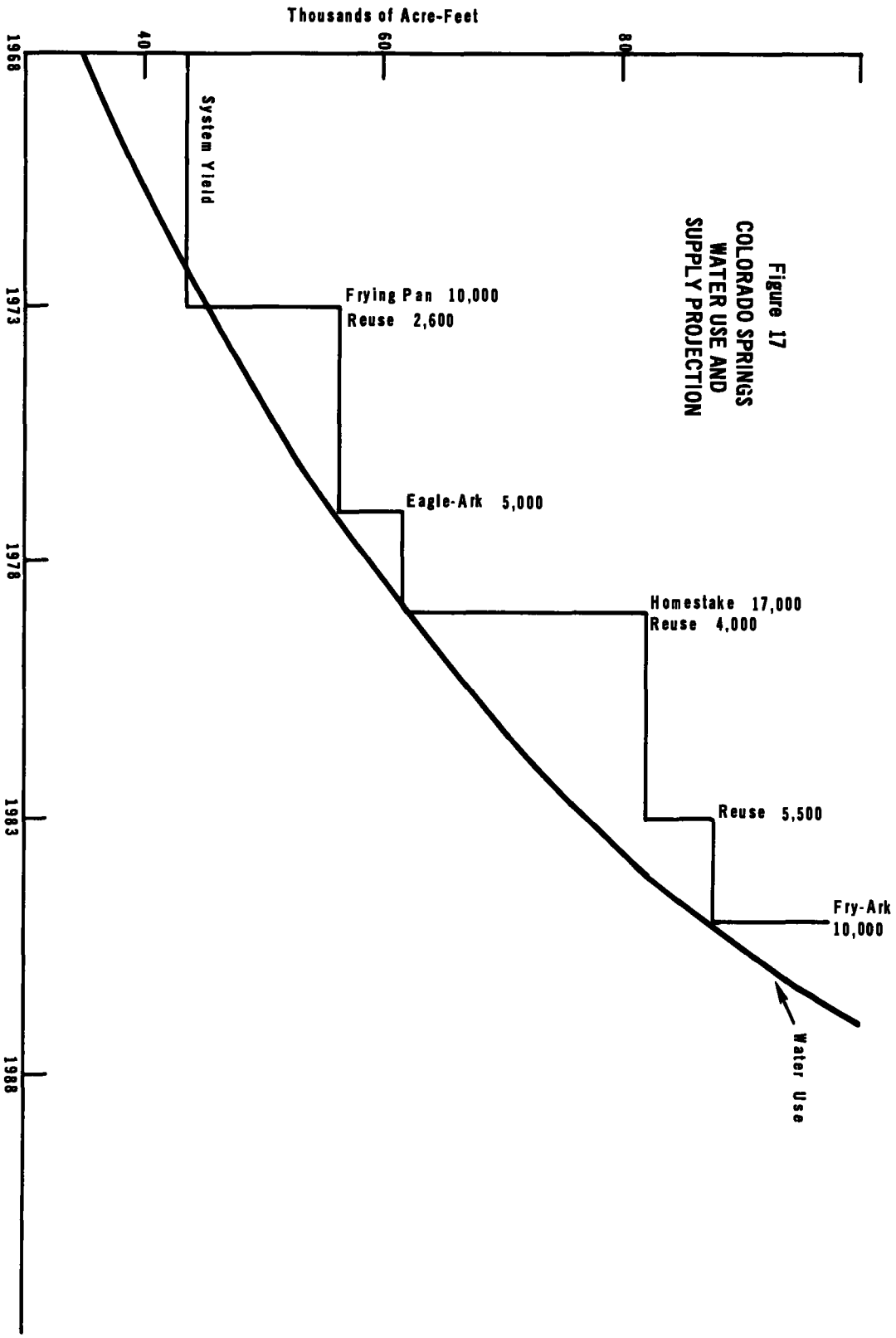


Figure 17
COLORADO SPRINGS
WATER USE AND
SUPPLY PROJECTION

TABLE 22

HISTORY AND PROJECTIONS OF CUSTOMERS SERVED BY COLORADO SPRINGS WATER SUPPLY SYSTEM

Year	No. of Customers[a]	Percent Estimate of County Population[b]
1960	83,400	58
1968	138,500	
1970	141,600	63
1980	273,000	73
1990	394,000	77 (83)

[a]Estimates by Black and Veatch.

[b]Estimates of county population by council of governments.

rate of 5.5 percent plotted against the projected expansion of the system. There is noticeable disparity in the rate of growth of the demand for water indicated in the two curves. The consultants' estimate assume some combination of a drop in per capita use or an increased importance for residential use. If residential use were to remain at 40 percent of total use, average residential per capita use would decline from 90 gallons presently to 76 gallons in 1980, and 65 gallons in 1990, a trend which is as yet not discernible.

Future Planning for Water Supply

The city has extensive plans for the future water supply capacity (Table 23). These include a second allotment of water from the Fryingpan-Arkansas project, a second phase of Homestake, and the Eagle-Arkansas diversion. Yield will be increased to nearly 100,000 acre-

TABLE 23

PLANNED ADDITIONS TO THE COLORADO SPRINGS, COLORADO WATER SUPPLY SYSTEM

Year	Plan	Yield (acre-feet)
1977	Eagle-Arkansas	5,000
1979	Homestake (2nd Phase)	17,000
1985	Fryingpan-Arkansas (2nd allotment)	10,000
	TOTAL	32,000
1979	Reuse	4,000
1983	Reuse	5,500
	TOTAL	9,500
	GRAND TOTAL	41,500
	Present Capacity	56,200
	Present and Future Total	97,700

Source: Colorado Springs, Colorado, Water Division records

feet annually including reuse with an annual capacity of over 12,000 acre-feet.[1]

What has been presented appears to be a rational, prudent plan for providing water for a rapidly growing city. Yields have been increased or are projected to increase slightly ahead of demand to minimize overinvestment in idle capacity. That the process has been expensive is a function of the location and the consequent requirement for transmountain diversion. This is all true if the estimate of yield is accurate.

[1]Colorado Springs, Colorado, Water Division, 1970.

Firm Yield

One of the hypotheses of this study is that yield is understated. The model is designed, in part, to test this hypothesis. Within the Colorado Springs context, a 31-year series of total stream runoff from the Pikes Peak watershed, the first major source of city water supply, was arranged in ascending order. The mean annual runoff for this period, which included a drought is over 24,000 acre-feet, the theoretical upper limit of yield if reservoir losses are disregarded. The engineering estimate of yield is just over half of the mean streamflow.

Measuring the flow sequence against the demand sequence for the years, 1948-1970, and eliminating two major additions for this period (Homestake, 12,000 acre-feet and the Blue River, 10,000 acre-feet), will provide an ex post facto look at the system and how it would have been at less than half of capacity. The system would consist of the following:

Pikes Peak	13,000 acre-feet
Wells	3,000 acre-feet
Cheyenne Creek	1,600 acre-feet
Northfield	700 acre-feet
	18,300 acre-feet
Estimated	
Homestake	13,000 acre-feet
Blue River	10,000 acre-feet
	23,000 acre-feet

Were the Expansions Necessary?

The two major expansions to the system between 1948 and 1970 were the Blue River, added in 1953, and Homestake, in 1966. These expansions

could have been postponed. If the total yield available to the city from other sources were completely utilized, with no provision for reservoir losses, and a modest provision for storage, the system would have provided a net surplus of water from the period from 1948 to 1970 (Table 24).

The sources with a firm yield of only 18,300 acre-feet supplied a demand which averaged over 21,000 acre-feet for 23 years and close to 30,000 acre-feet for the last ten-year period. This points out the conservative nature of the safe or firm yield rating. The main source of supply used for the analysis is Pikes Peak which is rated at 13,000 acre-feet. The flows for 31 years show a mean flow nearly twice the firm yield rating (Figure 18).

Postponing both expansions of the system until 1970 would not have been a workable plan. Reservoir losses would have occurred, more severe flow conditions might reasonably be encountered, diversion works to capture more of the flows might be costly, rights for storage may not be available, but some delay in the addition of the Blue River and Homestake Systems would have been more economically efficient. An ability to produce water from reusing effluent which could have displaced some nonpotable or potable uses would have provided a plan for an extended delay at least until 1963 for the first of the additions.

THE SIMULATION: ALTERNATIVE FUTURES

Application of the Model

The model is designed to test present planning for future use against alternatives to these plans. To do so it can provide alternative

TABLE 24

WATER USE AND SUPPLY, COLORADO SPRINGS, COLORADO: 1948-1970
(Acre-feet)

Year	Total Use Potable	Total Available from Pikes Peak	Total from Other Sources	Surplus	Deficit	Amount in Storage (Capacity 25,000)
1948	10163	29485		19322		19,322
1949	12863	24107	608[1]	11852		25,000
1950	11508	8827	359		2322	22,678
1951	11843	11070	0		733	21,905
1952	15174	19115	626	4567		25,000
1953	15557	17998	698[2]	3139		25,000
1954	12712	8845	934[3]		2933	22,067
1955	16814	17977	3560	4723		25,000
1956	18408	9964	3683		4761	20,239
1957	14547	56755	5208[4]	47416		25,000
1958	17777	25977	922	9142		25,000
1959	19979	20018	1477	1516		25,000
1960	24149[5]	20049	1620		2480	22,520
1961	19515	28717	1743	10945		25,000
1962	24812	15203	1623		7986	17,014
1963	24863	12963	1863		10037	6,977
1964	28071	14398	8361[6]		5312	1,665
1965	26100	34347	7261	15508		17,173
1966	31352	17795	11588[7]		1969	15,204
1967	29011	18384	9980		647	14,557
1968	36507	21252	10822		4433	10,124
1969	33924	31686	11116	8878		19,002
1970	40863	27700	10795		2368	16,634

1. Northfield system starts.
2. Blue River system starts delivering water (not included in calculations).
3. Monument Creek water used (reuse) also first well flows.
4. Last year of Monument Creek for potable water.
5. Southerland Creek MAF 587 A.F. Discountinued July 2, 1960.
6. New well field begins delivering water.
7. Cheyenne system incorporated both supply and use. Mean flow was used for 1965 and 1966 supply since production figures are unavailable.

Source: Chief of Operations, Colorado Springs Department of Utilities unpublished data, Colorado Springs, Colorado.

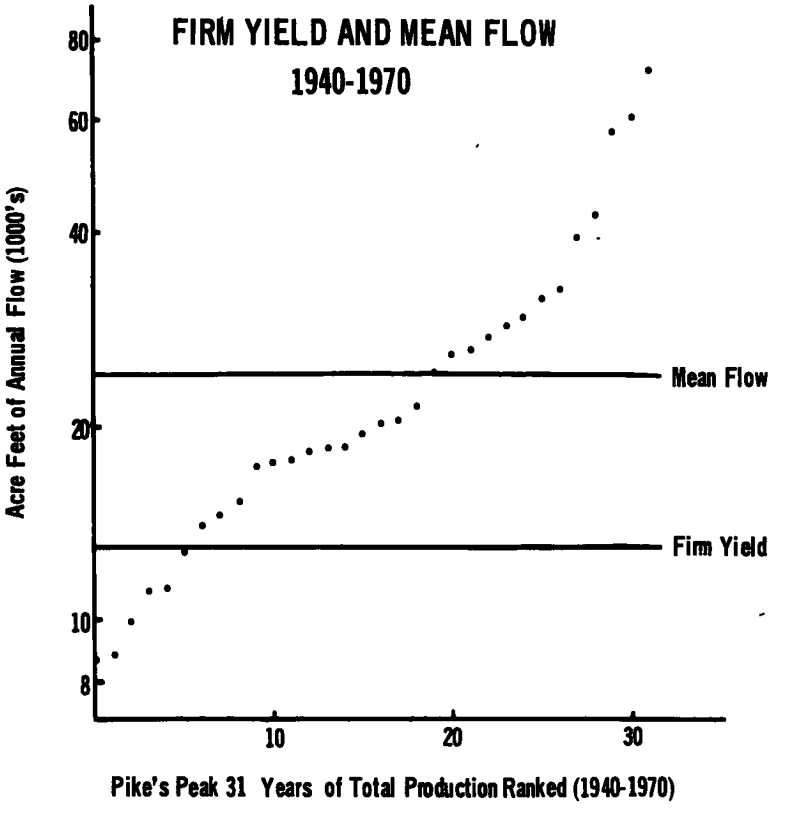
Figure 18

PRODUCTION OF

PIKE'S PEAK WATERSHED:

FIRM YIELD AND MEAN FLOW

1940-1970



futures for the natural events such as rainfall and streamflow, and the social events such as population change or pricing practices with which to judge the effectiveness of the planning.

The model cannot optimize, for what is optimal under one range of streamflows may be inefficient when another equally probable range of streamflows and populations are utilized. The simulations of the water systems should be able to assist in more rational planning.

Colorado Springs has an adequate supply of water by current planning estimates for the next 13 years. Reuse has been in operation furnishing effluent for irrigating lawns and parks since 1950. The quality of the effluent is being upgraded to supply cooling water for municipal electricial generation plants. What can simulation provide which can assist in this planning?

First, it can provide a method of investigating an alternate plan for reuse. Under this plan, water for power plant cooling would be supplied from the reservoirs until the capacity added by the Fryingpan-Arkansas water project was fully utilized (Figure 17). At such time the decision to reuse water would be contingent on water levels in the reservoir. Subsequent plans for the Eagle, Arkansas and other diversions would also be contingent on system performance. Reuse would be employed as needed, need also being defined in part by the amount of water in storage (see the decision process, Chapter V). When reuse was not required, water would be furnished from the reservoir. One alternative planning practice would be to use water as required from the reservoir for both potable and nonpotable use. When the reservoir drops below a

preselected level, the reuse would be employed to furnish water to the industrial and commercial users at a percentage of the total use. Increases in conventional capacity would be triggered by another reservoir level which would provide new capacity two years after a series of other conditions had been met Reuse capacity is added as required, sized to the maximum of month flow during any ten year period.

Second, it can provide a method of evaluating plans under alternative conditions of population growth which would be likely to occur. The planned expansion of the system in 1979 includes provision for both conventional additions to yield and reuse capacity. The Homestake project is indivisible and causes an oversupply until 1983 without the reuse component, which further adds to the substanial oversupply. Another reuse component, planned for 1983, could be delayed until after 1984, if potable water were substituted for renovated effluent (Figure 18).

These plans have been tested extensively and the results are described in Chapter V. In summary, the model is not a good planner but an excellent score keeper. By defining the games to be played, the planner can have a range of consequences with which to judge the attractiveness of an alternative planning decision.

CHAPTER V

WATER REUSE: AN ALTERNATIVE PLAN FOR COLORADO SPRINGS

In the preceding chapter the past experience and future planning of the Colorado Springs water supply and waste treatment was described. This chapter will present an alternative plan for the future. Both the plan formulated by the water department (the Plan) and the alternative plan (the Alternative) will be simulated.

The Plan

The planning period is for 50 years beginning in January, 1974. The yield of the system is estimated at 56,200 acre-feet of water annually which includes 3,600 acre-feet of reuse (Table 26). A second allotment from the Fryingpan-Arkansas project of 10,000 acre-feet is scheduled for 1984. Two other projects, the Eagle-Arkansas diversion and the second phase of the Homestake project, are scheduled for 1977 and 1979. The total capacity of the system after all the planned expansions is estimated at 100,000 acre-feet annually. Reuse capacity will be increased in 1979 and 1983.

The Alternative

The Alternative has the same conventional source of water supply at the start of the planning period. No reuse capacity exists in 1974. It will be added as the simulation requires. The continuous demands for reuse are incorporated into the industrial demand. All

users are supplied water from the reservoir. This will continue as long as the reservoir level remains above 30,000 acre-feet. Only when the reservoir level drops below 30,000 acre-feet will the reuse system begin operation. Reservoir water scheduled to be supplied to each water using sector will be reduced by a specified percentage of the monthly demand (Table 25).

TABLE 25

SPECIFIED PERCENTAGE OF MONTHLY DEMAND SUPPLIED FROM REUSE

Domestic	25
Commercial	50
Industrial	75
Military	50
Municipal	75

The amount of the reduction will be made up by renovated water from a specified treatment level. The reduced drain on the reservoir will allow the reservoir level to increase. If it does not rise above 30,000 acre-feet treated effluent will be introduced directly into the water supply. The renovated waste water will continue to be recycled back to the reservoir until the 30,000 acre-feet level is reached.[1]

Instead of providing more reuse, the conventional capacity of the system could be increased. The Plan adds units of capacity at

[1]The 30,000 acre-feet level has been selected by preliminary simulations to minimize the quantity and frequency of effluent returned to the reservoir. In any simulation when it does occur it will be noted in the analysis.

fixed times. The Alternative institutes a decision process at the end of each year. This decision process controls the addition of the Eagle-Arkansas and the Homestake projects. The Fryingpan-Arkansas addition is scheduled for 1985 by a previous commitment to the Bureau of Reclamation. The decision uses information readily available to a water manager.

The decision is based on three conditions. First, the program checks that if the reservoir level is more than 50,000 acre-feet no expansion will be made. Second, if the level is less than 50,000 acre-feet, the ratio of water used during the year to the minimum level reached during the year is checked. Finally, if this indicates less than an average nine-month supply, a further check is made on the streamflows for the year. If the total flow is less than can be expected to occur 75 percent of the time on the basis of the historical and generated flows, no expansion will take place. The three conditions must all be met: low reservoir level; less than 9 months supply of water, and, the streamflows equaled or exceeded 75 percent of the past period of record before any expansion decision is made. If all conditions are satisfied, the expansion will be undertaken. A two-year delay is instituted to provide time for implementation (Table 26).[1]

---

[1]In retrospect the two-year lead time is too short even though the water rights have been established and the sites acquired. The complete planning cycle from purchasing the site to bringing the project on line would exceed 10 years. The program can provide scheduled investments for the site, and preliminary work at scheduled periods and in the simulation of most cities would be advisable. For this simulation earlier investment would decrease somewhat the advantage of the Alternative over the Plan.

Population Projections

The critical variable in the amount of water required is the population served by the system. The simulation uses three population projections representing different assumptions of growth from the 1974 level of 174,000 (Figure 19). Two projections are necessary to match the population growth and water use projected by the consultants to the Water Division. The high projection closely matches the population growth, but under this assumption total water use is higher than projected. The medium population produces the projected use, but at a lower population level. This divergence between population and water use exists because the consultants are projecting a decrease in per-capita demand which may come in future years. The simulation demand modeles are based on historical data which does not show a declining rate of per-capita use. This results in the discrepancy between the projections of the consultants and by the model.

High Projections

The consultants have estimated a 1980 population of 273,000 rising to 394,000 by 1990. The high population projection reaches these figures within the indicated years and rises to 571,000 by 2023 (Figure 19).

Medium Projections

The medium population projection is designed to approximate the predicted potable use of 52 million gallons daily in 1980 and 4 million gallons a day in 1990. The population under this

Figure 19

POPULATION GROWTH ACCORDING TO HIGH, MEDIUM, AND LOW GROWTH RATES: 1974 – 2023

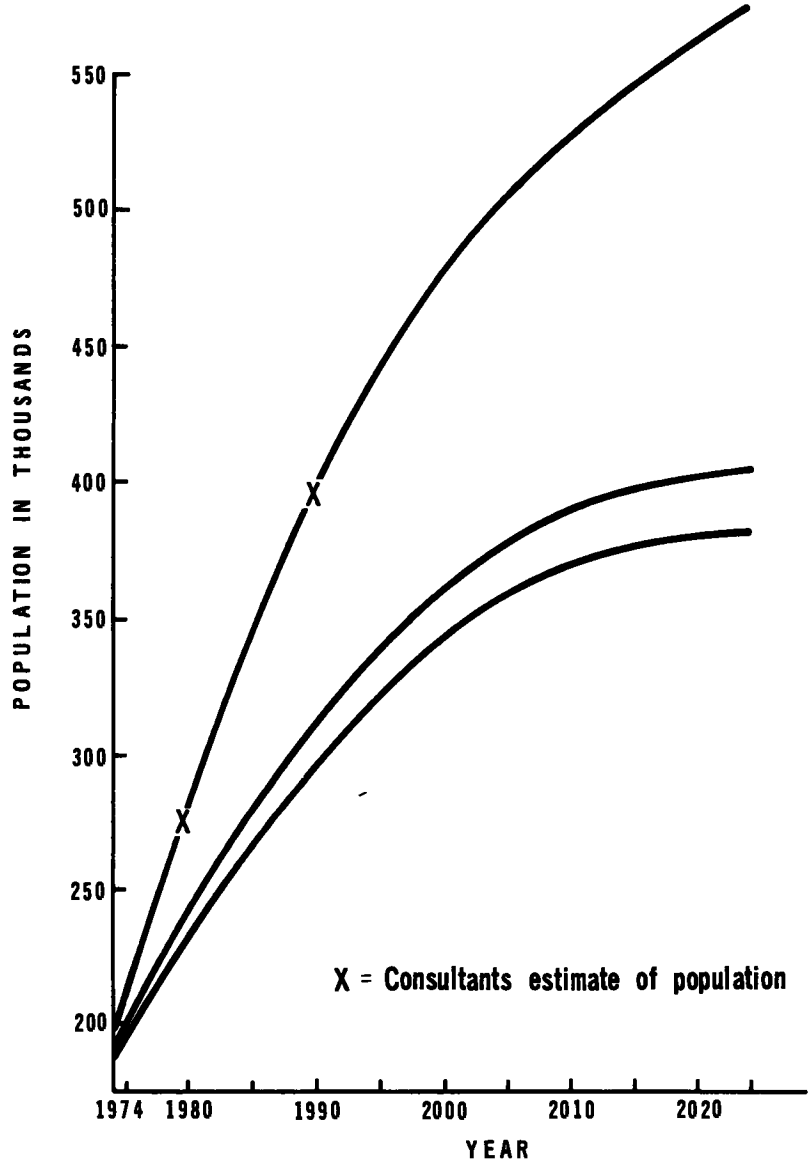


TABLE 26

THE PLAN AND THE ALTERNATIVE: SCHEDULED ADDITIONS TO CAPACITY

Item	The Plan	The Alternative
Conventional Capacity		
Existing	56,200 acre-feet	56,200 acre-feet
Additions		
Eagle Arkansas	1977	as required
Homestake (Phase 2)	1979	as required
Fryingpan-Arkansas	1985	1985
Reuse Capacity		
Existing	0*	0*
Additions		
#1	1974	as required
#2	1978	as required
#3	1983	as required

*Reuse capacity is assumed to be nonexistent at the beginning of the simulation and is added as required or scheduled.

assumption reaches 235,000 by 1980, 315,000 in 1990 and 411,000 by 2023 (Figure 19).

Low Projections

The growth rates in population and water use may be too high if recent trends in birth rates continue. The low projection was designed to test the future planning for water supply under more conservative estimates of growth. The population under this assumption reaches 383,000 by 2023 (Figure 19).

The Streamflow Series

A 100-year record of streamflows was simulated by the Program HEC-4. Since the simulation of the municipal system is for a fifty year period, some 50-year segment of the streamflow record must be selected. By use of the variable SKIP, a segment of the 100-year record is selected by skipping the indicated number of years.

The sections of the record were selected to illustrate the effects of drought at various times during the simulation. The timing has a significant impact on the consequences of the drought to the water system. Droughts which occur when water use represents a lower percentage of yield will have less effect than when use is greater. In these simulations the later years are more critical since the population is continually growing and as a consequence requires higher levels of supply. Three different Skips are used to provide streamflows for the simulation: Skip 22, Skip 31 and Skip 48. Skip 22 (Low Average Flow) has a period of persistent low flows from year 14 (Figure 20),Skip 31 (Late High Flow) has a drought beginning in year 27 (Figure 21), Skip 48 (Late Low Flow) is characterized by droughts in year 33 and year 47 (Figure 22).

WATER DEMAND EQUATIONS

This simulation uses five equations to project total demand. They were formulated in a city which separates water use into five sectors-- domestic, commercial, industrial, military and municipal

Figure 20

THREE YEAR MOVING AVERAGE OF ANNUAL STREAMFLOWS

Includes Eagle – Arkansas and Homestake

SKIP 22, LOW AVERAGE FLOW

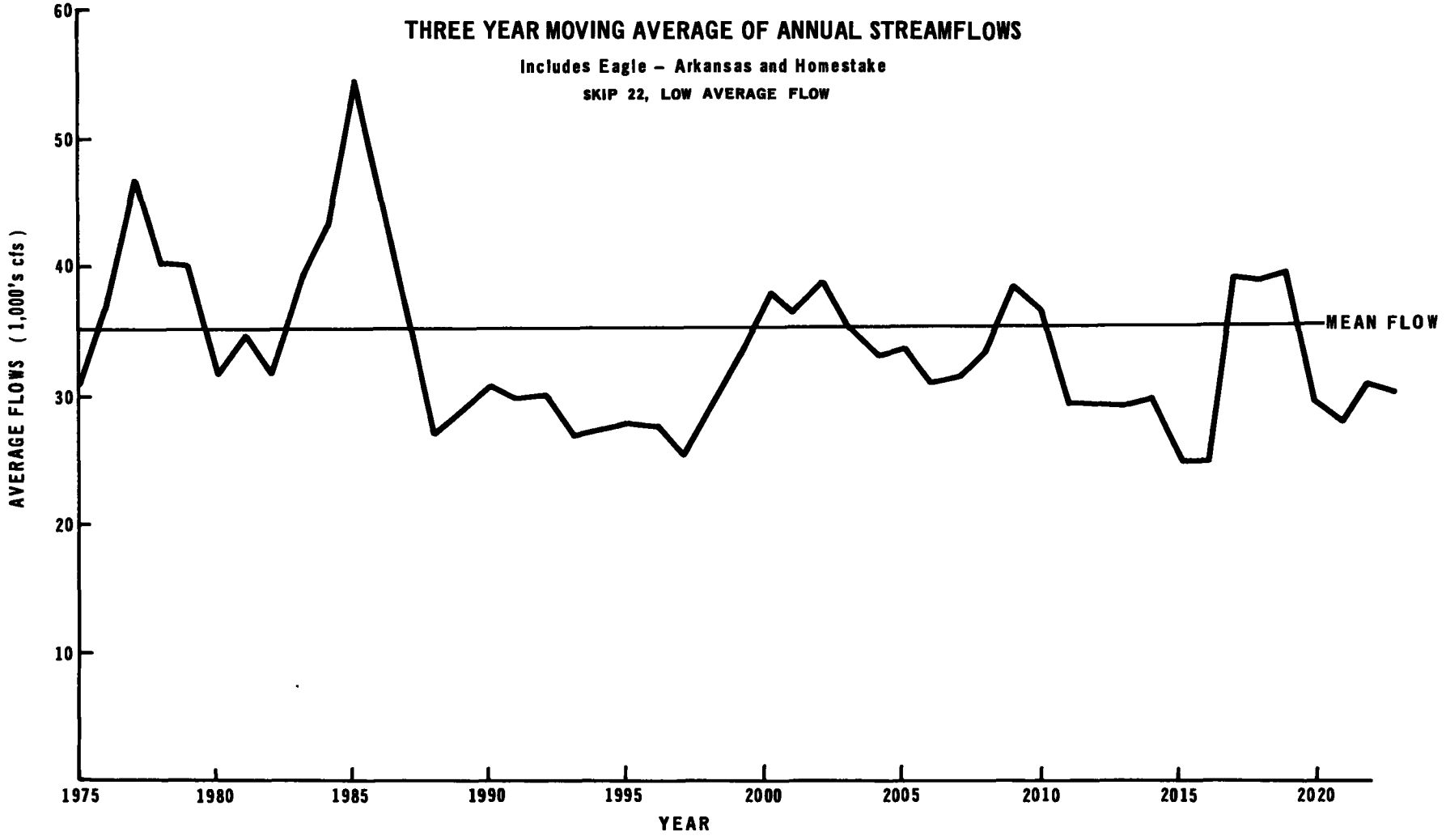


Figure 21

THREE YEAR MOVING AVERAGE OF ANNUAL STREAMFLOWS

Includes Eagle - Arkansas and Homestake

SKIP 31, LATE HIGH FLOW

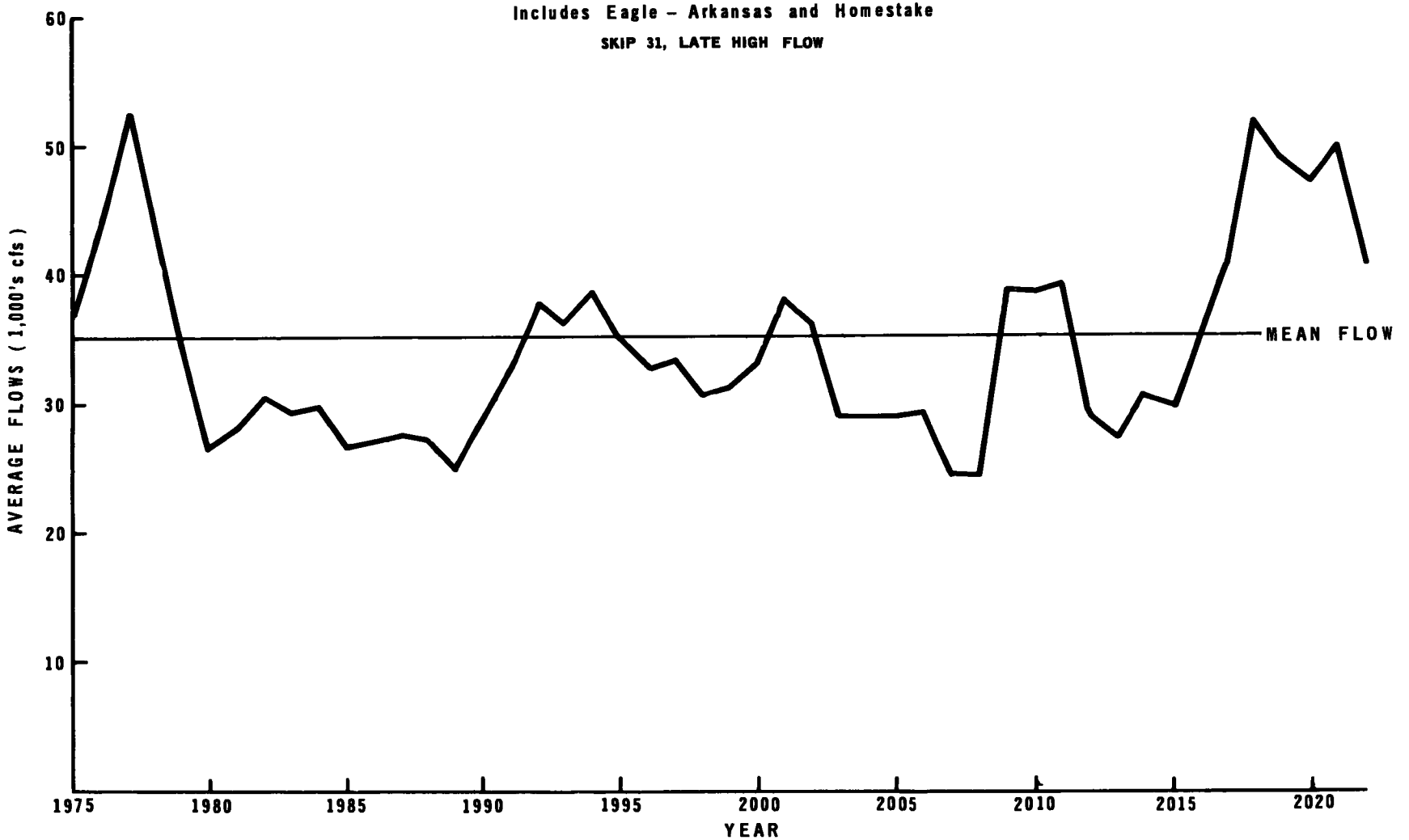
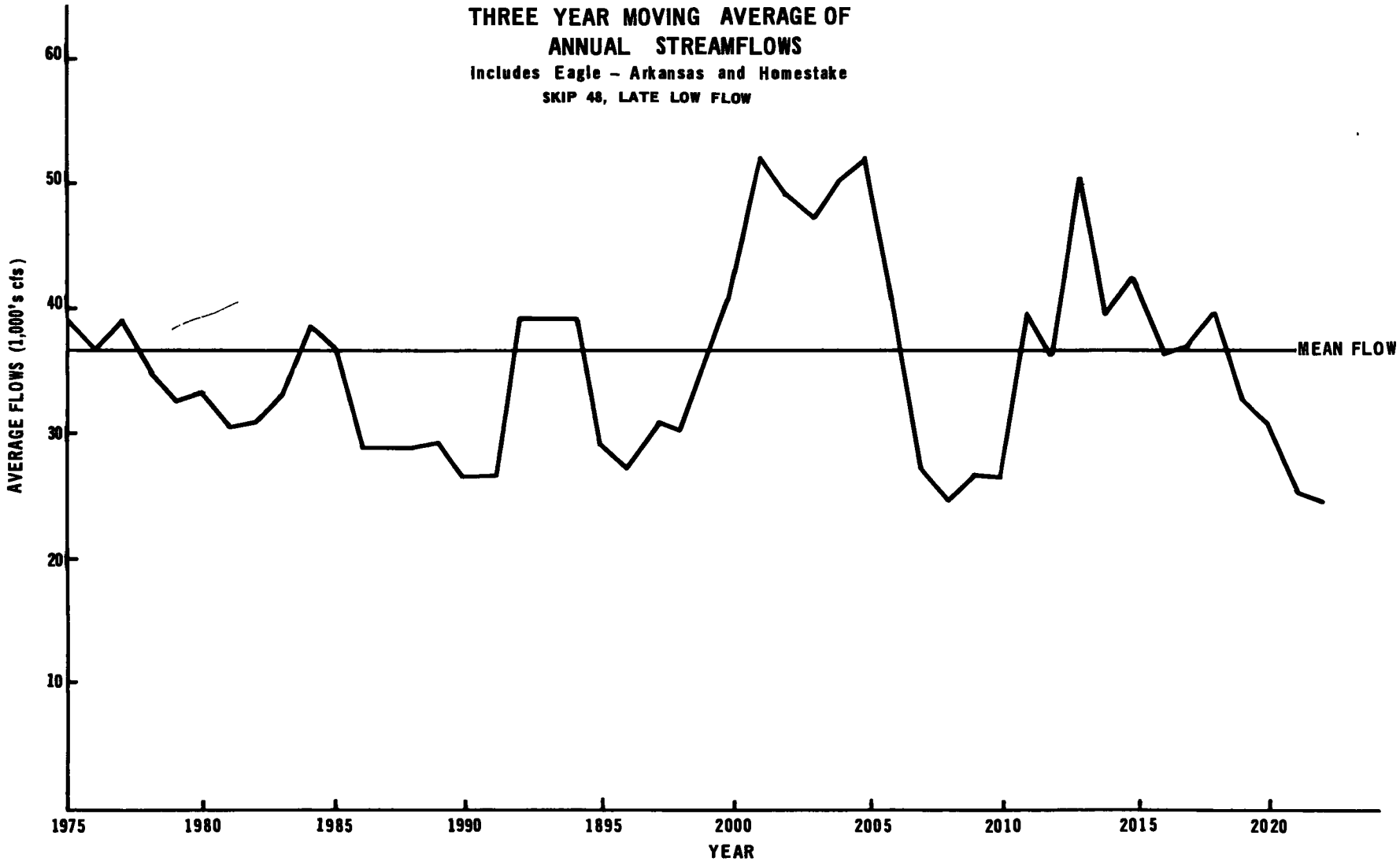


Figure 22


THREE YEAR MOVING AVERAGE OF
ANNUAL STREAMFLOWS
Includes Eagle - Arkansas and Homestake
SKIP 48, LATE LOW FLOW
AVERAGE FLOWS (1,000's cfs)
60
50
40
30
20
10
MEAN FLOW
1975
1980
1985
1990
1895
2000
2005
2010
2015
2020
YEAR

demands.[1] Records are kept of monthly use by sector. The monthly demands for 12 years, 144 observations, were used as input to a regression program. The independent variables in the regression for domestic demand were price, an index of rainfall, season, population, and time. Commercial demand used price, season, population and time as independent variables. Industrial demand variables were price, season, employment, and time. The equations for the military sector used price and time, while for municipal demand only time was used as an independent variable. The purpose of the regression was to test the significance of the variables and to establish coefficients which could be used to project demand. The results of the regressions are outlined in Table 27.

These equations provide a value for the expected demand of each sector for water for each month. This value is based on the monthly value of the independent variables and the coefficient established in the regression. The residual values, the error term, are used to introduce a stochastic element in the demand. The mean is added to and becomes part of the expected value of the monthly demand, while the standard deviation is multiplied by a random normal deviate and added monthly to the value of the demand equation introducing a stochastic element in the monthly demand for water.

---

[1]System losses are also estimated. These are calculated as the difference between water released from major input systems and the amount of water metered. This difference is included as part of municipal demand.

TABLE 27

SUMMARY OF RESULTS OF REGRESSION ANALYSIS AND RESULTING DEMAND EQUATIONS

Sector	R^2	Constant	Variable				
Residential	.76	-3.05	-0.007 Price	-0.06 Rainfall Index	+7.28 Season[a]	$+0.07 \times 10^3$ Population	+0.005 Time (in months) +E
Sign. Level t test		.05	.10	.00005	.05	.05	.005
Commercial	.29	-4.86	-0.058 Price	+1.048 Season[a]	$+0.145 \times 10^1$ population	-0.041 Time +E	
Sign. Level t test		.005	.01	.025	.0005	.0025	
Industrial	.50	+1.09	-0.005 Price	+0.52 Season[a]	$+0.20 \times 10^3$ Employment	+0.0007 Time +E	
Sign. Level t test		.0005	.05	.0005	.0005	.0005	
Military	.67	+2.84	+2.26 Season[a]	+0.02 Time	+E		
Sign. Level t test		.20	.0005	.0005			
Municipal	.22	+9.15	+2.40 Time	+E			
Sign. Level t test		.10	.0005				

n= 144 observations

[a]Season is a dummy variable equaling 0 except during the period of May through September.

The Rainfall and Seasonal Variables

Rainfall is one of the key variables in the domestic demand for water since one of the major uses in the residential demand is for lawn and garden sprinkling. In the simulation rainfall is projected together with streamflows in the program HEC-4. The monthly historical rainfall figures were used in a regression to establish the coefficients and test the significance of the variable. The significance as measured by the t test was low, .20.

While there was an observable correlation between high annual residential water use and low rainfall in the annual data, this did not necessarily reflect monthly conditions. A month might have a low water use if the preceeding month was rainy. This soil moisture carryover is part of the accepted indexes for drought. These drought indexes are based in part on factors which were not projected as part of the simulation. As a surrogate, a percipitation index, the cumulative departure from the mean rainfall is computed in a program RINDEX (Appendix D). This program calculates and accumulates monthly departures from the mean rainfall for each year of the historical water use data. The output is used as input to the program which computes the regression coefficients. By using this rainfall index the significance of the rainfall variable increased to .00005 as measured by the t test.

Season is a dummy variable with a value of zero except during the period May through September when it is set at one.

The Plan and The Alternative

The Plan and the Alternative will be compared in a number of simulations. Each comparison, designated a series, will consist of simulating the Plan for a given streamflow sequence and population projection and the Alternative for the same set of conditions. The object is to provide water to the city at minimum cost for a fifty year period. The present value of each simulation will be compared. Other indicators: spillage, water use, reservoir levels and the costs of components of the system will also be used as a basis of comparison in particular series.

The First Series

The first series was selected to duplicate the water use estimated by the consultants. The streamflow sequence, SKIP 48 (Late Low Flow), provides two droughts near the end of the simulation period.

Water Use: The Plan and the Alternative

Water use in the simulation is projected as the sum of the demands of the separate water using sectors: residential (domestic), industrial, commercial, municipal, military, and nonpotable use. The separate demands show a generally increasing trend, but in individual years they represent varying proportions of total water use (Table 28). Engineering consultants for the city have projected a daily use for 1980 and 1990 of 52 and 64 million gallons respectively.

TABLE 28

SIMULATED WATER USE IN COLORADO SPRINGS:
PERCENTAGE OF USE AND TOTAL ACRE-FEET

(Base Year - 1970 Actual Data)[1]

	Residential %	Commercial %	Industrial %	Military %	Municipal %	Total A.F.
1970	40.3	17.1	3.5	16.0	23.1	44206
1974	41.6	16.4	4.4	18.1	19.4	45554
1980	40.8	23.0	3.1	16.3	16.5	61129
1990	37.3	26.6	3.0	17.0	16.1	74481
2000	39.6	19.7	2.8	16.4	22.1	89495
2010	42.9	14.6	3.3	19.1	20.0	92477
2020	40.6	8.2	4.0	21.2	26.0	98790
2023	40.3	6.0	3.9	22.0	27.8	00673

[1]1970 date on water use--Colorado Springs,Colorado, Department of Public Utilities. Other data was projected using the simulation of the Plan for Colorado Springs.

Scheduled nonpotable use will increase this total to 54 and 70 million gallons a day.[1]

In the first simulation these rates are approximated in 1982, when the average daily withdrawal including nonpotable uses reaches 55.5 million gallons, and in 1991 when the rate reaches 69.3 million gallons average daily use (Figure 23). The total water use figures for both the Plan and the Alternative are equal.

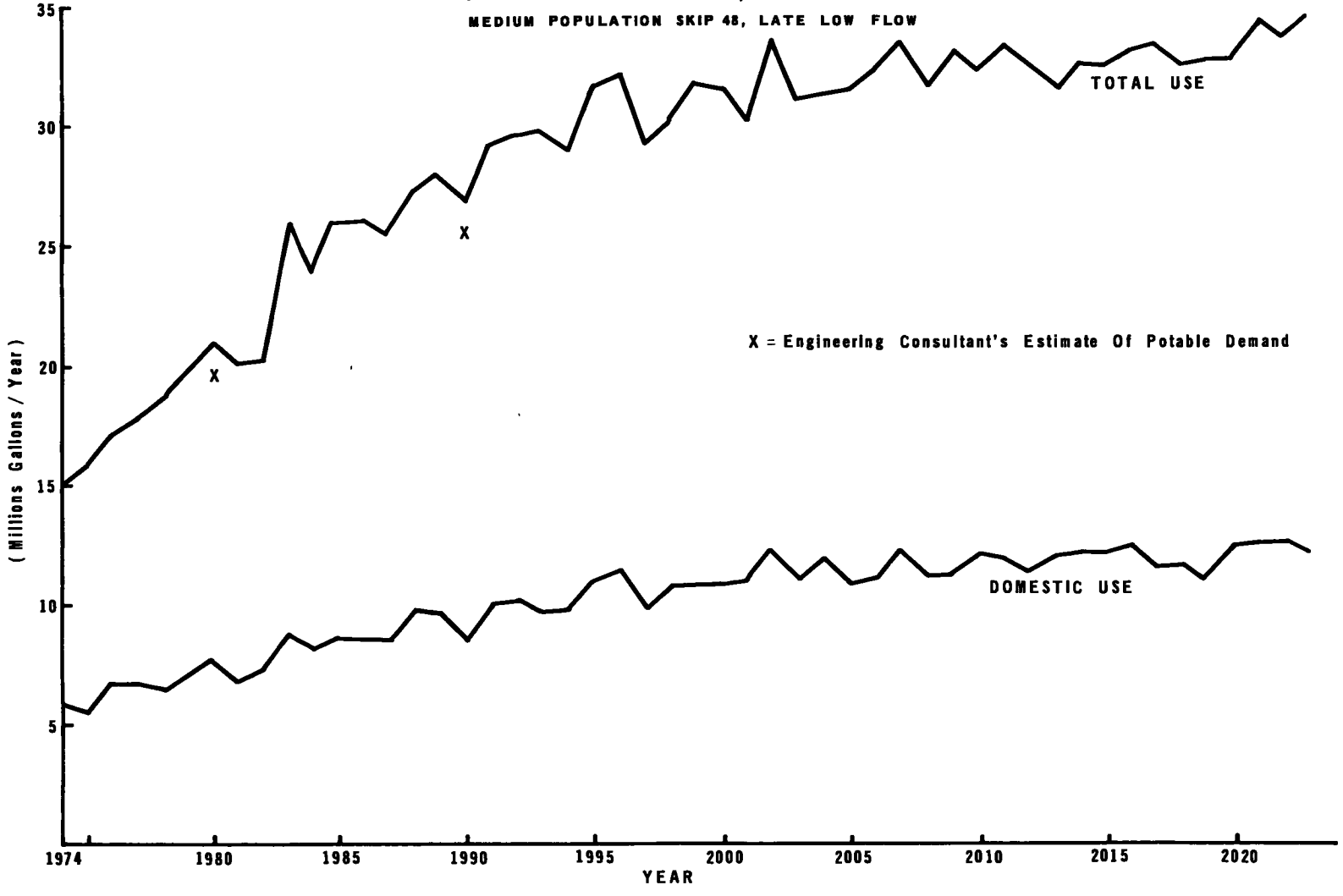
Additions to Capacity: The Plan

To provide water to meet these demands, the Plan used the scheduled series of additions, reuse capacity in 1974, 1979, and 1983,

[1]Although the Alternative does not supply nonpotable water on a continuing basis these continuous demands are incorporated into the industrial demand for water.

Figure 23

ANNUAL DOMESTIC AND TOTAL WATER USE, COLORADO SPRINGS: 1974 – 2023



the Eagle-Arkansas River diversion in 1977, the Upper Homestake in 1979 and finally the second allotment from the Fryingpan-Arkansas project in 1985.

Using the decision process outlined in Chapter 3, the Alternative provided different timing of investments. The increments were the same with the only difference being a .1 million gallon a day higher in treatment capacity for the Plan. The Fryingpan-Arkansas allotment, provided as the last addition in the Plan in 1985, was the first element, at that same date for the Alternative. The capacity to reuse effluent was first provided in 1996.[1] The Eagle-Arkansas diversion was delayed until 1998 and Homestake was finally brought into the system in the year 2000 (Figure 24).

Reservoir Levels: The Plan and the Alternative

The operation of a water system can be evaluated by the reservoir levels, spillage, and amount of water bypassed at the intakes. Constant high reservoir levels under conditions of varying streamflows are an indication of a system which is under-utilized. The reservoir levels resulting from the implementation of the Plan using the medium projection of population and the SKIP 48 streamflow sequences exhibit little variation except during the final years of the simulation (Figure 25). The Alternative simulation uses storage more efficiently responding to low flow years by a

[1]The model combines all investment in water reuse into the first year of any 10 year period. Thus while reuse capacity was provided and used in 1996, the investment is calculated from 1994. This is also true in the Plan in which investments in 1974, 1978 and 1982 are all assumed for financial evaluations, to date from 1974.

Figure 24

INVESTMENT SERIES IN WATER SYSTEM FOR COLORADO SPRINGS, COLORADO

MEDIUM POPULATION SKIP 48, LATE LOW FLOW

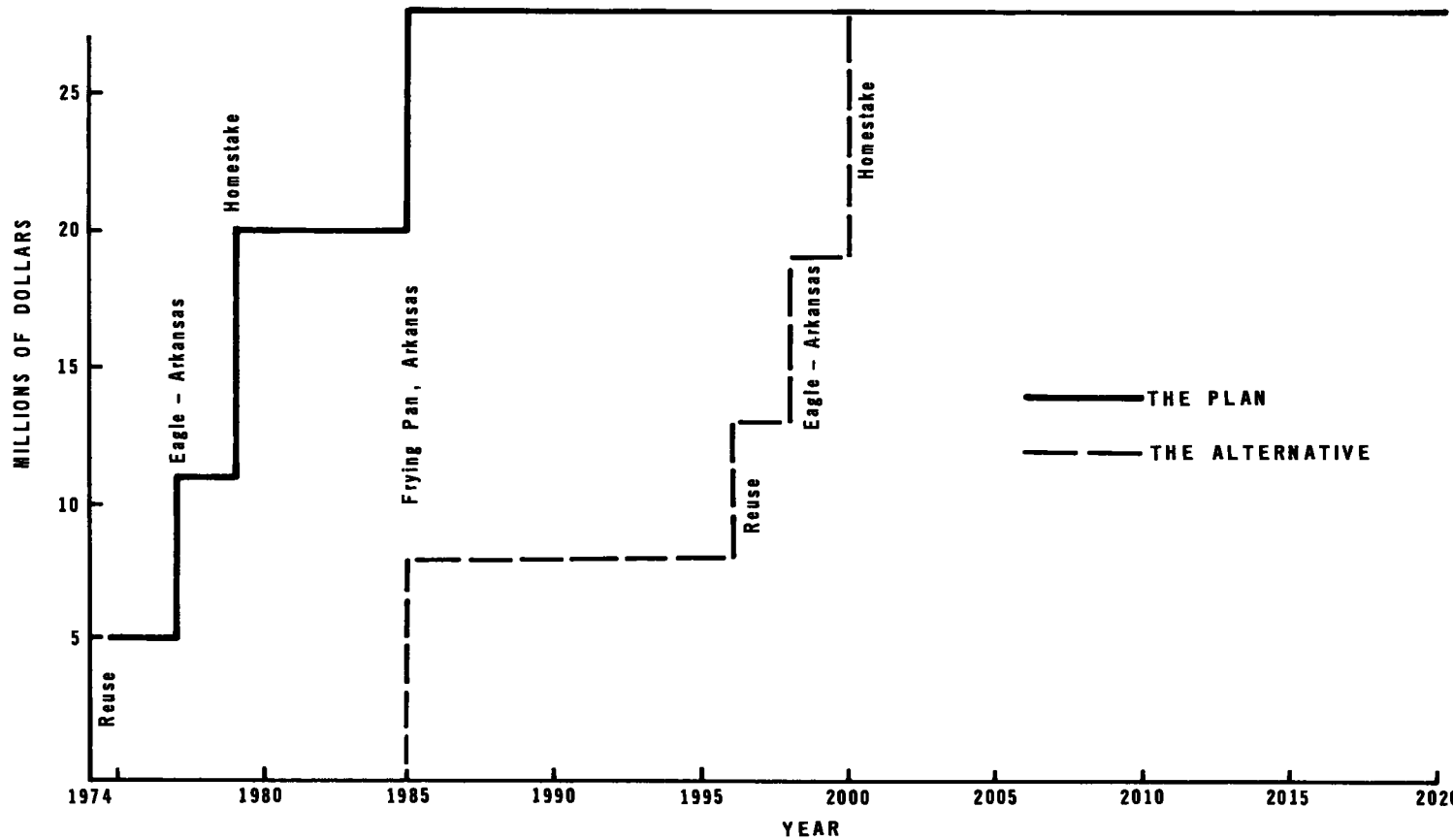


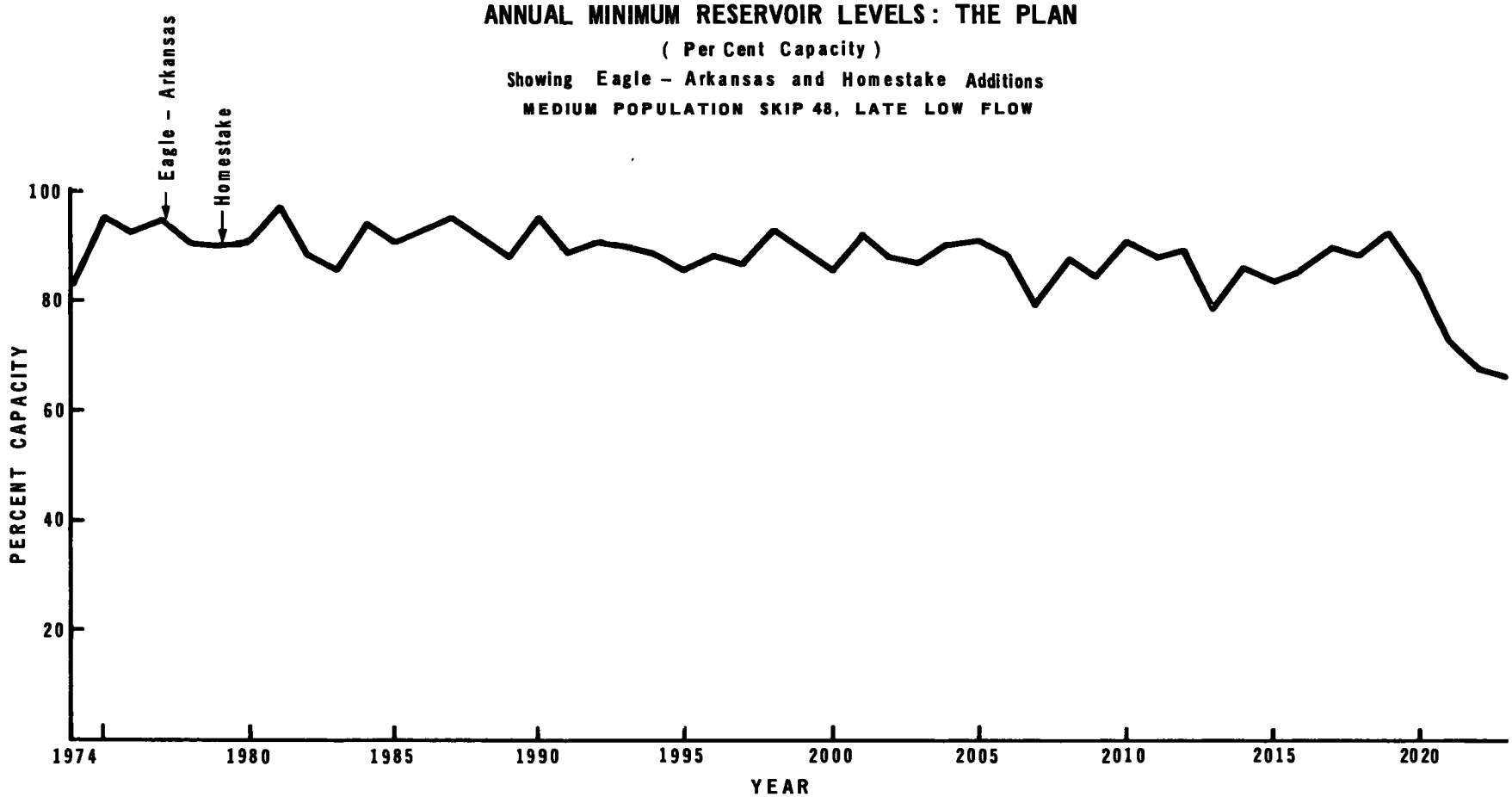
Figure 25

ANNUAL MINIMUM RESERVOIR LEVELS: THE PLAN

(Per Cent Capacity)

Showing Eagle - Arkansas and Homestake Additions

MEDIUM POPULATION SKIP 48, LATE LOW FLOW



decline in the amount of water stored (Figure 26).The spillage associated with both plans is markedly different. The Plan spills water during 43 of the 50 years projected against 12 in the Alternative Plan (Figure 27).

The Costs: The Plan and the Alternative

As previously noted, the investments in water supply and water reuse facilities were substantially equal, only the timing was different. This is not true of the costs of operating and maintaining the reuse system. The Plan reused 182 billion gallons of water over the 50 years. Most of this, 165 billion gallons, were treated to a tertiary level using coagulation, sedimentation, and granulted carbon absorption of the secondary treated effluent. The other 17 billion gallons was treated only by sand filtration. The total costs of the advanced waste treatment were $23 million or approximately 14 cents per thousand gallons. The Alternative reused water only twice and accumulated less than $2 million in costs for the advanced waste treatment process.

One could compare the Plan and the Alternative based on the difference of 21 million dollars in cost of treatment and disregard the timing of the expenditures completely. A more meaningful measure weighing not only the expenditure, but the timing, is obtained by discounting the expenditure to the present.

Using this method, the Plan expenditures have a present value of $21.5 million, the Alternative, $7.6 million. The equal costs for the water diversions and sewage treatment capacity have a

Figure 26

ANNUAL MINIMUM RESERVOIR LEVELS: THE ALTERNATIVE

(Per Cent Capacity)

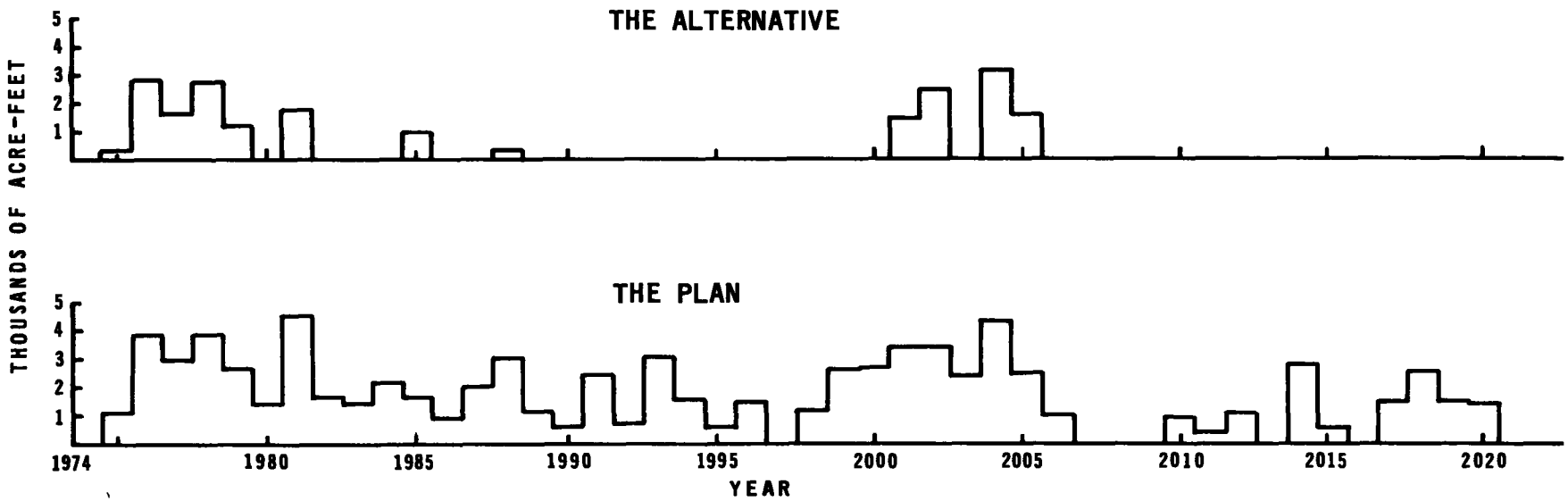
Showing Eagle – Arkansas and Homestake Additions also Periods of Reuse

MEDIUM POPULATION SKIP 48, LATE LOW FLOW

Figure 27

AVERAGE MONTHLY SPILLAGE BY YEAR, 1974 – 2023;
The Plan and The Alternative

MEDIUM POPULATION SKIP 48, LATE LOW FLOW



discounted value of $9.5. million more in the Plan than in the Alternative while the difference in operations and maintenance costs of reuse totaling $21 million more in the Plan has been reduced to a difference in present value of $4.4 million (Table 29). If the 9.5 percent interest rate is used, the absolute difference in present value declines at this rate, and the Plan has a present value of $17.9, the Alternative $5.2 million.

It should be noted that the Alternative Plan has made an inefficient use of reuse capacity. A large size plant has been provided in 1997 which furnishes effluent for only two years. After this plan had been simulated once, parameters could have been adjusted ex post to provide either earlier implementation of the water supply projects or lower acceptable levels of the reservoir to avoid reuse. Two points are relevant: 1) Any levels selected for the simulation ex post to minimize costs might not be optimum for other streamflow sequences; and, 2) The provision for reuse, while not the most efficient in this application, has allowed for the delay in the water supply projects. Reuse is a low capital intensive standby system, and is functioning exactly as a reuse system should--that is, to provide the kind of assurance of yield which has been provided by understating the potential output of streams and reservoirs.

The Second Series

The second series used the medium population projection and the streamflow series SKIP 31 (Late High Flow). In this series

TABLE 29

COLORADO SPRINGS WATER SUPPLY SYSTEM 1974-2023
PROJECTED OPERATION - THE ALTERNATIVE PLAN
MEDIUM POPULATION SKIP 48 LATE LOW FLOW

	The Plan	The Alternative
Total Water use 2023 (Acre-Feet)	106,000	106,000
Capacity of Waste Treatment Plant (millions of gallons daily)		
Decade 1	12	0
2	12	0
3	12	11.9
4	12	11.9
5	12	11.9
Total Reuse Water Processed (millions of gallons per decade)		
Decade 1	19,000	0
2	40,000	0
3	40,000	1,400
4	40,000	0
5	40,000	0
Additions to Capacity (date)		
Fryingpan-Arkansas	1985	1985
Eagle Arkansas	1977	1998
Homestake	1979	2000
Present Value (millions of dollars at 6.88 percent)		
Reuse capacity	2.2	0.7
Reuse operations and maintenance	4.8	0.4
Conventional capacity	14.5	6.5
	21.5	7.6

the Plan, insulated from changing streamflows because of the preselected sequence of additions, accumulated the same present value of investment as in SKIP 48 (Late Low Flow). The present value of the investment required for the Alternative declined by $100,000 (Table 30). This was the result of delays in both reuse from 1996 to 1998, and watersupply additions delayed from 1996 and 1998 to 2006 and 2008 (Figure 28). he minimum reservoir levels maintained are indicated in Figure 29.

In this second set of simulations, as in the first, the level of total water use reached 106,000 acre feet. Although this was 6,000 acre feet above the engineering estimate of yield, it has provided little stress for either the Plan or the Alternative.

Third Series

The high population projection increasing to 511,000 by 2023 provides a test of the Plan and the Alternative at higher levels of water use. This projection closely resembles the population prediction of the consulting engineers for 1980 and 1990 of 278,000 and 394,000 respectively. The stream sequence used is SKIP 48, Late Low Flow.

The water use sectors which will increase in this higher population series are residential, commercial and municipal, all of which use population as one of the independant variables in the water use models. Industrial use which uses employment as an independant variable increased at a slower rate. Military use and nonpotable use were not affected.

TABLE 30

COLORADO SPRINGS WATER SUPPLY SYSTEM 1974-2023
PROJECTED OPERATION - THE ALTERNATIVE PLAN
MEDIUM POPULATION SKIP 48 LATE LOW FLOW, SKIP 31 LATE HIGH FLOW

	SKIP 48	SKIP 31
Total water use 2023 (Acre-Feet)	106,000	106,000
Capacity of Waste Treatment Plant (millions of gallons daily)		
Decade 1	0	0
2	0	0
3	11.9	12.5
4	11.9	14.2
5	11.9	14.2
Total Reuse Water Processed (millions of gallons per decade)		
Decade 1	0	0
2	0	0
3	1400	2623
4	0	4026
5	0	0
Additions to Capacity (date)		
Fryingpan-Arkansas	1985	1985
Eagle Arkansas	1998	2006
Homestake	2000	2008
Present Value (millions of dollars at 6.88 percent)		
Reuse capacity	0.70	1.02
Reuse operations and maintenance	0.40	1.11
Conventional capacity (water supply)	6.50	5.40
Total	7.63	7.53

Figure 28

COMPARATIVE TIMING AND AMOUNT OF INVESTMENT

MEDIUM POPULATION SKIP 48, LATE LOW FLOW SKIP 31, LATE HIGH FLOW

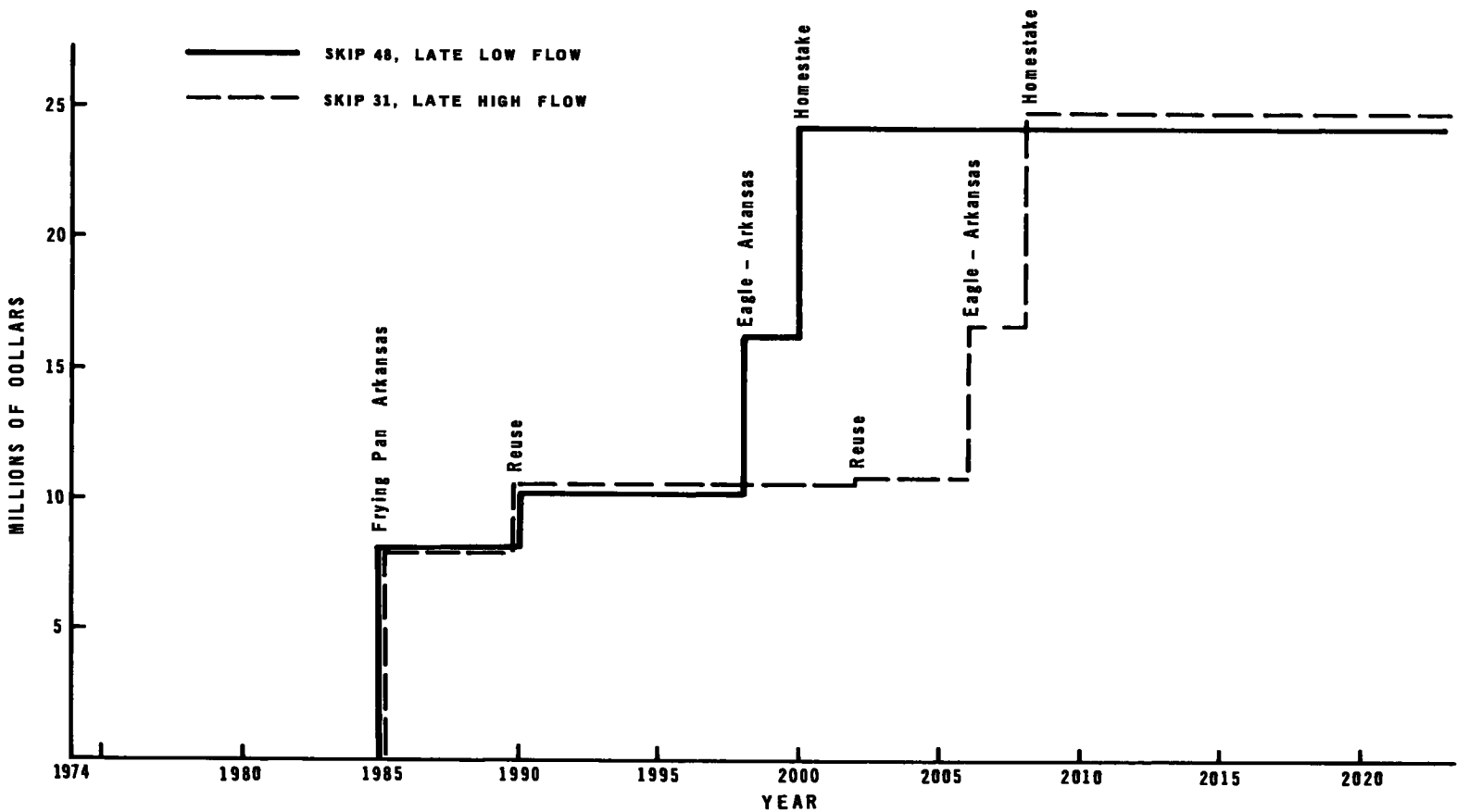


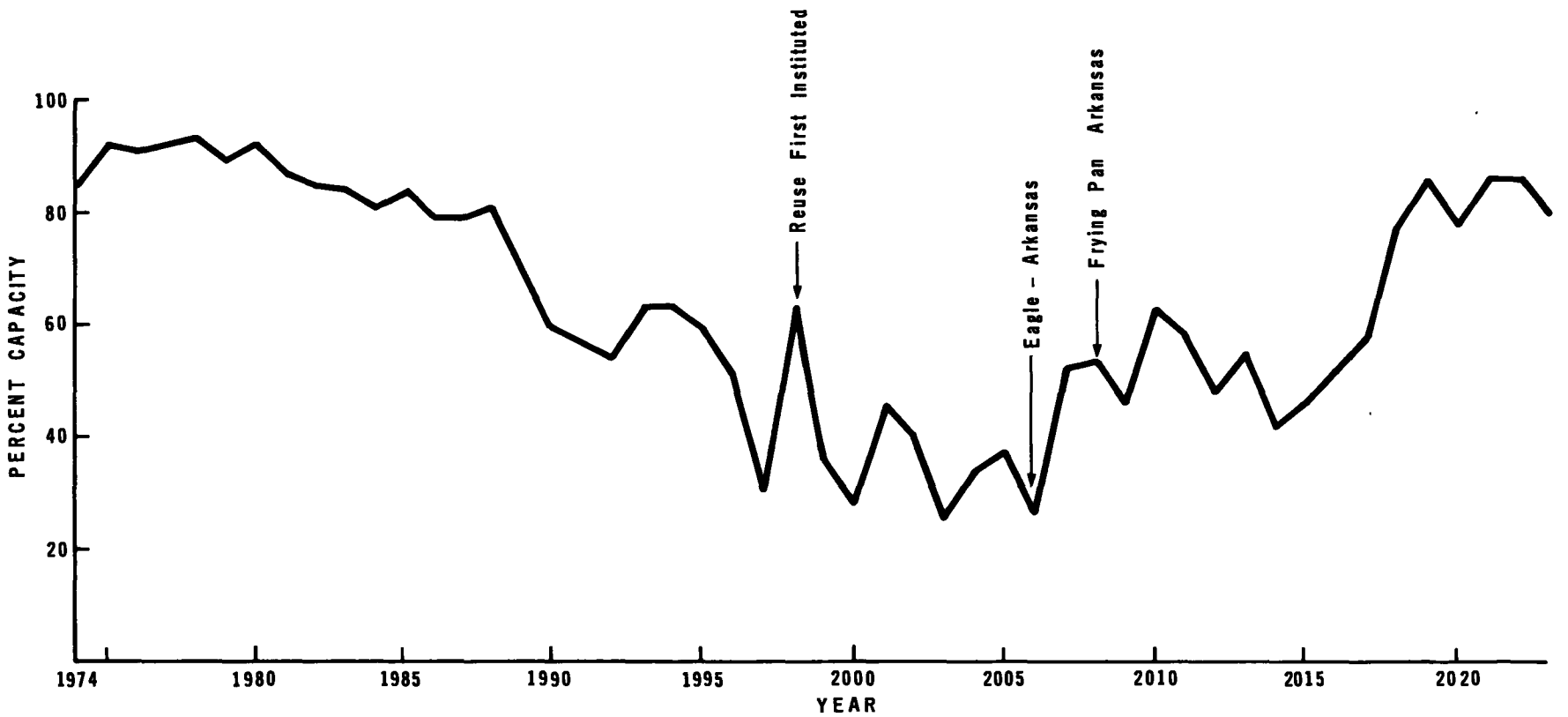
Figure 29

ANNUAL MINIMUM RESERVOIR LEVELS: THE ALTERNATIVE

(Per Cent Capacity)

Showing Eagle – Arkansas and Homestake Additions also Beginning of Reuse

MEDIUM POPULATION SKIP 31, LATE HIGH FLOW



The simulation of the Plan ended after the 36th year. The reservoir went dry in January of 2010 (Figure 30). Water use had reached 135,000 acre-feet. Spillage was extensive in the early years of the simulation. When demands reached 133,000 acre-feet in the year 2002, the reservoir levels failed to recover sufficiently during high flow years to meet the stress of low flow periods.

The Alternative continued to furnish water for the full 50 years. This required more investment in reuse plant and more reuse water produced during low flow years. The Eagle-Arkansas project was provided in 1993, and the Homestake in 1998. This was earlier than the previous simulation, but still represented a delay from the scheduled additions of the Plan (Figure 31).

The present value of the Plan is $21.1 million. The difference between this and the previous simulations is only in the exclusion of the last 14 years of operation and maintenance costs. The present value of the Alternative is $10.8 million for the 36 years. It increases to $11.9 million for the full 50 years (Table 31).

Potable Reuse

The Plan provides reuse water piped directly to the user in a separate distribution system. Such a system is in use and is now being extended in Colorado Springs. The Alternative assumes the same condition although individual months have required more extensive reuse than provided in the Plan.

In the Alternative when the directed reuse is not sufficient to maintain the reservoir level, the reservoir itself exerts a demand on the reuse plant for water. For these past simulations

Figure 30

ANNUAL MINIMUM RESERVOIR LEVELS: THE PLAN

(Per Cent Capacity)

Showing Eagle – Arkansas and Homestake Additions

HIGH POPULATION SKIP 48, LATE LOW FLOW

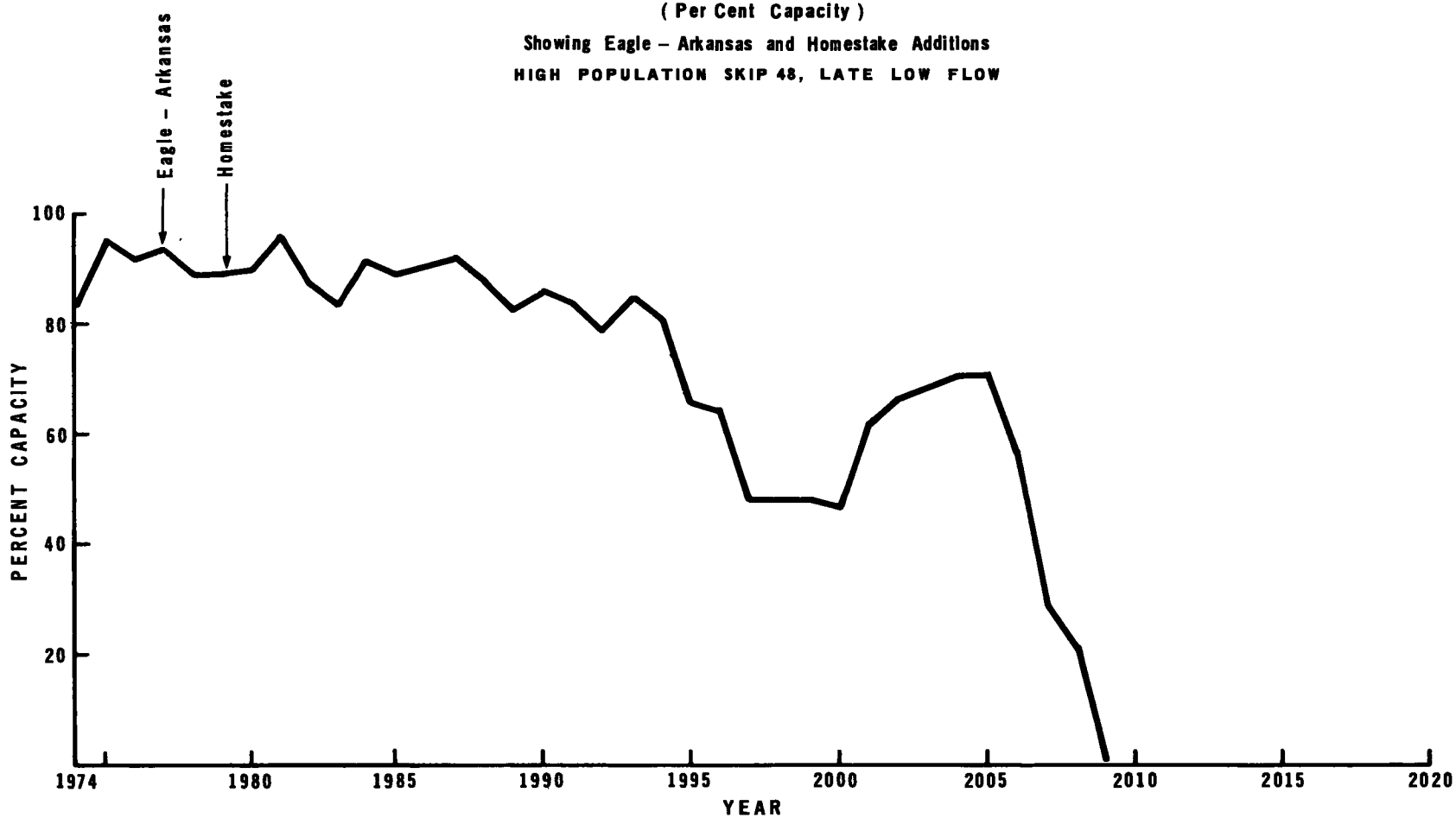


Figure 31

INVESTMENT IN WATER SUPPLY AND REUSE IN COLORADO SPRINGS, COLORADO

HIGH POPULATION SKIP 48, LATE LOW FLOW

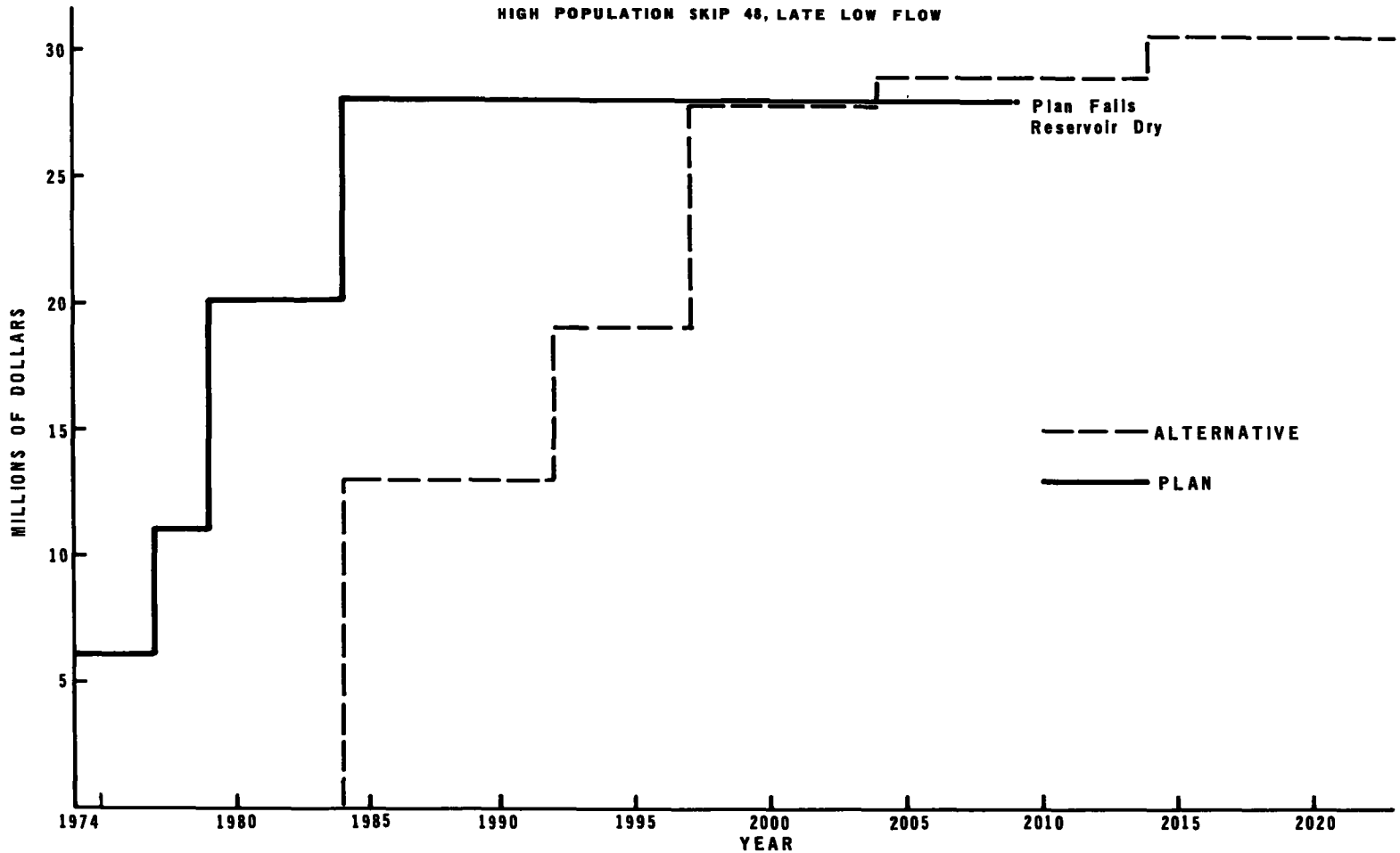


TABLE 31

COLORADO SPRINGS WATER SUPPLY SYSTEM 1974-2009
PROJECTED OPERATION - THE ALTERNATIVE PLAN
HIGH POPULATION SKIP 48, LATE LOW FLOW

	The Plan	The Alternative
Total water use 2009 (Acre-Feet)	135,000	135,000
Capacity of Waste Treatment Plant (millions of gallons daily)		
Decade 1	12	0
2	12	26.4
3	12	27.4
4	12	32.0
Total Reuse Water Processed (millions of gallons per decade)		
Decade 1	19,000	0
2	40,000	7,000
3	40,000	10,644
4	40,000	40,107
Additions to Capacity (date)		
Fryingpan-Arkansas	1985	1984
Eagle Arkansas	1977	1993
Homestake	1979	1998
Present Value (millions of dollars at 6.88 percent)		
Reuse capacity	2.20	1.91
Reuse operations and maintenance	4.44	1.69
Conventional capacity	14.50	7.17
Total	21.14	10.77

reuse supplied some of the demand when the reservoir levels dropped below 30,000 acre-feet. If renovated water were not provided until a lower level were reached, the reserve capacity left in storage plus the available streamflows might not be sufficient to supply enough water unless the capacity of the reuse plant were large. If water were required for introduction directly to the reservoir, the low level of stored flows available for dilution would tend to result in a high level of total dissolved solids. To correct this, some method of reducing the total dissolved solids in the recycled water would be required to maintain the level of the mixed water at less than 500 parts per million.

To test the effect of varying the reservoir levels, two simulations were run. For the first, the plant was turned on at 40,000 acre-feet and the second allowed the reservoir level to decline to 20,000 acre-feet. Turning the plant on at the 40,000 acre-feet level required less reuse capacity but higher expenditures for operation and maintenance (Table 32). Turning the plant on at 20,000 acre-feet, increased the needed capacity, decreased the operation and maintenance costs, and caused the Homestake project to be built two years earlier.

Setting the level for providing renovated water at 40,000 acre-feet requires more total reuse, but reservoir levels could be maintained by piping the selected proportion of effluent directly to the user. In only the last two years of the simulation was water returned directly to the reservoir in addition to the directed reuse. As the recycle level was dropped, the quantity of reused

water required was less, but more reused water was returned to the reservoir. At 20,000 acre-feet, water was returned to the reservoir to maintain the level in each of the final three decades.[1] The present value was also affected. The 40,000 acre-feet level had a present value of $1 million less than the low level.

Series Four and Five

Two other stream sequences SKIP 31, Late High Flow, and SKIP 22, Low Average Flow, were used with the high population projection. In each of these the Plan failed. In the former, during March of 2006 and for the later, March 2007. The Alternative simulation in both sequences continued to furnish water for the full fifty years.

The present value of the investment required for the Alternative runs were $11.2 for the SKIP 31 Late High Flow and $12.0 million for the SKIP 22 Low Average Flow, stream sequences for the entire 50-year simulation. The present value of the required investment for the Plan were approximately $21 million, varying only in the present value of the reuse not required for the final year of the SKIP 31 Late High streamflow simulation.

Series Six

A final set of simulations was run using a low projection of population which reaches 383,000 persons by 2023. In this, the Alternative never required the second phase of Homestake. The present value of the investment was less than $6 million. The Plan, again insensitive to external conditions, had a present value of $21 million.

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[1]For the third series at the 30,000 acre-feet level water was returned to the reservoir in five of the years. (Three of these required less than 100 million gallons for the year).

TABLE 32

PLANT CAPACITY REQUIRED FOR THREE LEVELS OF RECYCLING
HIGH POPULATION SKIP 48, LATE LOW FLOW
(millions of gallons per day)

Decade	RESERVOIR LEVEL		
	20,000 acre-feet	30,000 acre-feet	40,000 acre-feet
1	0	0	0
2	19.8	21.6	13.2
3	33.2	21.7	20.7
4	33.2	28.0	23.8
5	38.6	38.6	35.2

Summary of All Simulations

The Simulations have been run to compare the costs of providing the water supply needs of Colorado Springs, Colorado, by the use of the Plan and the Alternative. The comparisons were made for high, medium, and low population projections and for different streamflow sequences.

For every assumed population projection and streamflow condition simulated, the Alternative was a less costly method of supply than the Plan (Table 33). The costs of the Alternative varied, depending on levels of supply and demand. The Plan was independent of these conditions and required a series of investments with a present value of approximately $21 million.

Of the two methods of supply, the Plan is least desirable, under conditions of low population growth. The Alternative, assuming

TABLE 33

SUMMARY OF THE SIX SIMULATION SERIES: THE PLAN AND THE ALTERNATIVE

Series	Population Protection	Years of Simulation	Present Value ($ in millions at 6.88 percent) The Plan	The Alternative
1	Medium	50	21.5	7.6
2	Medium	50	21.5	7.5
3	High	35	21.1	10.8
4	High	32	20.9	10.0
5	High	33	21.0	12.0
6	Low	50	21.5	6.0

the lowest population projection, had an investment requirement with a present value of $6 million. Reuse was required for only seven of the fifty years simulated. Under this assumption the Eagle-Arkansas Project was delayed until 2013. The second phase of the Homestake Project was never required. The total investment required by the Alternative has a present value of $6 million, less than a third of the $21.5 million required for the Plan.

Under the high assumptions of population growth, the Plan always failed in the third decade of operation. The Alternative simulations were able to supply the city for the full 50 years at costs of $12 million or less. The medium population growth assumptions required an investment of approximately $7.5 million for the Alternative as compared to the $21 million for the Plan. Both the Plan and the Alternative provided water supply for the full planning period.

The Alternative is economically a more efficient method of providing for the water supply needs of Colorado Springs. The extra costs of the Plan arise from the additional costs of treating effluent when reservoirs are oversupplied and spilling and from the costs of premature investment in both conventional and reuse facilities. The Alternative processes water only when water supply is low and delays additions to capacity until the level of water in storage indicates a probable future need.

CHAPTER VI

CONCLUSIONS

This study focused on three questions relevant to the practicability of recycling renovated wastewater: (1) Can reuse be an efficient (low cost) method of supplementing water supply? (2) Are present reuse practices efficient? and (3) Can alternatives be formulated which are more efficient than present methods of reuse? A hypothesis was advanced that water systems had yields which were greater than the stated capacity.

Reuse was advocated as a method of increasing yields by: (1) Allowing the demands of the system to rise without providing conventional capacity thus using the reserve capacity in the system; (2) Substituting for high levels of assurance which would increase yield since system yield is inversely related to levels of assurance. A further claim made for reuse is that water systems with reuse capacity could shorten their planning horizon. This could delay or cancel the requirements for increased capacity where changing conditions were reflected in decreased projections for use. This last claim is unproven and unprovable in the context of this simulation.

The Colorado Springs Simulation

The application of a simulation model to Colorado Springs, Colorado, water supply provided insights to these questions. The future planning for the system including reuse were simulated under a wide range of streamflows and population projections. An alternative plan was

developed which provided for reuse only when required; hence, conventional additions to supply were postponed. For each simulation of the Plan, an Alternative was also simulated.

The model demonstrated reuse to be an efficient low cost method of supplementing the municipal supply. This was true even when the reuse application was in itself inefficient. In one simulation, a reuse plant was provided in the second decade which supplied water for only two years during the remaining thirty years of the simulation.[1] The plant served to provide the assurance presently provided by earlier additions of conventional capacity at a much lower total cost.

Present reuse practices (The Plan) were not efficient. Reuse was provided for many years when excess water was spilling from oversupplied reservoirs. Even under assumptions of high population growth, reuse remained unnecessary for much of the planning period.

The simulations indicate that Colorado Springs has more water than engineering estimates of yield indicate. Yield is measured at a critical low flow period which is assumed to have a selected level of recurrence.[2] The simulations used flows which were based on a synthetic 100-year record of flows. From this record, three 50-year segments were selected so that the most severe conditions of low flows would occur during the later period of the simulation when water use was highest. The lowest use which the system could sustain under these conditions was in excess of 130,000 acre-feet, 30 percent more than the 100,000 acre-feet estimated as the firm yield of the system.

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[1] Skip 48, Late Low Flow, medium population projection.

[2] As previously noted an even more rigorous standard is set.

Implications for Colorado Springs

What are the implications for Colorado Springs? First, reuse should be regarded as a standby source of water to be used only when water supply storage is low. Second, present plans for future additions to conventional supply probably should be delayed.

Reuse as envisaged in the Alternative Plans for Colorado Springs has proved a very efficient method of supplementing municipal supply. There are a number of considerations which have made this so: (1) The cost of acquisition of the dam sites has been part of previous sunk costs; (2) The water right acquisition has been adjudicated as part of other projects; and, (3) The major engineering inputs for the current projects have already been completed. These have allowed the specification of a relatively short time between a decision process for increasing conventional capacity and bringing the project on line. In other cities, these costs might be incurred earlier for projects which could then be delayed until reservoir levels, water use, and streamflow provided the conditions necessary for the implementing of the construction of a project. The resulting present value of the required investment in the Alternative simulation would be increased in comparison to the Plan.

What is the likelihood that Colorado Springs will shift to the Alternative rather than pursuing the Plan? The results of the simulation have not been discussed with the water management group at Colorado Springs, but many of the implications of the simulation may have already been recognized. There are, however, considerations which would tend to discourage water renovation and reuse as outlined in the Alternative even if the conclusions of the

simulation were accepted. Among these are: (1) The city might lose tentative rights to water. Water allocation in Colorado is based on the doctrine of prior appropriations. All water is assumed to be in the public domain until it is claimed and put to beneficial use. The date of the allocation established the priority of the user during periods of shortage. Users who can show a future beneficial use file claims as early as possible to establish the seniority of the right. In this respect, cities with growing populations are faced with the need to prove as two of the conditions of the award that there is a need for the water and that due and reasonable diligence be pursued in diverting the water and putting it to beneficial use.[1] Replacement of some of the present uses of renovated effluent would both decrease future need and delay required additions causing cities to possibly lose rights to water now conditionally appropriated. (2) Integrated planning would be required. This is not encouraged by the prevailing arrangements in the Department of Utilities. The water supply and sewage treatment divisions are geographically separated: the office of the Water Division is in the Utilities Building near the center of the city; the Sewer Division is at the treatment plant located on the periphery. The separation in distance has its counterpart in functions, for example both employ different consulting firms to advise on the functioning of the systems. Although there is a recognition of the potential value of reused water in the future (it is designated

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[1]Denver, Colorado, was denied a right to water in 1961 in part because the supply was adequate for a reasonable time in the future and also that due diligence in pursuing the diversion was not exercised. Joseph 1. Sax, Water Law Planning and Policy, (The Bobbs-Merrill Company, Inc., 1968), p. 188.

"the last water hole" in a publication of the Department of Utilities[1]) there is no real attempt to coordinate the planning. (3) The water supply planners express doubts concerning the technology of water renovation and reuse. The reuse program has had problems with the product quality: The odor of the irrigation water at times has caused complaints by the users. The water division which has been delivering a high quality product to the public would have little desire to accept a technology which might represent problems. (4) There would be little support by the city management for integrating nonpotable use with the potable water supply system. It might be acceptable, but it would not be received with acclamation. The Alternate would be adopted only to provide an economically more efficient system. However, this has not been a factor in planning for water supply. The public utilities have been able to provide funds for extensive development pledging only their combined revenues.

Implications for Other Areas

The simulation of the Colorado Springs, Colorado, water system can provide some generalizations that may apply to other areas. The most obvious is that a program of renovating water should not be undertaken when potable water is spilling from oversupplied reservoirs. At some point when reservoirs stop spilling and levels decrease, renovated water should be used to supply users who are indifferent to receiving stored flows or recycled water. As requirements for water increase, users may require encouragement to displace potable

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[1]Arnberg, History, p. 44.

supply with renovated effluent. The encouragement could take the form of restrictions against the use of virgin flows for specific purposes. The level at which the change over should take place is a function of the future expectations of use and supply. Simulations involving changes in both supply and demand would produce probabilistic guidelines.[1]

The Colorado Springs system has underestimated yield. There have been suggestions that most water systems do have yields which are higher than the engineering estimates. If this is so, conventional water projects could be delayed until the excess capacity is used. Reuse could supply part of the demands if the delay in adding to the capacity of the system caused a shortage.

The reuse application which seems most productive is to substitute the capacity to reuse water for the high levels of assurance either stated in the 95-98 percent safe yield or implied in the designation firm yield. As levels of assurance decline, yield from the same reservoir and stream combinations rises. For every one percent decrease in assurance, the reuse plant could be used an additional one percent of the time.

Reuse should not be viewed as a parallel source of supply under a common administration with the sewage system, but as a management alternative available to the water supply planners. Consequently, the manager of the water supply system has three supply alternatives at any

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[1] A complex municipal system could be simulated for approximately $10,000. It would require a programmer for two months and three hours of computer time on the equivalent of a Central Data Corporation model 6600 computer. This does not include costs of data collection.

time: (1) furnish water from storage, (2) from reuse, or, (3) add to capacity. If these options are exercised effectively, the municipality will be supplied water at a lower cost than if reuse were not one of the planning alternatives.

Changes in the Model

The model now makes no connection between costs of water and the price at which it is sold. One of the independent variables used is price. All uses incorporating price show a negative elasticity, use declines as price rises. The model assumes a series of prices which rise over time. The prices are used to calculate total income from the operation of the water system. Costs of providing water supply at present have no relationship to the price charged for water. The model could be adapted to provide a cost calculation which could then be reflected in a periodic price adjustments.

Additional Data

The simulation has specified arbitrarily the percentage of each demand that could be satisfied by renovated effluent. The amount of demand that could be supplied by reuse should be determined for those areas where treated effluent is being considered as a supplementary source of supply.

There has been no consideration of the opportunity costs of providing reservoirs for water storage or of diverting stream flows. In some areas this would be a significant factor which would increase the relative benefits of renovation and reuse and should be incorporated into the simulation.

Required Research

Evaluating the Safety

The public health problems of the reuse of water for potable supply require additional research. Especially troublesome are the long term effects of drinking water containing elements not responsive to present treatment processes or not subject to treatments which would remove them. Studies on these effects are long overdue, not only because of the planned reuse of effluent, but for the half of the urban and suburban populations which has already had the choice made for it through inadvertent reuse of renovated wastewater.

Evaluating the Acceptability

While studies of public attitudes towards reuse of renovated wastewater support the view that knowledge of the process and education increase the acceptance of reuse, the actual question is whether the engineers and public health officials will recommend reuse and/or will the politicians adopt such a process?

Additional studies are needed in the area of the value and attitudes of public health officials and engineers since our preliminary study indicates that their personal attitudes influence their professional judgements toward reuse.

Studies are also needed on the way political decisions about reuse are made. Preliminary models of the adoption process have already been formulated, and these should be developed and tested

in those areas where decisions on reuse are being made.[1]

Finally, the present reuse practices of many municipal systems serve as models for other communities considering reuse. A critical examination of present practices will serve as a guide for future applications. If present trends continue, planned reuse may supply only unnecessary additional capacity to systems already oversupplied with water.

Water reuse is being encouraged by Federal law as a potential source of increased supply. The reuse of renovated waste water has been shown, under specified conditions, to be a socially acceptable and economically efficient source of municipal water supply. Many present reuse applications are not efficient. The use of a simulation model can provide a more valid method of judging the benefits of reuse, provided that consulting engineers and public health officials will consider and, when appropriate, recommend reuse as one of the alternatives in water supply planning. The over-riding goal now is for the integration of water reuse in municipal water supply planning. The thrust is no longer whether reuse is possible; rather, the focus should be upon the programs and research directed toward the opportunities for efficient implementation.

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[1]David McCauley, "Political Decisions Making Models", in Community Adoption of Water Reuse Systems in the United States, Roger Kasperson et al. (Worcester: A Report to the Office of Water Resources Research, 1973).

APPENDIX A

A MANUAL FOR SIMULATING THE MUNICIPAL WATER SYSTEM

by Roy A. Wyscarver[1/]

Introduction

The use of program TINKLE requires that certain technical considerations be met and that the appropriate preparatory work be completed. This can best be described by the following outline.

A. Technical Considerations

B. Preparation of Hypothetical Stream Flow Data

   1. Generation of Stream Flow Data

   2. Sorting the Data

C. Preparation of Water Demand Equations

   1. Construction of a Rain Index

   2. Performing the Regressions

   3. Calculation of the Mean and Standard Deviations of the Residuals.

   4. Modifying Program Tinkle to Incorporate the Results of 2 and 3.

D. Other (Optional) Modifications

   1. Incorporating Additional Punched Output

   2. Changing the Water Quality Constant

E. Machine Dependent Modifications (if required)

   1. Logical Unit Numbers for Peripheral Devices

   2. EOF Function

   3. Clock and Date Routines

   4. RANF Function

1/ The program and the documentation are by Roy A. Wyscarver formerly of the Department of Economics, Clark University.

A. TECHNICAL CONSIDERATIONS

The primary technical considerations are a computer with a sufficiently large memory and the availability of peripheral devices. The program was designed on a CDC 6600 and required 140,000 (octal) bytes of core to load and 65,000 (octal) bytes of core to execute. This would be equivalent to 57,344 (decimal) bytes of core for execution on most other computers. However, the load size could be smaller depending upon the compiler size.

In addition to a reader, printer, and card punch, the program requires 3 tapes, or 3 disk files, or combination thereof.

The run time for program TINKLE will depend primarily on whether disk files or tape files are employed. Disk files were employed and run times of 25 seconds central processing time and 90 seconds of input/output time were typical for a 50 year simulation.

B. PREPARATION OF HYPOTHETICAL STREAM FLOW DATA

B.1 Generation of Stream Flow Data

The U.S. Army Corps of Engineers Monthly Streamflow Simulation program (publication 723-340 HEC 4) is used with the modification and restrictions outlined below to generate streamflows.

Following Card No.	Insert This Statement
1005	REAL QI(15)
2672	QI(I) = Q(M,K)
2677	WRITE (10) (QI(I),I=1,12)

The line numbers referred to above correspond to those used in the publication cited earlier. For our purposes, 10 was defined as a disk file but this could also be defined as a tape file.

The order of arrangement of the data used with the HEC-4 program is the same as that outlined in the Corp of Engineers publication with two exceptions:

The first station of historical data (in the first pass, if a multi-pass run is employed) that is input to the program must be monthly rainfall data. All other stations of historical data may be arranged as desired; but the last group of stations (however many stations there are) must represent streams that are currently unavailable as inputs to the reservoir but may later be used for this purpose.

B.2 Sorting the Data

The data generated in the previous step has an order of arrangement that is inconsistent with the order that program tinkle requires. Hence, program SORT - found in Appendix D - was used to rearrange the generated data in the required order.

In this program, Tape 1 refers to the old data file generated in B.1 while Tape 2 refers to the new data file to be generated. The program requires one data control card in the following format:

Column	Item	Format
1-5	1/2 the total number of years of generated stream flows produced by step B.1	99999
6-10	Total number of streams & rain	99999
11-15	First year of Generated Flows	99999

C. PREPARATION OF WATER DEMAND EQUATIONS

C.1 Construction of a Rain Index

Certain demands for water are a function of the cumulative amount of rain received relative to what is normally received, a rain index was created to be used as an independent variable in these demand equations. The index is created for the same period that the regression data used in C.2 covers.

The methodology behind this index is best described as follows:

$$RI_i = \sum_{j=1}^{i} (R_j - \overline{R}_j) \qquad \text{for } i = 1,2,\ldots,12$$

where i = the current month

RI_i = the value of the rain index in the ith month

j = a summation subscript

R_j = rainfall in the jth month

$\overline{R}_j$ = average rainfall for the jth month

The rain index is a cumulative sum of the deviations of actual rainfall from the average rainfall.

The program used to generate this index can be found in Appendix D. The program requires one data control card followed by the monthly rainfall data cards used in B.1 with the HEC-1 streamflow generator. The data control card must be the first card and adhere to the following format:

Column	Item	Format
1-2	The beginning year of the rainfall data, e.g. 1970 would be 70	99
3-4	The total number of years of rainfall data	99

C.2 Performing the Regressions

Once the rain index has been created, and the other data collected, regressions can be performed to determine parameters of the demand equations. We employed Zellner's "Three Stage Least Squares" program in calculating the parameter although any other regression package would be satisfactory.

The regression models employed are:

Domestic Demand = $\alpha_1 + \alpha_2 P_{DC} + \alpha_3 RI + \alpha_4 S + \alpha_5 POP + \alpha_6 T + E$

Commercial Demand = $\alpha_1 + \alpha_2 P_{DC} + \alpha_3 S + \alpha_4 POP + \alpha_5 T + E$

Industrial Demand = $\alpha_1 + \alpha_2 P_I + \alpha_3 S = \alpha_4 E + \alpha_5 T + E$

Military Demand = $\alpha_1 + \alpha_2 P_m + \alpha_3 S + \alpha_4 T + E$

Municipal Demand = $\alpha_1 + \alpha_2 P_c + \alpha_3 T = E$

where P_{DC} = Domestic and Commercial Price

P_I = Industrial Price

P_m = Military Price

P_c = Municipal Price

RI = Rain Index

POP = Population

E = Employment

T = Cumulative Time in Months

S = Dummy Variable for Seasonal Variations

Note that in the simulation, the dummy variable S is assigned a value of one (1) from June through September and zero (0) otherwise. This, however, is not an absolute for it depends on the local conditions of the area under simulation. The months in which S = 1 should be determined from examination of the data and by knowledge of the area.

C.3 Calculation of the Mean & Standard Deviation of the Residuals

This step is not necessary if the mean and standard deviation of the residuals are provided by the regression package employed in step C.2. However, the program used did not provide these statistics and the program in Appendix D was used to calculate them.

Before using the program, three parts must be programmed. In part I, each of the variables below must be respecified to reflect the user's particular situation.

Variable Name	Represents	Maximum Value
NOBS	Total number of observations for the dependent variable.	240
NEQ	Total number of regression equations from C.2.	10
NIV	Total number of <u>different</u> independent variables.	20

In part II, format number 10 must be changed to reflect the format of the data used in the regressions of C.2. Finally, part III must be programmed to incorporate the regression equations and their estimated parameters. Each equation must be of the following general form:

$$Y(I,J) = X(I,J) + \alpha_L{*}X(I,L)\ \alpha + \ldots \alpha_K{*}X(I,K)\ \ldots + \alpha_N{*}X(I,N)$$

where $Y(I,J)$ = the dependent variable for the Jth regression equation

$X(I,J)$ = the constant for the Jth regression equation

α's = the estimated coefficients

$X(I,L)$ = the first independent variable in the Jth regression equation

$X(I,K)$ = the intermediate in dependent variables in the Jth regression equation

$X(I,N)$ = the last independent variable in the Jth regression equation.

Once the programming changes have been made, the user employs the program by placing the data cards from C.2 behind the program as shown below.

<u>Setup for C.3</u>

Program MASD
Data from C.2

C.4 Modifying Program TINKLE to incorporate the Results of C.2 and C.3

The results of C.2 and C.3 are both to be inserted in subroutine demand. For step C.2, the α's obtained for each demand equation must replace the existing α's in the program as follows:

α's for Demand Equation	Replace on Existing Numbers on Card Number
Domestic	28 & 29
Commercial	30
Industrial	31
Military	32
Municipal	33

For step C.3, the new means must replace the existing numbers on card number 34. (The order is Domestic, Commercial, Industrial, Military, Municipal). Similarly, the new standard deviations must replace the existing ones on card number 35. The order is the same as with the means.

Finally, card 36 must be changed. On this card the variable HTC has been assigned a value of 264. HTC is the cumulative time in months that has elapsed since the beginning month of the regression data and the month just prior to the first month that will be simulated. For example, if the regression data began in 1960:1 and ran through 1970:12 and the simulation is to begin in 1972:1, then the HTC should have a value of 132.

D. OTHER (OPTIONAL) MODIFICATIONS

D.1 Incorporating Additional Punched Output

Additional punched output, for other variables, can be obtained by inserting additional fortran coding in subroutine output between card number 427 and card number 428. The coding should be similary to that in the existing program.

D.2 Changing the Water Quality Constant

This constant can be changed by replacing the number 250.0 on card 36 of the subroutine demand with the desired new constant.

E. MACHINE DEPENDENT MODIFICATIONS (IF REQUIRED)

E.1 Logical Unit Numbers for Peripheral Devices

Since the logical unit numbers may vary from machine to machine, these can be modified to take on different values by changing card number 30 in subroutine BLKDATA. The current assignment follows:

Device	L.U. Number	V.N.	Comments
Crd Reader	5	NR	
L. Printer	6	NP	
Crd Punch	7	NC	
Disk File	15	Tape 1	Generated Stream Flows
Disk File	16	Tape 2	Intermediate Stream Flow Data
Disk File	17	Tape 3	Interrupt Messages

E.2 EOF Function

Use of this program on any machine other than a CDC will require replacing the EOF functions. This function appears at three points in the program.

Routine Name	Card Number
Tinkle	46 & 47
Output	151 & 152
Intrpt	32 & 33

Each set of cards above has the general form:

```
READ (TAPE) list
IF (EOF (TAPE)) 10, 20
```

where 20 is the next statement to be executed if an end-of-file (EOF) is not encountered, and

10 is the statement that is to be executed when an EOF is encountered.

Each set of statements must be replaced with a statement of the following general form (or its equivalent).

```
READ ( TAPE, END=10)  List
```

E.3 Clock and SDate Routines

Subroutine INFO contains statements to retrieve the time of day and date via the CLOCK & SDATE routines. Since these are CDC supplied routines they must be changed in transferring to another computer system. The fortran coding necessary for transferring to an IBM 360 is included in the source listing of subroutine INFO. For other systems, contact the local systems programmer.

E.4 RANF Function

The RANF function is CDC's random number generator and appears on cards number 7 & 8 in subroutine RNORM. Both of these cards must be modified to incorporate the appropriate random number generator provided by other computer systems.

APPENDIX B

DATA CARD PREPARATION

In this section, the formats, restrictions, and order of arrangement for each data card are specified. The data consists of a title card and 12 different types of data cards. Since some of the entries on data card type I depend on the number of cards or entries on the other data cards, it is recommended that data card type I be prepared as the other data cards are completed.

The data card type is printed in the upper right hand corner of each page to facilitate easy reference. In addition, an abbreviated format for each data card type is located at the end of this section and should be a more convenient reference for the experienced user.

Finally, each data card, with the exception of data card types I & II, has a mnemonic label to facilitate relocation of data cards that become out of sequence through handling.

TITLE CARD

The title card consists of any title punched in columns 1 thru 72. The title need not be centered, and should begin in column 1 for the appropriate spacing on the output. The title, along with the date, time of day, and page number, will appear on the first line of every page of output generated. An example title follows.

```
---------------- C O L U M N S --------------------
         111111111122222222223333333333444444444455555555556666666666777777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

COLORADO SPRINGS WATER SUPPLY SIMULATION : TEST RUN
```

PARAMETERS DATA CARD

To prepare this data card, one proceeds as follows: beginning in column 2 punch a dollar sign ($) immediately followed by the word PARAM. In the remaining columns on the card, one punches any one of the variable names (found in the next page) followed by an equals sign (=), the value that the variable name is to be set at, and a comma(,). This is repeated for each variable name whose preset value is not the desired one. If one card is not sufficient for all the entries, then continue on another card or cards but never punch anything in column 1 for it is always ignored. In addition, one should not carry an entry across cards, that is, each entry should fit in the available space on the card or not punched on that card. The general form of this card is—

$PARAM VARIABLE NAME 1=9, VARIABLE NAME 2=9.99, VARIABLE NAME 3=99.9, $

From the general form one can see that the last entry is followed by a dollar sign ($). This is a must.

Any subset of the variable names found on the next page may appear on the card and they may be arranged in any order. The entries may begin or end in any column except column 1, i.e. the format is semi-free.

****PARAMETER LIST****

ITEM	VARIABLE	DESCRIPTION	PRESENT VALUE	COMMENTS
TIME	NYRPRJ	NUMBER OF YEARS IN SIMULATION.....,	50	maximum of 50 yrs
	YRST	SIMULATION BEGINS IN .....,	1972	
STREAMS	NOSTA	TOTAL NUMBER OF STREAMS.....,	30	Maximum of 40
	NSTA	BEGINNING NUMBER OF STREAMS.....,	28	≤ NOSTA
	YR	HISTORICAL DATA BEGINS IN.....,	0	See Restriction 1.
	IYR	NUMBER OF YEARS OF HISTORICAL DATA,	10	≤ 60-NYRPRJ
	SKIP	NUMBER OF YRS OF STREAM DATA SKIP,	0	
RESERVOR	LEAK	LEAKAGE CONSTANT.....,	10.0	C.F.S.
	RLMAX	MAXIMUM CAPACITY.....,	125614.0	A.F./Mo
	RCPL	CONSERVATION POOL LEVEL.....,	3325.0	A.F./Mo
	RLEVEL	CURRENT LEVEL.....,	66743.0	A.F./Mo
	PLEVEL	PREVIOUS LEVEL.....,	65704.0	A.F./Mo
	RLOCAL	LOCAL WATER LEVEL.....,	33371.5	A.F./Mo
	WQR	CURRENT WATER QUALITY.....,	70.0	P.P.M.
	PROBL	PROBABILITY LIMIT FOR EXPANSION..,	0.70	
	EXPL	RESERVOIR LEVEL FOR EXPANSION....,	0.0	A.F./Mo
	EXPR	STORAGE FACTOR RATIO FOR EXPANSION,	0.0	A.F./Mo
RECYCLE	OPTN1	RECYCLE (0=NO, 1=YES).....,	1	See Restriction 2 & 3
	RECYCL	STARTING POSITION.....,	1	-1=Manual on,0=off,+1=Auto On
	RRON	RECYCLE ON LEVEL.....,	30000.0	A.F./Mo
	RROFF	RECYCLE OFF LEVEL.....,	42667.0	A.F./Mo
PLANS	NOFILE	NUMBER OF PLANNING FILES.....,	0	
DEMANDS	NODS	NUMBER OF DISTRIBUTION SUBDIVISION,	0	See Restriction 3 & 4
	NOCD	NUMBER OF STANDBY DEMANDS.....,	0	See Restriction 4
	EG	GROWTH RATE OF EMPLOYMENT.....,	0.0045	Monthly Rate
	PG	GROWTH RATE OF POPULATION.....,	0.0045	Monthly Rate
	EMPLOY	STARTING EMPLOYMENT.....,	7240.0	
	POP	STARTING POPULATION.....,	150000.0	
	PRICED	STARTING PRICE, DOMESTIC AND COMM.	0.717	$/1000 Gallons
	PRICEI	STARTING PRICE, INDUSTRIAL.....,	0.400	$/1000 Gallons
	PRICEM	STARTING PRICE, MILITARY.....,	0.000	$/1000 Gallons
	PRICEC	STARTING PRICE, MUNICIPAL.....,	0.000	$/1000 Gallons
	PRICEN	STARTING PRICE, NON-POTABLE.....,	0.270	$/1000 Gallons
	DPRIDC	SUMMER PRICE INCREASE, DOM COM...,	1.000	≤ 1.0
	DPRII	SUMMER PRICE INCREASE, INDUSTRIAL,	1.000	≤ 1.0
	DEFCC	DEFLATOR, CONSTRUCTION COSTS.....,	1.000	
	DEFOMC	DEFLATOR, OPER. MAIN. COSTS.....,	1.000	
AWT	OPTN2	TREAT EFFLUENT (0=NO, 1=YES).....,	0	See Restriction 2.
	RITL	RECYCLE ITTERRATION LIMIT.....,	30	
	PT2	PROCESS TYPE, LEVEL 2.....,	1	See Restriction 5 & Codes.
	PT3	PROCESS TYPE, LEVEL 3.....,	3	See Restriction 5 & Codes
	LDR1	PERCENT DEMAND RETURNED, LEVEL 1.,	0.00	≤ 1.0
	LDR2	PERCENT DEMAND RETURNED, LEVEL 2.,	0.00	≤ 1.0
	LDR3	PERCENT DEMAND RETURNED, LEVEL 3.,	0.00	≤ 1.0
	LDR4	PERCENT DEMAND RETURNED, LEVEL 4.,	0.00	≤ 1.0
	LL(1)	PERCENT CONSUMPTION, COAG SED....,	0.00	≥ 0.0 but ≤ 1.0

Data Card Type 1.

ITEM	VARIABLE	DESCRIPTION	PRESENT VALUE	COMMENTS
	LL(2)	PERCENT CONSUMPTION, FILTRATION...,	0.00	≥ 0.00 but < 1.0
	LL(3)	PERCENT CONSUMPTION, G. CARB.A....,	0.00	≥0.00 but <1.0
	LL(4)	PERCENT CONSUMPTION, ACT.SLUDGE...,	0.00	≥0.00 but <1.0
OTHER	R(1)	INTEREST RATE 1.....,	0.040	<1.0
	R(2)	INTEREST RATE 2.....,	0.065	<1.0
	R(3)	INTEREST RATE 3.....,	0.080	<1.0
EDIT	IDSNQ	INTERMEDIATE DATA, STREAM NET FLOW,	0	0=No; 1=Yes
	FREQ	FREQUENCY OF IDSNQ PRINTOUT.....,	5	Every five years
	DCII	DATA CARD TYPE II PRINTOUT.....,	1	0=No; 1=Yes
	DCIII	DATA CARD TYPE III PRINTOUT.....,	1	↑
	DCIV	DATA CARD TYPE IV PRINTOUT.....,	1	
	DCV	DATA CARD TYPE V PRINTOUT.....,	1	
	DCVI	DATA CARD TYPE VI PRINTOUT.....,	1	
	DCVII	DATA CARD TYPE VII PRINTOUT.....,	1	
	DCVIII	DATA CARD TYPE VIII PRINTOUT.....,	1	
	DCIX	DATA CARD TYPE IX PRINTOUT.....,	1	
	DCX	DATA CARD TYPE X PRINTOUT.....,	1	
	DCXI	DATA CARD TYPE XI PRINTOUT.....,	1	
	DCXII	DATA CARD TYPE XII PRINTOUT.....,	1	↓
	GRAPH	PUNCH DATA FOR GRAPH PROGRAM.....,	0	0=No;1=Yes; See Res. 6.

Restrictions:

1. The beginning year for historical data must be specified.
2. If OPTN1=0, then the remaining entries for recycling are ignored, also OPTN2 must equal zero (0).
3. If OPTN1=1, then NODS must be nonzero (>0) and data card type VII must be included in the data deck.
4. If either NODS or NOCD are zero (0), then data card type VII and VIII respectively must not be included in the data deck.
5. If less than 4 levels of AWT are desired, then the unwanted levels must be removed from the top (level 3) by specifying a code of 5.

6. The graph output consists of one observation for each year of the simulation for each item below.

Population	Per Capita Water Use: Commercial	Rank of Flows.
Employment	Percent Capacity of Reservoir	
Per Capita Water Use: Domestic	Total Water Use in MG.	

Codes:

Code No.	Treatment Process Type
1	Coagulation & sedimentation
2	Filtration
3	Granulated carbon absorption
4	Activated sludge
5	None

Example Data Card:

```
----------------COLUMNS--------------------

        1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

$PARAM NOSTA=29,  NSTA=27, YR=1962, RECYCL=-1, RRON=41667.0, NOFILE=3,
 NODS=17, NOCD=4, LDR1=0.75, LDR2=0.75, LDR3=0.75, LDR4=0.75, LL(1)=4*0.03,
 DCII=0, DCIII=0, DCIV=0, DCV=0, DCVII=0, DCVIII=0, DCIX=0, DCX=0, DCXI=0,
  DCXII=0$
```

Data Card Type II

STREAM FLOW CONSTRAINT DATA

COLUMN	ITEM	FORMAT	COMMENTS
1-3	Station Number	999	
4-23	Stream Name		Maximum of 20 characters
24	Type of Water	9	1 for local
			2 for import
25	Number of Cuts	9	Maximum of 3
26-31	Pipeline Constraint	999.99	C.F.S. - If left blank, 999.99 C.F.S.
			is assumed.
32	Blank		
33-34	Beginning Month, Season 1	99	If left blank, 1 is assumed
35-36	Ending Month, Season 1	99	If left blank, 12 is assumed
37-42	Min. C.F.S., Cut 1	999.99	
43-48	Max. C.F.S., Cut 1	999.99	If left blank, 999.99 C.F.S. is assumed
49-50	Beginning Month, Season 2	99	If left blank, 1 is assumed
51-52	Ending Month, Season 2	99	If left blank, 12 is assumed
53-58	Min. C.F.S., Cut 2	999.99	
59-64	Max. C.F.S., Cut 2	999.99	If left blank, 999.99 C.F.S. is assumed
65-66	Beginning Month, Season 3	99	If left blank, 1 is assumed
67-68	Ending Month, Season 3	99	If left blank, 12 is assumed
69-74	Min. C.F.S., Cut 3	999.99	
75-80	Max. C.F.S., Cut 3	999.99	If left blank, 999.99 C.F.S. is assumed

Restrictions:

1. There must be one data card for each stream that begins in the simulation and one data card for each stream that may be added during the simulation. In all

there must be NOSTA cards (see data card type I).

2. The order in which the data cards are arranged must correspond to the order in which the generated stream flows are written on Tape 1. This order must be preserved through data card type IV.
3. If it is desired to cut off a stream flow during a particular season, then the min. C.F.S. would be 999.99 and the max. C.F.S. should be left blank (see Sheep Creek in the example).
4. If a seasonal cut is desired, then the beginning month, season 1 must be 1 and the ending month on the last cut must be 12. (See North Cascade Creek in the example).

```
- - - - - - - - - - - - - - - - - - C O L U M N S - - - - - - - - - - - - - - - - - - - - - - - -
         1111111111122222222223333333333444444444455555555556666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789O1234567890

152LOWER FOUNTAIN      11              0.00 63.04
149SOUTH CHEYENNE CREEK11 48.00
147NORTH CHEYENNE CREEK11 70.00        0.50
154LOWER RUXTON CREEK  11
111NORTH CATAMOUNT CREE11              0.00 41.91
113SOUTH CATAMOUNT CREE11              0.00 19.49
115CRYSTAL CREEK       12              0.00 15.43     15.83  19.89
117NORTH CASCADE CREEK 13       0105   1.00  6.930609  2.00   7.931012  1.00  6.93
118SOUTH CASCADE CREEK 11
120FRENCH CREEK        11              0.00 50.25
129BOEHMER CREEK       11 15.00        2.82
130LITTLE BEAVER       12              0.00  2.50      3.77
132MIDDLE BEAVER       11
141CABIN CREEK         13       0103999.99  0.000410  0.00   3.131112999.99  0.00
146BEAR CREEK          11              0.00 37.94
136WINDY CREEK         11
138MAIN RUXTON CREEK   11
139LION CREEK          11
140SHEEP CREEK         13       0103999.99  0.000410  0.00       1112999.99  0.00
142SOUTH RUXTON CREEK  11
143WILLOW CREEK        11
156MONTE-CRISTO DIVERS 23       0104999.99  0.000510  0.00       1112999.99  0.00
159BEMROSE-HOOSIER DIV 23       0104999.99  0.000510  0.00       1112999.99  0.00
173SOUTH PLATTE MIDDLE 23       0104999.99  0.000508210.00240.00 0912999.99  0.00
166BLUE RIVER AT BRECK 23       0104999.99  0.000508  0.00       0912999.99  0.00
161MCCULLOUGH DIVERSIO 23       0104999.99  0.000510  0.00       1112999.99  0.00
144HOMESTAKE CREEK GOLD23       0103999.99  0.000408             0912999.99  0.00
153EAGLE RIVER AT RED C23       0103999.99  0.000408  8.00238.00 0912999.99  0
167CROSS CREEK NR MINT 23       0104999.99  0.000508  8.00       0812999.99  0.00
```

Data Card Type III

HISTORICAL ANNUAL STREAM FLOW DATA

COLUMN	ITEM	FORMAT	COMMENTS
1-4	HIST		
5-8	Station Number	999	
9-16	Annual Stream Flow, Year 1	99999.99	C.F.S.
17-24	, Year 2		
25-32	, Year 3		
33-40	, Year 4		
41-48	, Year 5		
49-56	, Year 6		
57-64	, Year 7		
65-72	, Year 8		
73-80	Annual Stream Flow, Year 9	99999.99	C.F.S.

Restrictions:

1. There must be one data card for each stream that begins in the simulation and one data card for each stream that may be added during the simulation. If more than nine (9) years of historical data are to be provided, then IYR/9 data cards must be provided for each stream.
2. The order of the data cards is as follows: data cards for the first nine years are arranged to correspond to the order in which the generated stream flows are written on tape 1. The same thing is done for the second nine years and placed behind the first nine years. This is repeated for each group of nine years.

```
- - - - - - - - - - - - - - - - - C O L U M N S - - - - - - - - - - - - - - - - - - - - - -
         1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

HIST 152    9.25    7.08    7.58   20.50   10.67   10.00   12.83   13.33   14.16
HIST 149   00.00   00.00   00.00   00.00   00.00   00.00   25.38   31.84   54.23
HIST 147    2.67    4.42    5.50    5.42    3.75    4.25    3.75    4.75    4.25
HIST 154     .42     .42    1.08    1.25     .92     .67    1.17    1.33    1.42
HIST 111    0.80    0.45    0.83    1.69     .42     .63     .61    1.71    1.40
HIST 113    1.34    1.22    1.50    2.94    1.59    2.05    2.11    3.18    2.86
HIST 115     .60     .31     .71    1.26     .62     .72     .68    1.38    1.09
HIST 117     .95     .46     .54    1.07     .87     .97    1.08    1.60    1.43
HIST 118    1.40    1.26    1.24    1.88    1.51    1.78    1.81    2.26    2.03
HIST 120     .58     .99     .68    4.85    1.98    3.02    3.14    4.70    4.13
HIST 129   41.07   29.18   47.02   95.18   37.10   40.45   68.43   85.78   81.99
HIST 130     .31     .78     .69     .75     .41     .28    1.21     .25     .10
HIST 132    2.86    1.07    1.13    5.00    1.43    1.45    1.82    5.94    5.69
HIST 141     .53     .36     .82    2.08     .83     .92    1.08    1.63    1.39
HIST 146    1.24    1.33    1.16    2.57    1.31    1.80    1.69    2.22    2.18
HIST 136     .25     .15     .10     .28     .06     .20     .21     .14     .14
HIST 138    1.64    1.24    1.57    2.70    1.90    1.86    1.83    2.22    1.99
HIST 139     .58     .46     .72    1.43     .81     .69     .86    1.04    1.03
HIST 140     .13     .09     .18     .74     .28     .21     .31     .49     .42
HIST 142     .68     .64     .73    1.66    1.03    1.75    1.46    1.63    1.35
HIST 143     .27     .22     .21     .49     .24     .23     .20     .32     .34
HIST 156    5.75    4.92    4.17    3.83    4.83    6.58    6.91    5.92    4.33
HIST 159    2.50     .92    2.08    1.75    1.00    1.67    2.42    1.75    1.67
HIST 173   80.00  347.33   89.08   88.17  177.67   93.75   75.08   72.50   76.50
HIST 166   64.83   44.08   52.00   47.92   46.33   45.58   54.50   45.17   47.08
HIST 161    6.92    6.58    4.59    4.67    3.42    5.58    5.92    4.83    4.42
HIST 144   79.41   52.75   63.75   76.75   34.83   63.33   71.50   67.50   60.75
HIST 153   50.90   23.25   30.58   49.92   20.33   33.16   41.25   26.75   32.67
HIST 167   58.08   35.75   21.00   37.83   20.25   33.42   46.42   34.33   33.58
HIST 152   10.67
HIST 149   26.14
HIST 147    3.17
HIST 154     .92
HIST 111     .39
HIST 113    1.84
HIST 115     .58
HIST 117     .93
HIST 118    1.55
HIST 120    3.32
HIST 129   48.84
HIST 130     .10
HIST 132    1.59
HIST 141    1.07
HIST 146    1.66
HIST 136     .27
```

```
- - - - - - - - - - - - - - - - - - COLUMNS - - - - - - - - - - - - - - - - - - - - -
         1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890


HIST 136     .27
HIST 138    1.87
HIST 139     .85
HIST 140     .27
HIST 142    1.09
HIST 143     .27
HIST 156    4.92
HIST 159    1.58
HIST 173   82.67
HIST 166   49.50
HIST 161    5.17
HIST 144   57.50
HIST 153   33.08
HIST 167   43.75
```

Data Card Type IV

RESERVOIR LOSSES DATA

COLUMN	ITEM	FORMAT	COMMENTS
1-4	RESV		
6-8	Blank		
9-14	Minimum Required Reservoir Outflow, Jan	999.99	C.F.S.
15-20	, Feb		
21-26	, Mar		
27-32	, Apr		
33-38	, May		
39-44	, June		
45-50	, July		
51-56	, Aug		
57-62	, Sept		
63-68	, Oct		
69-74	, Nov		
75-80	Minimum Required Reservoir Outflow, Dec	999.99	C.F.S.

Restrictions:

1. This restriction is the same as restriction no. 1 data card type II.
2. This restriction is the same as restriction no. 2 data card type II.
3. It should be noted that, although the data is in C.F.S., the program will convert it to A. F. per month.

```
- - - - - - - - - - - - - - - - - - COLUMNS - - - - - - - - - - - - - - - - - - - - - -
         1111111111222222222233333333334444444444555555555566666666667777777778
1234567890123456789012345678901234567890123456789012345678901234567890123456789 0
```

RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.75	0.75	0.75	0.75	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	1.20	1.20	1.20	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.0	6.64	11.00	12.00	12.00	8.00	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.0	1.68	3.50	4.00	4.00	2.78	0.00	0.00	0.00	0.00
RESV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Data Card Type V.

RESERVOIR EVAPORATION DATA

COLUMN	ITEM	FORMAT	COMMENTS
1-4	EVAP		
5-8	Blank		
9-14	Reservoir Evaporation Constant, Jan	9.9999	
15-20	, Feb		
21-26	, Mar		
27-32	, Apr		
33-38	, May		
39-44	, June		
45-50	, July		
51-56	, Aug		
57-62	, Sept		
63-68	, Oct		
69-74	, Nov		
75-80	Reservoir Evaporation Constant, Dec	9.9999	

Restrictions:

1. The reservoir evaporation constant is a number between zero (0) and one (1) that represents the proportion of the total volume of the reservoir which evaporates during the given month.
2. Only one (1) of these cards is required for the constants are assumed to be the same for each year of the simulation.

```
---------------- C O L U M N S ----------------------
        1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

EVAP    0.00  0.00  0.00  0.00  0.005 0.01  0.01  0.01  0.01  0.005 0.00  0.00
```

Data Card Type VI.

PLANNING DATA

COLUMN	ITEM	FORMAT	COMMENTS
1-4	PLAN		
5	Blank		
6-7	File Number	99	-File Number, First Card (Nothing in Cols 8-80) +File Number, Intermediate Cards 0, Last Card (Nothing in Cols 8-80)
8	Blank		
9-11	Plan Number	999	Identifying Number for Users Convenience
12	Blank		
13-15	Time at which the plan is to be initiated	999	In Cumulative Months, If File No. 5, Zero
16	Blank		
17-19	Lag Time Until the Completion of the Plan	999	In Months, File 5 only.
20	Blank		
21-23	Code for this File	999	See Table 1
24	Blank		
25-30	Attribute 1	999999	See Table 1
31	Blank		
32-37	Attribute 2	999999	See Table 1
38	Blank		
39-44	Attribute 3	999999	See Table 1
45-80	Reserved for Future Use		

Restrictions:

1. File Number 1. This file contains only plans for stream, reservoir, well or project expansion; or future implementation of recycling that

are currently scheduled for completion regardless of need or appropriateness. In addition, the provision has been made for the fixed and variable costs associated with each type of expansion. Every entry in this file must not have a lag time. The codes and attributes are listed in Table 1.

2. File Number 2. This file contains plans for increasing the value of the constant in the industrial demand for water equation in order to incorporate continuous standby demands for industrial use that must be supplied from reservoir water (AWT level Number 0) when recycling is not employed. Every entry in this file must have a lag time of zero. The codes and attributes are listed in Table 1.

3. File Number 3. This file contains plans for changing the distribution data for recycling during periods of water restriction and for increasing and/or adding to the continuous standby demands for recycled water. Once again the lag time must be zero. The codes and attributes are listed in Table 1.

4. File Number 4. This file contains plans for changing the values of certain independent variables in the demand for water equations, namely, domestic/commercial price (PRICED), industrial price (PRICEI), military price (PRICEM), municipal price (PRICEC), non-potable price (PRICEN), employment growth rate (EG), and population growth rate (PG). The lag time must be zero and the prices are in dollars per thousand gallons. The codes and attributes are listed in Table 1.

5. File Number 5. This file contains plans for stream, reservoir, well, or project expansions that are to be implemented when the need arises or decisions dictate that it is appropriate. As in File Number 1, the associated fixed and variable costs may be included if any exist. There must be a lag time and there must not be a begin time (cols. 13-15 must be blank except for the following special case: when more than one event is to be implemented at the same point in time, some positive dummy number, such as 888, must appear in the columns for the begin time to indicate that another event must also occur. For example, if both a stream and a reservoir are to be brought in at the same time, then the begin time for the stream would be 888 while the begin time for the reservoir would be blank.) The codes and attributes are the same as file no. 1 (except code 5) and are listed in Table 1.

6. File Number 6. This file is reserved for future use and is of the same type as File Number 5.

7. In preparing the data cards for this section, the cards in files number 1 thru 4 must be arranged low value first based on the begin time (col. 13-15). File Number 5 should be arranged low value first based on the plan number (col. 9-11).

8. In specifying the begin times one should remember that the plan will be implemented at the end of the month and in effect at the first of the next month. For example, if a begin time of 11 is specified, then the plan is implemented at the end of the 11th month and in effect at the first of the 12th month. The only exception is File 2, where plans are implemented at the beginning of the month and in effect that month as well.

This data card and data cards Type VII and VIII may require user numbers and/or AWT level numbers. These numbers and their physical representation are described below.

User Number	User
1	Domestic
2	Commercial
3	Industrial
4	Military
5	Municipal

AWT Level Number	State of AWT
0	None
1	1 Stage of AWT
2	2 Stages of AWT
3	3 Stages of AWT
4	4 Stages of AWT

TABLE 1.

FILE NUMBER	CODE	ATTRIBUTE 1	ATTRIBUTE 2	ATTRIBUTE 3
1	1	Number of Additional Streams	Nothing	Nothing
	2	Additional Reservoir Capacity in AF/Mo	New Recycle on Level in AF/Mo	New Recycle OFF Level in AF/Mo
	3	Month Change is to take Place (1-12)	Additional Well Flow in AF/Mo	Nothing
	4	Month Change is to take Place (1-12)	Additional Project Flow in AF/Mo	Nothing
	5	New Value for OPTN1	New Value for RRON (Recycle on Level)	New Value for RROFF (Recycle OFF level)
	6	Stream: Fixed Costs in Millions of $	Stream: Variable Cost $ per C.F.S.x100	Nothing
	7	Reservoir: Fixed Costs in Millions of $	Reservoir: Variable Cost $ per A.F. x 100	Nothing
	8	Wells: Fixed Costs in Millions of $	Wells: Variable Costs $ per A.F. x 100	Nothing
	9	Projects: Fixed Costs in Millions of $	Projects: Variable Costs $ per A.F. x 100	Nothing
2	1	3	Amount of increase in Continuous Stand-by Demand in M.G./Day	Nothing
3	1	User Number	AWT Level Number	New Percentage x 1000
	2	User Number	AWT Level Number	Additional Continuous Standby Demand in MG/DAY x 100
	3	User Number	AWT Level Number	Non Continuous Standby Demand in MG/Day x 100
4	1	New PRICED (Domestic) x 1000	Nothing	Nothing
	2	New PRICEI (Industrial) x 1000	Nothing	Nothing
	3	New PRICEM (Military) x 1000	Nothing	Nothing
	4	New PRICEC (Municipal) x 1000	Nothing	Nothing
	5	New PRICEN (Non Potable) x 1000	Nothing	Nothing
	6	New EG (Employment) x 10000	Nothing	Nothing
	7	New PG (Population) x 10000	Nothing	Nothing
5	Same as File No.1	Same as File Number 1	Same as File Number 1	Same as File Number 1
6	-	Reserved for Future Use	Reserved for Future Use	Reserved for Future Use

```
---------------- C O L U M N S ----------------------
         1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

PLAN -1
PLAN 01 102 011        4      1    600
PLAN 01 102 011        4      2    700
PLAN 01 102 011        4      3    700
PLAN 01 102 011        4      4    850
PLAN 01 102 011        4      5    850
PLAN 01 102 011        4      6    900
PLAN 01 102 011        4      7   1000
PLAN 01 102 011        4      8   1100
PLAN 01 102 011        4      9   1100
PLAN 01 102 011        4     10    900
PLAN 01 102 011        4     11    800
PLAN 01 102 011        4     12    700
PLAN 01 103 065        1      1
PLAN 01 105 095        1      1
PLAN 01 106 095        2  41755  35000  44000
PLAN 01 104 179        4      1    600
PLAN 01 104 179        4      2    700
PLAN 01 104 179        4      3    700
PLAN 01 104 179        4      4    700
PLAN 01 104 179        4      5    850
PLAN 01 104 179        4      6    900
PLAN 01 104 179        4      7   1000
PLAN 01 104 179        4      8   1100
PLAN 01 104 179        4      9   1100
PLAN 01 104 179        4     10    900
PLAN 01 104 179        4     11    800
PLAN 01 104 179        4     12    700
PLAN 0
PLAN -3
PLAN 03 301 065        2      5      1      2
PLAN 03 302 095        2      5      1      4
PLAN 03 303 144        2      5      1      5
PLAN 0
PLAN -4
PLAN 04 401 024        1  50000
PLAN 04 402 024        2  45000
PLAN 04 404 072        1  60000
PLAN 04 405 072        2  50555
PLAN 04 406 072        4  17000
PLAN 04 407 108        1  70000
PLAN 04 408 108        2  60000
PLAN 04 409 108        4  20000
PLAN 04 410 144        1  80000
PLAN 04 411 144        2  75000
```

```
-----------------COLUMNS----------------------
         1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

PLAN 04 411 144        2  75000
PLAN 04 412 144        4  25000
PLAN 04 413 180        1  90000
PLAN 04 415 180        4  30000
PLAN 04 416 216        1 100000
PLAN 04 417 216        4  35000
PLAN 04 418 276        1 120000
PLAN 04 419 276        2 120000
PLAN 04 420 276        4  40000
PLAN 04 421 350        1 150000
PLAN 04 422 350        2 150000
PLAN 04 423 350        4  50000
PLAN 04 424 450        1 180000
PLAN 04 425 450        2 180000
PLAN 04 426 450        4  60000
PLAN  0
```

DISTRIBUTION DATA FOR RECYCLING DURING PERIODS OF WATER RESTRICTION

COLUMN	ITEM	FORMAT	COMMENTS
1-4	DIST		
5-10	Blanks		
11	Blank		
12	Water Demanded by User No.	9	1,2,3,4, or 5
13	Blank		
14	Water From AWT Level No.	9	0,1,2,3, or 4
15	Blank		
16-20	Percentage of Total Water Demanded by User No. to be Supplied From AWT Level No.	9.999	$\leqslant$ 1.0
24	Blank		
22	Water Demanded by User No.	9	1,2,3,4, or 5
23	Blank		
24	Water From AWT Level No.	9	0,1,2,3, or 4
25	Blank		
26-30	Percentage of Total Water Demanded by User No. to be Supplied From AWT Level No.	9.999	$\leqslant$ 1.0
.	.		
.	.		
.	.		
.	Repeat as Above		
.	.		
.	.		
.	.		
.	.		
71	Blank		
72	Water Demanded by User No.	9	1,2,3,4, or 5
73	Blank		
74	Water From AWT Level No.	9	0,1,2,3, or 4
75	Blank		
76-80	Percentage of Total Water Demanded by User No. to be Supplied From AWT Level No.	9.999	$\leqslant$ 1.0

Restrictions:

1. The appropriate user nos. and AWT level nos. employed above, are described in the tables given under data card type VI.

2. The percentages may be any number ranging from 0.0 to 1.0 inclusive.

3. The total number of sets of data (a set consists of a user no, an AWT level no. and a percentage) must be specified on data card type I as NODS.

4. Since this data card may create some confusion, the following explanation is in order. First, consider Table 2.

Data Card Type VII

TABLE 2

Aggregate Demands for Water By --	%Supplied From AWT Level					Total
	0	1	2	3	4	
1. Domestic Users	0.77				0.23	1.00
2. Commercial Users	0.77	0.05			0.18	1.00
3. Industrial Users	0.25	0.30		0.15	0.30	1.00
4. Military Users	0.65	0.10			0.25	1.00
5. Municipal Users	0.20	0.50	0.10	0.10	0.10	1.00

Under normal conditions all five (5) demands, except for continuous standy demands, would be supplied from AWT level 0 water. However, when the reservoir drops below the recycle on level (RRON), a shortage in supply exists and drainage on the reservoir can be lessened by taking less water from the reservoir (AWT level 0) and making up the deficit in demand by supplying users with recycled water. Thus, a decision must be made as to what percentage of each user's aggregate demand will be supplied from which AWT level; hence the purpose of this data input.

Thus, Table 2 conveys that during periods of shortage in supply, 77% of the aggregate demand required by domestic users will be supplied from AWT level 0 while 23% will be supplied from AWT level 4 and similarly for the other user's.

Also note that each row must sum to one (1.0), otherwise there will be unsatisfied demands that will be lost.

5. If more than one data card is required, the ones that are completely filled with entries must appear first in the order of arrangement. However, the order of the completely filled cards is unimportant but some logical structure should be adopted to minimize confusion.

```
- - - - - - - - - - - - - - - - - - COLUMNS - - - - - - - - - - - - - - - - - - - - -
         1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890


DIST       1 0 0.770 1 4 0.230 2 0 0.770 2 1 0.050 2 4 0.250 3 0 0.250 3 1 0.300
DIST       3 3 0.150 3 4 0.300 4 0 0.650 4 1 0.100 4 4 0.250 5 0 0.200 5 1 0.500
DIST       5 2 0.100 5 3 0.100 5 4 0.100
```

Data Card Type VIII

CONTINUOUS STANDBY DEMANDS
FOR RECYCLED WATER DATA

COLUMN	ITEM	FORMAT	COMMENTS
1-7	CDEMAND		
8-10	Blanks		
11	Blank		
12	Water Demanded by User No.	9	1,2,3,4, or 5
13	Blank		
14	Water from AWT Level No.	9	1,2,3, or 4
15	Blank		
16-20	Amount of Water Demanded in M.G./Day	999999	
21	Blank		
22	Water Demanded by User No.	9	1,2,3,4, or 5
23	Blank		
24	Water From AWT Level No.	9	1,2,3, or 4
25	Blank		
26-30	Amount of Water Demanded in M.G./Day	999999	
.	.		
.	.		
.	.		
.	Repeat as Above		
.	.		
.	.		
.	.		
71	Blank		
72	Water Demanded by User No.	9	1,2,3,4, or 5
73	Blank		
74	Water from AWT Level No.	9	1,2,3, or 4
75	Blank		
76-80	Amount of Water Demanded in M.G./Day	999999	

Restrictions:

1. The appropriate user nos. and AWT level nos. employed above, are described in the tables given under data card type VI. Note, however, that AWT level 0 is meaningless for this data.

2. The purpose of this data is to incorporate existing demands for recycled water that is expected to remain at a constant level indefinitely or until some future point in time. Changes in the initial levels of demand are by use of the planning file. Note also that these demands are in addition to the monthly demand equations in the program.

3. The total number of sets of data (a set consists of a user no., an AWT level no., and an amount demanded) must be specified on data card type I as NOCD.

4. If more than one data card is required, then restriction 5 on data card type VII should be adherred to.

```
- - - - - - - - - - - - - - - - - - COLUMNS - - - - - - - - - - - - - - - - - - - - -
         1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

CDEMAND    2 1     3 3 1     4 5 1     3 5 1     2
```

Data Card Type IX

AVERAGE MONTHLY RAINFALL DATA

COLUMN	ITEM	FORMAT	COMMENTS
1-6	RAINAV		
7-8	Blanks		
9-14	Average Rainfall in Jan	99.999	Inches
15-20	Feb		
21-26	Mar		
27-32	April		
33-38	May		
39-44	June		
45-50	July		
51-56	Aug		
57-62	Sept		
63-68	Oct		
69-74	Nov		
75-80	Average Rainfall in Dec	99.999	Inches

Restrictions:

1. The average monthly rainfall data should be calculated from the same data that was used to construct the rainindex used in the regression equations to project domestic water demand.

```
- - - - - - - - - - - - - - - - - - - - C O L U M N S - - - - - - - - - - - - - - - - - - - -
         1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

RAINAV    .202  .243  .603  .821 1.452 2.254 2.855 2.037 1.438  .626  .419  .459
```

Data Card Type X

MONTHLY AGRICULTURE DEMAND DATA

COLUMN	ITEM	FORMAT	COMMENTS
1-6	AGRICL		
7-8	Blanks		
9-14	Agriculture Demand, Jan	999999	Millions of Gallons/Day
15-20	Feb		
21-26	Mar		
27-32	April		
33-38	May		
39-44	June		
45-50	July		
51-56	Aug		
57-62	Sept		
63-68	Oct		
69-74	Nov		
75-80	Agriculture Demand, Dec	999999	Millions of Gallons/Day

Restrictions:

1. The distribution of agriculture water demand is assumed to remain constant for each year of the simulation.

```
- - - - - - - - - - - - - - - - - - COLUMNS - - - - - - - - - - - - - - - - - - - - - -
         1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

AGRICL       0    0    0    0    0    0    0    0    0    0    0    0
```

Data Card Type XI

MONTHLY WELL FLOW DATA

COLUMN	ITEM	FORMAT	COMMENTS
1-6	WELLS		
7-8	Blanks		
9-14	Well Flow for Jan	999999	A. F./Month
15-20	Feb		
21-26	Mar		
27-32	April		
33-38	May		
39-44	June		
45-50	July		
51-56	Aug		
57-62	Sept		
63-68	Oct		
69-74	Nov		
75-80	Well Flow for Dec	999999	A.F./Month

Restrictions:

1. This data is for initial flows only. Expansions of wells is accomplished by use of the planning file.

```
- - - - - - - - - - - - - - - - - - COLUMNS - - - - - - - - - - - - - - - - - - - - - -
         1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

WELLS        2    2    3    5    9    9    9    6    3    3    2    2
```

Data Card Type XII

MONTHLY FLOWS FROM WATER PROJECTS

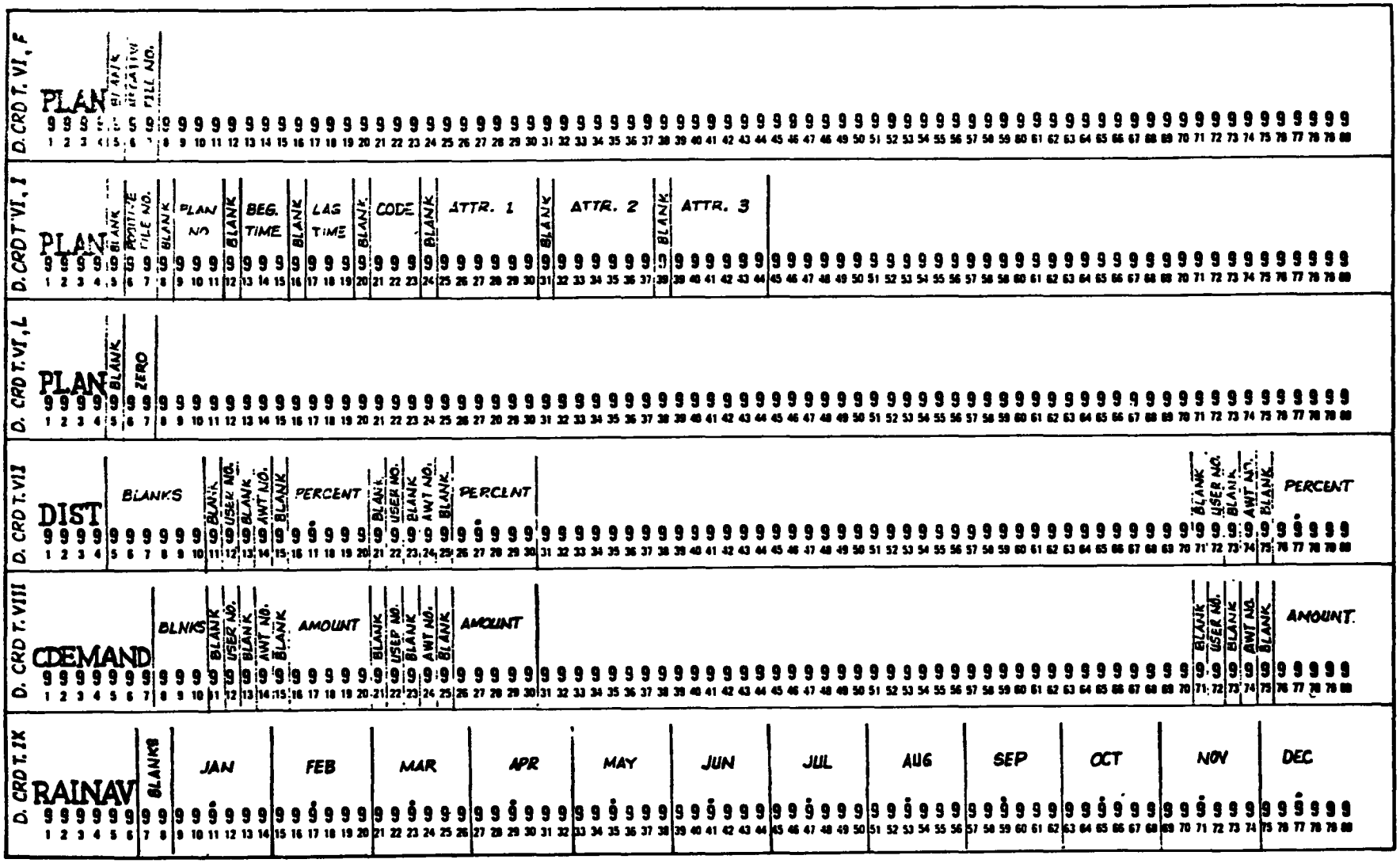
COLUMN	ITEM	FORMAT	COMMENTS
1-6	PROJCT		
7-8	Blanks		
9-14	Flows From Projects in Jan	999999	A.F./Month
15-20	Feb		
21-26	Mar		
27-32	April		
33-38	May		
39-44	June		
45-50	July		
51-56	Aug		
57-62	Sept		
63-68	Oct		
69-74	Nov		
75-80	Flows From Projects in Dec	999999	A.F./Month

Restrictions:

1. As with well flows, this data reflects flows from projects that are in effect at the beginning of the simulation. They too can be expanded by use of the planning files.

```
- - - - - - - - - - - - - - - - - - COLUMNS - - - - - - - - - - - - - - - - - - - - - -
         1111111111122222222223333333333444444444455555555556666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

PROJCT       0    0    0    0    0    0    0    0    0    0    0    0
```


D. CRD T. VI, F
PLAN
BLANK
POSITIVE FILE NO.
D. CRD T. VI, I
PLAN
BLANK
POSITIVE FILE NO.
BLANK
PLAN NO
BLANK
BEG. TIME
BLANK
LAG TIME
BLANK
CODE
BLANK
ATTR. 1
BLANK
ATTR. 2
BLANK
ATTR. 3
D. CRD T. VI, L
PLAN
BLANK
ZERO
D. CRD T. VII
DIST
BLANKS
BLANK
USER NO.
BLANK
AWT NO.
BLANK
PERCENT
BLANK
USER NO.
BLANK
AWT NO.
BLANK
PERCENT
BLANK
USER NO.
BLANK
AWT NO.
BLANK
PERCENT
D. CRD T. VIII
CDEMAND
BLNKS
BLANK
USER NO.
BLANK
AWT NO.
BLANK
AMOUNT
BLANK
USER NO.
BLANK
AWT NO.
BLANK
AMOUNT
BLANK
USER NO.
BLANK
AWT NO.
BLANK
AMOUNT.
D. CRD T. IX
RAINAV
BLANKS
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

TITLE CARD

TITLE	BLANKS

$PARAM

VARIABLE NAMES $

D. CRD T. II

STA NO.	STREAM NAME	TYPE	NO. CUTS	PIPELINE CONSTRNT	BLANK	CUT 1 B. MO.	CUT 1 E. MO.	CUT 1 MIN CFS	CUT 1 MAX CFS	CUT 2 B. MO.	CUT 2 E. MO.	CUT 2 MIN CFS	CUT 2 MAX CFS	CUT 3 B. MO.	CUT 3 E. MO.	CUT 3 MIN CFS	CUT 3 MAX CFS

D. CRD T. III

HIST

STA NO.	YEARS OF DATA 1	2	3	4	5	6	7	8	9

D. CRD T. IV

RESV

BLANK	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

D. CRD T. V

EVAP

BLANK	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

D. CRD. T X	BLANKS	JAN.	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
AGRICL													
9 9 9 9 9 9	9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9
1 2 3 4 5 6	7 8	9 10 11 12 13 14	15 16 17 18 19 20	21 22 23 24 25 26	27 28 29 30 31 32	33 34 35 36 37 38	39 40 41 42 43 44	45 46 47 48 49 50	51 52 53 54 55 56	57 58 59 60 61 62	63 64 65 66 67 68	69 70 71 72 73 74	75 76 77 78 79 80

D. CRD. T. XI	BLANKS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
WELLS													
9 9 9 9 9 9	9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9
1 2 3 4 5 6	7 8	9 10 11 12 13 14	15 16 17 18 19 20	21 22 23 24 25 26	27 28 29 30 31 32	33 34 35 36 37 38	39 40 41 42 43 44	45 46 47 48 49 50	51 52 53 54 55 56	57 58 59 60 61 62	63 64 65 66 67 68	69 70 71 72 73 74	75 76 77 78 79 80

D. CRD. T. XII	BLANKS	JAN.	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
PROJCT													
9 9 9 9 9 9	9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9
1 2 3 4 5 6	7 8	9 10 11 12 13 14	15 16 17 18 19 20	21 22 23 24 25 26	27 28 29 30 31 32	33 34 35 36 37 38	39 40 41 42 43 44	45 46 47 48 49 50	51 52 53 54 55 56	57 58 59 60 61 62	63 64 65 66 67 68	69 70 71 72 73 74	75 76 77 78 79 80

9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

FILE 5 SKIP 10 MED GROWTH ITTERATION LIMIT 5 DATE 07/11/73 TIME 9 39 31 PAGE 1

*****PARAMETER LIST*****

ITEM	VARIABLE	DESCRIPTION	VALUE
TIME	NYRPRJ	NUMBER OF YEARS IN SIMULATION.....,	50
	YRST	SIMULATION BEGINS IN .....,	1974
STREAMS	NOSTA	TOTAL NUMBER OF STREAMS.....,	29
	NSTA	BEGINNING NUMBER OF STREAMS.....,	27
	YR	HISTORICAL DATA BEGINS IN.....,	1964
	IYR	NUMBER OF YEARS OF HISTORICAL DATA,	10
	SKIP	NUMBER OF YRS OF STREAM DATA SKIP.,	10
RESERVOIR	LEAK	LEAKAGE CONSTANT.....,	10.0000
	RLMAX	MAXIMUM CAPACITY.....,	125614.0000
	RCPL	CONSERVATION POOL LEVEL.....,	3325.0000
	RLEVEL	CURRENT LEVEL.....,	66743.0000
	PLEVEL	PREVIOUS LEVEL.....,	65704.0000
	RLOCAL	LOCAL WATER LEVEL.....,	33371.5000
	WQR	CURRENT WATER QUALITY.....,	70.0000
	PROBL	PROBABILITY LIMIT FOR EXPANSION...,	.2500
	EXPL	RESERVOIR LEVEL FOR EXPANSION.....,	70000.0000
	EXPR	STORAGE FACTOR RATIO FOR EXPANSION,	1.0000
RECYCLE	OPTN1	RECYCLE (0=NO, 1=YES).....,	1
	RECYCL	STARTING POSITION .....,	1
	RRON	RECYCLE ON LEVEL.....,	30000.0000
	RROFF	RECYCLE OFF LEVEL.....,	42667.0000
PLANS	NOFILE	NUMBER OF PLANNING FILES.....,	4
DEMANDS	NOOS	NUMBER OF DISTRIBUTION SUBDIVISION,	17
	NOCD	NUMBER OF STANDBY DEMANDS.....,	4
	EG	GROWTH RATE OF EMPLOYMENT.....,	.0045
	PG	GROWTH RATE OF POPULATION.....,	.0045
	EMPLOY	STARTING EMPLOYMENT.....,	8000.0000
	POP	STARTING POPULATION.....,	176000.0000
	PRICED	STARTING PRICE, DOMESTIC AND COMM.,	.7170
	PRICEI	STARTING PRICE, INDUSTRIAL.....,	.4000
	PRICEM	STARTING PRICE, MILITARY.....,	.6660
	PRICEC	STARTING PRICE, MUNICIPAL.....,	0.0000
	PRICEN	STARTING PRICE, NON-POTABLE.....,	.2700
	DPRIDC	SUMMER PRICE INCREASE, DOM) COM..,	1.0000
	DPRII	SUMMER PRICE INCREASE, INDUSTRIAL.,	1.0000
	DEFCC	DEFLATOR, CONSTRUCTION COSTS.....,	1.0000
	DEFOMC	DEFLATOR, OPER.) MAIN. COSTS.....,	1.0000
AWT	OPTN2	TREAT EFFLUENT (0=NO, 1=YES).....,	0
	RITL	RECYCLE ITTERRATION LIMIT.....,	5
	PT1	PROCESS TYPE, LEVEL 1.....,	4
	PT2	PROCESS TYPE, LEVEL 2.....,	1
	PT3	PROCESS TYPE, LEVEL 3.....,	3
	LDR1	PERCENT DEMAND RETURNED, LEVEL 1..,	.8000
	LDR2	PERCENT DEMAND RETURNED, LEVEL 2..,	.8000
	LDR3	PERCENT DEMAND RETURNED, LEVEL 3..,	.8000
	LDR4	PERCENT DEMAND RETURNED, LEVEL 4..,	.8000
	LL(1)	PERCENT CONSUMPTION, COAG) SED...,	.0300
	LL(2)	PERCENT CONSUMPTION, FILTRATION...,	.0300
	LL(3)	PERCENT CONSUMPTION, G. CARB. A. .,	.0300
	LL(4)	PERCENT CONSUMPTION, ACT. SLUDGE..,	.0300

*****PARAMETER LIST*****

ITEM	VARIABLE	DESCRIPTION	VALUE
OTHER	R(1)	INTEREST RATE 1.....,	.0575
	R(2)	INTEREST RATE 2.....,	.0800
	R(3)	INTERFST RATE 3.....,	.120D
EDIT	IDSNQ	INTERMEDIATE DATA, STREAM NET FLOW,	0
	FREQ	FREQUENCY OF IDSNQ PRINTOUT .....,	5
	OCII	DATA CARD TYPE II PRINTOUT.....,	0
	DCIII	DATA CARD TYPE III PRINTOUT.....,	0
	DCIV	DATA CARD TYPE IV PRINTOUT.....,	0
	DCV	DATA CARD TYPE V PRINTOUT.....,	0
	DCVI	OATA CARD TYPE VI PRINTOUT.....,	1
	DCVII	DATA CARD TYPE VII PRINTOUT.....,	0
	DCVIII	DATA CARD TYPE VIII PRINTOUT.....,	0
	DCIX	DATA CARD TYPE IX PRINTOUT.....,	0
	DCX	DATA CARO TYPE X PRINTOUT.....,	0
	DCXI	OATA CARD TYPE XI PRINTOUT.....,	0
	DCXII	DATA CARD TYPE XII PRINTOUT.....,	0
	GRAPH	PUNCH DATA FDR GRAPH PROGRAM.....,	0

******** DUMP OF THE PLANNING MATRIX ********

FILE NO	NUMBER ENTRYS	FIRST ENTRY	LAST-ENTRY
1	13	1	13
2	-1	0	0
3	3	14	16
4	28	17	44
5	6	45	50
6	-1	0	0

COLM	PLAN	TIME	LAGS	CODE	ATTR 1	ATTR 2	ATTR 3	SUCCES	PREOCS
1	104	179	-0	4	1	900	-0	2	7777
2	104	179	-0	4	2	900	-0	3	1
3	104	179	-0	4	3	900	-0	4	2
4	104	179	-0	4	4	900	-0	5	3
5	104	179	-0	4	5	800	-0	6	4
6	104	179	-0	4	6	700	-0	7	5
7	104	179	-0	4	7	600	-0	8	6
8	104	179	-0	4	8	700	-0	9	7
9	104	179	-0	4	9	700	-0	10	8
10	104	179	-0	4	10	800	-0	11	9
11	104	179	-0	4	11	800	-0	12	10
12	104	179	-0	4	12	800	-0	13	11
13	104	179	-0	9	8	520	-0	9999	12
14	301	65	-0	2	5	2	200	15	7777
15	302	95	-0	2	5	2	400	16	14
16	303	144	-0	2	5	2	500	9999	15
17	471	23	-0	6	38	-0	-0	18	7777
18	481	23	-0	7	40	-0	-0	19	17
19	482	83	-0	7	30	-0	-0	20	18
20	472	86	-0	6	28	-0	-0	21	19
21	473	143	-0	6	23	-0	-0	22	20
22	483	143	-0	7	25	-0	-0	23	21
23	410	144	-0	1	900	-0	-0	24	22
24	411	144	-0	2	750	-0	-0	25	23
25	412	144	-0	3	750	-0	-0	26	24
26	413	180	-0	1	1000	-0	-0	27	25
27	415	180	-0	3	800	-0	-0	28	26
28	474	203	-0	6	18	-0	-0	29	27
29	484	203	-0	7	20	-0	-0	30	28
30	416	216	-0	1	1200	-0	-0	31	29
31	475	263	-0	6	13	-0	-0	32	30
32	485	263	-0	7	15	-0	-0	33	31
33	418	276	-0	1	1600	-0	-0	34	32
34	419	276	-0	2	1600	-0	-0	35	33
35	420	276	-0	3	1000	-0	-0	36	34
36	476	323	-0	6	9	-0	-0	37	35
37	486	323	-0	7	10	-0	-0	38	36
38	421	350	-0	1	2000	-0	-0	39	37
39	422	350	-0	2	2000	-0	-0	40	38
40	423	350	-0	3	2000	-0	-0	41	39

COLM	PLAN	TIME	LAGS	CODE	ATTR 1	ATTR 2	ATTR 3	SUCCES	PREDCS
41	487	383	-0	7	5	-0	-0	42	40
42	424	450	-0	1	2500	-0	-0	43	41
43	425	450	-0	2	2500	-0	-0	44	42
44	426	450	-0	3	1500	-0	-0	9999	43
45	501	888	24	1	1	-0	-0	46	7777
46	502	-0	24	6	6	-0	-0	47	45
47	503	888	24	1	1	-0	-0	48	46
48	504	888	24	6	3	-0	-0	49	47
49	505	888	24	2	41755	40000	50000	50	48
50	506	-0	24	7	6	-0	-0	9999	49
51	-0	-0	-0	-0	-0	-0	-0	0	0
52	0	0	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	0
57	0	0	0	0	0	0	0	0	0
58	0	0	0	0	0	0	0	0	0
59	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0
61	0	0	0	0	0	0	0	0	0
62	0	0	0	0	0	0	0	0	0
63	0	0	0	0	0	0	0	0	0
64	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0	0
66	0	0	0	0	0	0	0	0	0
67	0	0	0	0	0	0	0	0	0
68	0	0	0	0	0	0	0	0	0
69	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0
71	0	0	0	0	0	0	0	0	0
72	0	0	0	0	0	0	0	0	0
73	0	0	0	0	0	0	0	0	0
74	0	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	0	0
76	0	0	0	0	0	0	0	0	0
77	0	0	0	0	0	0	0	0	0
78	0	0	0	0	0	0	0	0	0
79	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0

ANNUAL SUMMARY OF WATER OEMAND BY ALL USERS

		D O M E S T I C								I N D U S T R L L		
YEAR	PERCENT RESTRICTIN OF OEMANO	TOTAL WATER USE (MG)	POPULATION THOUSANDS	PER CAPITA WATER USE (G)	PRICE WINTER $/1000	PRICE SUMMER $/1000	RAIN- FALLS IN	TOTAL REVENUE 1000$	REVENUE LOST/RS $	TOTAL WATER USE (MG)	EMPLOYMENT THOUSANOS	PER CAPITA WATER USE (G)
1974	0.0	5144.	186.	28.	.717	.717	13.1	3687.9	0.0	1833.	8.	217.
1975	0.0	5073.	196.	26.	.717	.717	21.1	3637.6	0.0	1818.	9.	204.
1976	0.0	6321.	205.	31.	.717	.717	10.7	4532.1	0.0	1892.	9.	203.
1977	0.0	5823.	216.	27.	.717	.717	24.1	4175.0	0.0	1955.	10.	201.
1978	0.0	6703.	226.	30.	.717	.717	13.1	4806.3	0.0	2113.	10.	207.
1979	0.0	7098.	237.	30.	.717	.717	12.9	5089.0	0.0	2113.	11.	198.
1980	0.0	7388.	248.	30.	.717	.717	14.4	5297.5	0.0	2131.	11.	191.
1981	0.0	7208.	257.	28.	.717	.717	15.9	5168.0	0.0	2214.	12.	191.
1982	0.0	8181.	267.	31.	.717	.717	9.7	5865.4	0.0	2351.	12.	197.
1983	0.0	8355.	277.	30.	.717	.717	14.5	5990.5	0.0	2401.	12.	194.
1984	0.0	7665.	287.	27.	.717	.717	20.5	5495.8	0.0	2369.	13.	185.
1985	0.0	9176.	297.	31.	.900	.717	13.6	6686.6	0.0	2442.	13.	185.
1986	0.0	8862.	306.	29.	.900	.900	14.6	7975.6	0.0	2464.	14.	181.
1987	0.0	9734.	315.	31.	.900	.900	11.2	8761.0	0.0	2561.	14.	183.
1988	0.0	9491.	325.	29.	1.000	.900	17.3	8630.5	0.0	2636.	14.	184.
1989	0.0	8990.	335.	27.	1.000	1.000	18.3	8990.0	0.0	2649.	15.	180.
1990	0.0	10287.	345.	30.	1.000	1.000	11.6	10287.4	0.0	2714.	15.	179.
1991	0.0	11859.	353.	34.	1.200	1.000	8.7	12049.8	0.0	2830.	15.	183.
1992	0.0	11176.	362.	31.	1.200	1.200	10.4	13411.1	0.0	2804.	16.	177.
1993	0.0	10563.	370.	29.	1.200	1.200	14.2	12675.0	0.0	2815.	16.	174.
1994	0.0	10429.	379.	27.	1.200	1.200	19.3	12514.7	0.0	2915.	17.	177.
1995	0.0	11848.	388.	31.	1.200	1.200	11.9	14217.5	0.0	3028.	17.	180.
1996	0.0	12444.	395.	31.	1.600	1.200	10.6	15315.4	0.0	3070.	17.	179.
1997	0.0	12232.	402.	30.	1.600	1.600	13.2	19570.7	0.0	3004.	17.	173.
1998	0.0	12273.	410.	30.	1.600	1.600	14.9	19637.2	0.0	2942.	18.	167.
1999	0.0	12936.	417.	31.	1.600	1.600	12.8	20697.8	0.0	3081.	18.	172.
2000	0.0	12987.	424.	31.	1.600	1.600	8.7	20778.7	0.0	3150.	18.	173.
2001	0.0	12756.	429.	30.	1.600	1.600	15.4	20409.9	0.0	3154.	18.	171.
2002	0.0	13912.	434.	32.	1.600	1.600	11.1	22258.4	0.0	3222.	19.	173.
2003	0.0	13115.	440.	30.	2.000	2.000	14.2	25792.8	0.0	3200.	19.	170.
2004	0.0	13595.	445.	31.	2.000	2.000	12.5	27189.6	0.0	3275.	19.	172.
2005	0.0	13041.	450.	29.	2.000	2.000	15.0	26081.4	0.0	3322.	19.	173.
2006	0.0	13147.	453.	29.	2.000	2.000	11.9	26293.7	0.0	3342.	19.	172.
2007	0.0	13981.	455.	31.	2.000	2.000	15.8	27961.8	0.0	3377.	20.	172.
2008	0.0	13227.	458.	29.	2.000	2.000	15.8	26454.7	0.0	3457.	20.	174.
2009	0.0	14254.	461.	31.	2.000	2.000	10.2	28508.1	0.0	3560.	20.	177.
2010	0.0	14345.	464.	31.	2.000	2.000	10.0	28689.6	0.0	3535.	20.	174.
2011	0.0	13987.	466.	30.	2.500	2.500	12.7	32206.5	0.0	3551.	21.	173.
2012	0.0	14387.	469.	31.	2.500	2.500	6.7	35968.6	0.0	3564.	21.	172.
2013	0.0	13758.	472.	29.	2.500	2.500	17.3	34394.7	0.0	3635.	21.	173.
2014	0.0	15199.	475.	32.	2.500	2.500	7.8	37998.5	0.0	3684.	21.	174.
2015	0.0	14499.	478.	30.	2.500	2.500	17.2	36247.2	0.0	3737.	21.	175.
2016	0.0	14504.	481.	30.	2.500	2.500	14.5	36260.4	0.0	3694.	22.	171.
2017	0.0	14527.	484.	30.	2.500	2.500	12.1	36317.8	0.0	3824.	22.	175.
2018	0.0	15035.	486.	31.	2.500	2.500	10.8	37586.8	0.0	3840.	22.	174.
2019	0.0	13403.	489.	27.	2.500	2.500	21.0	33508.5	0.0	3862.	22.	173.
2020	0.0	14686.	492.	30.	2.500	2.500	14.1	36714.2	0.0	4010.	23.	177.
2021	0.0	15246.	495.	31.	2.500	2.500	7.6	38114.8	0.0	4004.	23.	175.
2022	0.0	15104.	498.	30.	2.500	2.500	14.6	37759.3	0.0	4063.	23.	176.
2023	0.0	15497.	501.	31.	2.500	2.500	13.2	38741.3	0.0	4041.	23.	173.

ANNUAL SUMMARY OF WATER DEMAND BY ALL USERS

I A L				C O M M E R C I A L						M I L I T A R Y				L
PRICE WINTER $/1000	PRICE SUMMER $/1000	TOTAL REVENUE 1000$	REVENUE LOST/RS $	TOTAL WATER USE (MG)	PER CAPITA WATER USE (G)	PRICE WINTER $/1000	PRICE SUMMER $/1000	TOTAL REVENUE 1000$	REVENUE LOST/RS $	TOTAL WATER USE (MG)	PRICE $/1000	TOTAL REVENUE 1000$	REVENUE LOST/RS $	L
.400	.400	733.2	0.0	2267.	12.	.717	.717	1625.5	0.0	2531.	.666	1685.6	0.0	
.400	.400	727.3	0.0	2862.	15.	.717	.717	2051.9	0.0	2594.	.666	1727.5	0.0	
.400	.400	756.6	0.0	3397.	17.	.717	.717	2435.6	0.0	2651.	.666	1765.3	0.0	
.400	.400	782.0	0.0	3653.	17.	.717	.717	2619.3	0.0	2658.	.666	1770.0	0.0	
.400	.400	845.0	0.0	3830.	17.	.717	.717	2746.4	0.0	3058.	.666	2036.4	0.0	
.400	.400	845.2	0.0	4250.	18.	.717	.717	3047.3	0.0	2792.	.666	1859.4	0.0	
.400	.400	852.5	0.0	4590.	18.	.717	.717	3291.0	0.0	3062.	.666	2039.3	0.0	
.400	.400	885.7	0.0	4597.	18.	.717	.717	3295.9	0.0	3180.	.666	2117.7	0.0	
.400	.400	940.5	0.0	5052.	19.	.717	.717	3622.1	0.0	3006.	.666	2002.3	0.0	
.400	.400	960.3	0.0	6002.	22.	.717	.717	4303.1	0.0	3144.	.666	2093.8	0.0	
.400	.400	947.4	0.0	5596.	20.	.717	.717	4012.4	0.0	2915.	.666	1941.2	0.0	
.750	.400	1048.7	0.0	5955.	20.	.900	.717	4366.6	0.0	3669.	.750	2470.6	0.0	
.750	.750	1847.9	0.0	6103.	20.	.900	.900	5493.1	0.0	3516.	.750	2637.3	0.0	
.750	.750	1920.9	0.0	6607.	21.	.900	.900	5946.7	0.0	3553.	.750	2664.6	0.0	
.750	.750	1977.2	0.0	6287.	19.	1.000	.900	5704.2	0.0	3614.	.800	2724.6	0.0	
.750	.750	1986.4	0.0	7011.	21.	1.000	1.000	7010.7	0.0	3780.	.800	3023.7	0.0	
.750	.750	2035.5	0.0	7628.	22.	1.000	1.000	7627.9	0.0	3876.	.800	3101.0	0.0	
.750	.750	2122.7	0.0	7716.	22.	1.200	1.000	7835.5	0.0	3826.	.800	3060.8	0.0	
.750	.750	2103.3	0.0	7463.	21.	1.200	1.200	8955.4	0.0	3957.	.800	3165.5	0.0	
.750	.750	2111.5	0.0	7855.	21.	1.200	1.200	9426.4	0.0	4385.	.800	3508.2	0.0	
.750	.750	2186.5	0.0	7898.	21.	1.200	1.200	9477.4	0.0	4001.	.800	3200.8	0.0	
.750	.750	2271.1	0.0	8593.	22.	1.200	1.200	10311.8	0.0	4335.	.800	3468.0	0.0	
1.600	.750	2502.9	0.0	8576.	22.	1.600	1.200	10569.2	0.0	4453.	1.000	3634.2	0.0	
1.600	1.600	4807.1	0.0	8080.	20.	1.600	1.600	12928.5	0.0	4389.	1.000	4388.7	0.0	
1.600	1.600	4706.8	0.0	8332.	20.	1.600	1.600	13330.6	0.0	4693.	1.000	4692.9	0.0	
1.600	1.600	4929.9	0.0	8844.	21.	1.600	1.600	14150.2	0.0	4610.	1.000	4609.5	0.0	
1.600	1.600	5040.4	0.0	8638.	20.	1.600	1.600	13821.4	0.0	4506.	1.000	4506.1	0.0	
1.600	1.600	5046.1	0.0	8315.	19.	1.600	1.600	13304.7	0.0	4722.	1.000	4722.3	0.0	
1.600	1.600	5155.3	0.0	8837.	20.	1.600	1.600	14138.6	0.0	4933.	1.000	4932.7	0.0	
2.000	2.000	6292.0	0.0	7807.	18.	2.000	2.000	15334.8	0.0	5152.	2.000	9874.4	0.0	
2.000	2.000	6550.7	0.0	8190.	18.	2.000	2.000	16380.1	0.0	4995.	2.000	9990.8	0.0	
2.000	2.000	6644.1	0.0	8695.	19.	2.000	2.000	17390.7	0.0	5215.	2.000	10430.0	0.0	
2.000	2.000	6683.8	0.0	8701.	19.	2.000	2.000	17402.5	0.0	5634.	2.000	11268.3	0.0	
2.000	2.000	6754.9	0.0	8680.	19.	2.000	2.000	17359.3	0.0	5260.	2.000	10519.6	0.0	
2.000	2.000	6913.6	0.0	7845.	17.	2.000	2.000	15690.9	0.0	5345.	2.000	10690.8	0.0	
2.000	2.000	7119.9	0.0	8402.	18.	2.000	2.000	16804.6	0.0	5846.	2.000	11692.6	0.0	
2.000	2.000	7070.5	0.0	8211.	18.	2.000	2.000	16422.1	0.0	5424.	2.000	10848.1	0.0	
2.500	2.500	8136.0	0.0	7869.	17.	2.500	2.500	17853.6	0.0	5864.	2.000	9974.4	0.0	
2.500	2.500	8909.9	0.0	7927.	17.	2.500	2.500	19818.7	0.0	5983.	1.500	8974.2	0.0	
2.500	2.500	9088.4	0.0	6294.	13.	2.500	2.500	15734.3	0.0	5729.	1.500	8593.1	0.0	
2.500	2.500	9210.5	0.0	7518.	16.	2.500	2.500	18795.8	0.0	5915.	1.500	8872.3	0.0	
2.500	2.500	9343.3	0.0	7352.	15.	2.500	2.500	18380.8	0.0	5927.	1.500	8890.5	0.0	
2.500	2.500	9234.5	0.0	7198.	15.	2.500	2.500	17994.0	0.0	6217.	1.500	9326.0	0.0	
2.500	2.500	9560.8	0.0	7256.	15.	2.500	2.500	18140.8	0.0	6166.	1.500	9248.7	0.0	
2.500	2.500	9599.7	0.0	7440.	15.	2.500	2.500	18599.0	0.0	6420.	1.500	9630.2	0.0	
2.500	2.500	9654.9	0.0	7399.	15.	2.500	2.500	18496.4	0.0	6454.	1.500	9681.7	0.0	
2.500	2.500	10023.9	0.0	7298.	15.	2.500	2.500	18244.9	0.0	6432.	1.500	9648.5	0.0	
2.500	2.500	10010.5	0.0	7092.	14.	2.500	2.500	17729.5	0.0	6578.	1.500	9866.6	0.0	
2.500	2.500	10156.7	0.0	6419.	13.	2.500	2.500	16047.9	0.0	6764.	1.500	10146.6	0.0	
2.500	2.500	10103.4	0.0	6899.	14.	2.500	2.500	17246.8	0.0	6737.	1.500	10105.7	0.0	

ANNUAL SUMMARY OF WATER DEMAND BY ALL USERS

MUNICIPAL				NON POTABLE							
TOTAL WATER USE (MG)	PRICE $/1000	TOTAL REVENUE 1000$	REVENUE LOST/RS $	TOTAL WATER USE (MG)	PRICE $/1000	TOTAL REVENUE 1000$	REVENUE LOST/RS $	COMBINED WATER USE (MG)	COMBINED REVENUES 1000$	COMBINED LOST/RES $	YEAR
2717.	0.000	0.0	0.0	0.	.270	0.0	0.0	14492.	7732.	0.	1974
3276.	0.000	0.0	0.0	0.	.270	0.0	0.0	15624.	8144.	0.	1975
2551.	0.000	0.0	0.0	0.	.270	0.0	0.0	16812.	9490.	0.	1976
3177.	0.000	0.0	0.0	0.	.270	0.0	0.0	17266.	9346.	0.	1977
3253.	0.000	0.0	0.0	0.	.270	0.0	0.0	18957.	10434.	0.	1978
3127.	0.000	0.0	0.0	0.	.270	0.0	0.0	19380.	10841.	0.	1979
3094.	0.000	0.0	0.0	0.	.270	0.0	0.0	20266.	11480.	0.	1980
3297.	0.000	0.0	0.0	0.	.270	0.0	0.0	20496.	11467.	0.	1981
4526.	0.000	0.0	0.0	0.	.270	0.0	0.0	23116.	12430.	0.	1982
3928.	0.000	0.0	0.0	0.	.270	0.0	0.0	23829.	13348.	0.	1983
3276.	0.000	0.0	0.0	0.	.270	0.0	0.0	21820.	12397.	0.	1984
4007.	0.000	0.0	0.0	0.	.270	0.0	0.0	25248.	14573.	0.	1985
4214.	0.000	0.0	0.0	0.	.270	0.0	0.0	25159.	17954.	0.	1986
3459.	0.000	0.0	0.0	0.	.270	0.0	0.0	25915.	19293.	0.	1987
4284.	0.000	0.0	0.0	0.	.270	0.0	0.0	26313.	19036.	0.	1988
4234.	0.000	0.0	0.0	0.	.270	0.0	0.0	26662.	21011.	0.	1989
3681.	0.000	0.0	0.0	0.	.270	0.0	0.0	28186.	23052.	0.	1990
4688.	0.000	0.0	0.0	0.	.270	0.0	0.0	30918.	25069.	0.	1991
4804.	0.000	0.0	0.0	0.	.270	0.0	0.0	30204.	27635.	0.	1992
4849.	0.000	0.0	0.0	0.	.270	0.0	0.0	30467.	27721.	0.	1993
4556.	0.000	0.0	0.0	0.	.270	0.0	0.0	29799.	27379.	0.	1994
5251.	0.000	0.0	0.0	0.	.270	0.0	0.0	33056.	30268.	0.	1995
5259.	0.000	0.0	0.0	0.	.270	0.0	0.0	33801.	32022.	0.	1996
5121.	0.000	0.0	0.0	0.	.270	0.0	0.0	32826.	41695.	0.	1997
4782.	0.000	0.0	0.0	0.	.270	0.0	0.0	33021.	42367.	0.	1998
5977.	0.000	0.0	0.0	0.	.270	0.0	0.0	35448.	44387.	0.	1999
6073.	0.000	0.0	0.0	0.	.270	0.0	0.0	35355.	44147.	0.	2000
4858.	0.000	0.0	0.0	0.	.270	0.0	0.0	33806.	43483.	0.	2001
6303.	0.000	0.0	0.0	0.	.270	0.0	0.0	37206.	46485.	0.	2002
6002.	0.000	0.0	0.0	0.	.270	0.0	0.0	35276.	57294.	0.	2003
5107.	0.000	0.0	0.0	0.	.270	0.0	0.0	35163.	60111.	0.	2004
5859.	0.000	0.0	0.0	0.	.270	0.0	0.0	36132.	60546.	0.	2005
6105.	0.000	0.0	0.0	0.	.270	0.0	0.0	36929.	61648.	0.	2006
6365.	0.000	0.0	0.0	0.	.270	0.0	0.0	37663.	62596.	0.	2007
6213.	0.000	0.0	0.0	0.	.270	0.0	0.0	36087.	59750.	0.	2008
6747.	0.000	0.0	0.0	0.	.270	0.0	0.0	38810.	64125.	0.	2009
5687.	0.000	0.0	0.0	0.	.270	0.0	0.0	37202.	63030.	0.	2010
6913.	0.000	0.0	0.0	0.	.270	0.0	0.0	38184.	68171.	0.	2011
6430.	0.000	0.0	0.0	0.	.270	0.0	0.0	38292.	73671.	0.	2012
6824.	0.000	0.0	0.0	0.	.270	0.0	0.0	36239.	67810.	0.	2013
6361.	0.000	0.0	0.0	0.	.270	0.0	0.0	38678.	74877.	0.	2014
7061.	0.000	0.0	0.0	0.	.270	0.0	0.0	38577.	72862.	0.	2015
8002.	0.000	0.0	0.0	0.	.270	0.0	0.0	39615.	72815.	0.	2016
7047.	0.000	0.0	0.0	0.	.270	0.0	0.0	38821.	73268.	0.	2017
6912.	0.000	0.0	0.0	0.	.270	0.0	0.0	39646.	75416.	0.	2018
7427.	0.000	0.0	0.0	0.	.270	0.0	0.0	38545.	71341.	0.	2019
7890.	0.000	0.0	0.0	0.	.270	0.0	0.0	40316.	74632.	0.	2020
7977.	0.000	0.0	0.0	0.	.270	0.0	0.0	40897.	75721.	0.	2021
7662.	0.000	0.0	0.0	0.	.270	0.0	0.0	40012.	74110.	0.	2022
8492.	0.000	0.0	0.0	0.	.270	0.0	0.0	41665.	76197.	0.	2023

ANNUAL SUMMARY OF SUPPLY IN STORAGE

YEAR	RESERVOIR LEVEL (000) AF	PERCENT MAX CAPACITY ON JAN 1	MAX CAPACITY TO ANNUAL WATER USE	TOTAL FLOW C.F.S.	PROBABILITY OF TOTAL FLOW
1974	114.	91.	2.82	6106.	.900
1975	121.	96.	2.62	2674.	.909
1976	113.	90.	2.43	5871.	.917
1977	119.	95.	2.37	2297.	.769
1978	115.	92.	2.16	2006.	.714
1979	115.	92.	2.11	3383.	.867
1980	114.	91.	2.02	3575.	.875
1981	113.	90.	2.00	2507.	.706
1982	97.	77.	1.77	1900.	.556
1983	90.	71.	1.72	2126.	.632
1984	111.	89.	1.88	2985.	.800
1985	109.	87.	1.62	2810.	.762
1986	111.	89.	1.63	2399.	.636
1987	93.	74.	1.58	1817.	.435
1988	94.	75.	1.55	2058.	.542
1989	107.	85.	1.53	3944.	.920
1990	110.	87.	1.45	3672.	.885
1991	104.	83.	1.32	4925.	.926
1992	82.	65.	1.35	1988.	.429
1993	104.	82.	1.34	3605.	.828
1994	109.	87.	1.37	2524.	.633
1995	106.	85.	1.24	3008.	.742
1996	89.	71.	1.21	2653.	.625
1997	100.	80.	1.25	4210.	.909
1998	102.	81.	1.24	5347.	.941
1999	102.	81.	1.15	4951.	.914
2000	67.	53.	1.16	1811.	.278
2001	49.	39.	1.21	2153.	.459
2002	30.	24.	1.23	2380.	.447
2003	36.	29.	1.51	2465.	.436
2004	94.	56.	1.84	3062.	.575
2005	85.	51.	1.51	2666.	.439
2006	78.	47.	1.48	2921.	.452
2007	47.	28.	1.45	2402.	.302
2008	53.	32.	1.81	2743.	.432
2009	64.	38.	1.66	3164.	.556
2010	49.	29.	1.62	2250.	.239
2011	41.	24.	1.71	2262.	.234
2012	79.	47.	1.76	4046.	.771
2013	76.	46.	1.50	3659.	.714
2014	96.	57.	1.41	4275.	.820
2015	101.	60.	1.41	3130.	.529
2016	108.	64.	1.38	4164.	.769
2017	95.	57.	1.40	3239.	.566
2018	67.	40.	1.38	2434.	.259
2019	100.	60.	1.56	4347.	.800
2020	63.	38.	1.35	2348.	.214
2021	50.	30.	1.48	2685.	.333
2022	96.	57.	1.64	4957.	.879
2023	94.	56.	1.31	3763.	.678

SUMMARY DF ADVANCED WASTE TREATMENT(AWT) BY DECADE
(IN MILLIDNS DF GALLDNS)

DECADE	CDAGULATIDN) SEDIMENTATIDN	FILTRATIDN	GRANULATED CARB ABSDRPTN	ACTIVATED SLUDGE	IDN EXCHANGE
1	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0
3	10.7	0.0	7.7	18.3	7.5
4	14.0	0.0	13.6	24.4	12.9
5	16.1	0.0	15.6	28.4	15.2

*****STREAM ADDITIONS*****

DATES	STA	STREAM NAME	TYPE
2003/ 0	153	EAGLE RIVER AT RED C	2
2005/ 0	167	CROSS CREEK NR MINT	2

ADVANCED WASTE TREATMENT OPERATION BY YEAR
(IN MILLIONS OF GALLONS)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
RESERVOIR FLOW	475.	512.	551.	566.	622.	635.	663.	672.	758.	781.
-SYSTEM LOSSES	109.	134.	119.	154.	161.	179.	149.	147.	185.	202.
=SECONDARY TREATED FLOW	366.	378.	432.	412.	461.	457.	515.	525.	573.	579.
-LOCAL WATER	143.	122.	143.	142.	204.	205.	211.	219.	246.	237.
-WATER SOLD	7.	8.	10.	9.	8.	8.	10.	10.	11.	11.
-AGRICULTURE USE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW AVAILABLE AT AWT	216.	247.	280.	261.	248.	243.	293.	296.	316.	331.
-CUTBACKS	216.	247.	280.	261.	248.	243.	293.	296.	316.	331.
=FLOW TO AWT, PASS 1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
+FLOW, RECYCLED	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW THRU LEVEL 1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
-CONSUMPTION LEVEL 1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
-DEMAND AT LEVEL 1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
-FLOW RETURNED,STREAMS,T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW THRU LEVEL 2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
-CONSUMPTION LEVEL 2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
-DEMAND AT LEVEL 2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW THRU LEVEL 3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
-CONSUMPTION LEVEL 3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
-DEMAND AT LEVEL 3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW AVAILABLE LEVEL 4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
-RESERVOIR DEMANDS,U	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW THRU LEVEL 4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
-RESERVOIR DEMANDS,T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
-DEMAND AT LEVEL 4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW RETURNED,STREAMS,T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
FLOW RETURNED, USERS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
+CUTBACKS AND EXCESSES	216.	247.	280.	261.	248.	243.	293.	296.	316.	331.
=FLOW RETURNED,STREAMS,U	216.	247.	280.	261.	248.	243.	293.	296.	316.	331.
+FLOW RETURNED,STREAMS,T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW RETURNED,STREAMS,S	216.	247.	280.	261.	248.	243.	293.	296.	316.	331.
CHECK RESULT	216.	247.	280.	261.	248.	243.	293.	296.	316.	331.

ADVANCED WASTE TREATMENT OPERATION BY YEAR
(IN MILLIONS OF GALLONS)

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
RESERVOIR FLOW	715.	828.	824.	850.	862.	874.	924.	1014.	990.	999.
-SYSTEM LOSSES	147.	190.	175.	202.	199.	229.	197.	199.	238.	212.
=SECONDARY TREATED FLOW	568.	639.	649.	647.	664.	645.	727.	815.	753.	787.
-LOCAL WATER	226.	241.	269.	307.	328.	301.	295.	304.	320.	339.
-WATER SOLD	11.	13.	13.	11.	11.	11.	14.	17.	14.	15.
-AGRICULTURE USE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW AVAILABLE AT AWT	331.	385.	368.	329.	325.	333.	417.	495.	419.	434.
-CUTBACKS	331.	385.	368.	329.	325.	333.	417.	495.	419.	434.
=FLOW TO AWT, PASS 1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
+FLOW, RECYCLED	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW THRU LEVEL 1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
-CONSUMPTION LEVEL 1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
-DEMAND AT LEVFL 1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
-FLOW RETURNED,STREAMS,T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW THRU LEVEL 2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
-CONSUMPTION LEVEL 2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
-DEMAND AT LEVEL 2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW THRU LEVEL 3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
-CONSUMPTION LEVEL 3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
-DEMAND AT LEVEL 3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW AVAILABLE LEVEL 4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
-RESERVOIR DEMANDS,U	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW THRU LEVEL 4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
-RESERVOIR DEMANDS,T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
-DEMAND AT LEVEL 4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW RETURNED,STREAMS,T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
FLOW RETURNED, USERS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
+CUTBACKS AND EXCESSES	331.	385.	368.	329.	325.	333.	417.	495.	419.	434.
=FLOW RETURNED,STREAMS,U	331.	385.	368.	329.	325.	333.	417.	495.	419.	434.
+FLOW RETURNED,STREAMS,T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW RETURNED,STREAMS,S	331.	385.	368.	329.	325.	333.	417.	495.	419.	434.
CHECK RESULT	331.	385.	368.	329.	325.	333.	417.	495.	419.	434.

ADVANCED WASTE TREATMENT OPERATION BY YEAR
(IN MILLIONS OF GALLONS)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
RESERVOIR FLOW	977.	1083.	1108.	1077.	1083.	1162.	1159.	1108.	1090.	890.
-SYSTEM LOSSES	229.	270.	270.	258.	252.	262.	296.	263.	291.	164.
=SECONDARY TREATED FLOW	748.	814.	838.	818.	831.	900.	863.	845.	799.	726.
-LOCAL WATER	325.	407.	415.	336.	285.	309.	368.	440.	382.	349.
-WATER SOLD	14.	13.	14.	16.	18.	20.	16.	13.	14.	12.
-AGRICULTURE USE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW AVAILABLE AT AWT	409.	393.	409.	466.	527.	571.	479.	391.	404.	365.
-CUTBACKS	409.	393.	409.	466.	527.	571.	479.	391.	371.	284.
=FLOW TO AWT, PASS 1	0.	0.	0.	0.	0.	0.	0.	0.	33.	81.
+FLOW, RECYCLED	0.	0.	0.	0.	0.	0.	0.	0.	73.	176.
=FLOW THRU LEVEL 1	0.	0.	0.	0.	0.	0.	0.	0.	107.	257.
-CONSUMPTION LEVEL 1	0.	0.	0.	0.	0.	0.	0.	0.	3.	8.
-DEMAND AT LEVEL 1	0.	0.	0.	0.	0.	0.	0.	0.	78.	163.
-FLOW RETURNED,STREAMS,T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW THRU LEVEL 2	0.	0.	0.	0.	0.	0.	0.	0.	26.	87.
-CONSUMPTION LEVEL 2	0.	0.	0.	0.	0.	0.	0.	0.	1.	3.
-DEMAND AT LEVEL 2	0.	0.	0.	0.	0.	0.	0.	0.	12.	39.
=FLOW THRU LEVEL 3	0.	0.	0.	0.	0.	0.	0.	0.	13.	45.
-CONSUMPTION LEVEL 3	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
-DEMAND AT LEVEL 3	0.	0.	0.	0.	0.	0.	0.	0.	2.	8.
=FLOW AVAILABLE LEVEL 4	0.	0.	0.	0.	0.	0.	0.	0.	11.	36.
-RESERVOIR DEMANDS,U	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW THRU LEVEL 4	0.	0.	0.	0.	0.	0.	0.	0.	11.	36.
-RESERVOIR DEMANDS,T	0.	0.	0.	0.	0.	0.	0.	0.	0.	5.
-DEMAND AT LEVEL 4	0.	0.	0.	0.	0.	0.	0.	0.	11.	32.
=FLOW RETURNED,STREAMS,T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
FLOW RETURNED, USERS	0.	0.	0.	0.	0.	0.	0.	0.	9.	16.
+CUTBACKS AND EXCESSES	409.	393.	409.	466.	527.	571.	479.	391.	371.	284.
=FLOW RETURNED,STREAMS,U	409.	393.	409.	466.	527.	571.	479.	391.	379.	300.
+FLOW RETURNED,STREAMS,T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW RETURNED,STREAMS,S	409.	393.	409.	466.	527.	571.	479.	391.	379.	300.
CHECK RESULT	409.	393.	409.	466.	527.	571.	479.	391.	379.	300.

ADVANCED WASTE TREATMENT OPERATIDN BY YEAR
IIN MILLIONS OF GALLONS)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
RESERVOIR FLDW	980.	1185.	1210.	1235.	994.	1081.	1120.	1052.	1022.	1188.
-SYSTEM LOSSES	251.	277.	301.	289.	302.	308.	283.	320.	298.	296.
=SECONDARY TREATED FLOW	728.	908.	909.	946.	691.	773.	837.	732.	723.	892.
-LOCAL WATER	313.	278.	347.	402.	309.	316.	341.	291.	238.	289.
-WATER SOLD	14.	21.	19.	18.	13.	15.	16.	15.	16.	20.
-AGRICULTURE USE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW AVAILABLE AT AWT	402.	609.	544.	525.	369.	442.	480.	427.	470.	583.
-CUTBACKS	353.	609.	544.	525.	316.	387.	436.	363.	405.	583.
=FLOW TD AWT, PASS 1	49.	0.	0.	0.	53.	55.	44.	64.	64.	0.
+FLOW, RECYCLED	99.	0.	0.	0.	114.	115.	78.	127.	135.	0.
=FLOW THRU LEVEL 1	148.	0.	0.	0.	167.	170.	122.	191.	199.	0.
-CONSUMPTION LEVEL 1	4.	0.	0.	0.	5.	5.	4.	6.	6.	0.
-DEMAND AT LEVEL 1	103.	0.	0.	0.	116.	117.	60.	124.	140.	0.
-FLOW RETURNED,STREAMS,T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW THRU LEVEL 2	40.	0.	0.	0.	46.	48.	58.	61.	52.	0.
-CONSUMPTION LEVEL 2	1.	0.	0.	0.	1.	1.	2.	2.	2.	0.
-DEMAND AT LEVEL 2	17.	0.	0.	0.	20.	20.	14.	25.	22.	0.
=FLOW THRU LEVEL 3	22.	0.	0.	0.	25.	26.	43.	35.	29.	0.
-CONSUMPTION LEVEL 3	1.	0.	0.	0.	1.	1.	1.	1.	1.	0.
-DEMAND AT LEVEL 3	2.	0.	0.	0.	3.	3.	3.	3.	3.	0.
=FLOW AVAILABLE LEVEL 4	19.	0.	0.	0.	22.	23.	39.	31.	25.	0.
-RESERVOIR DEMANDS,U	7.	0.	0.	0.	4.	2.	8.	8.	2.	0.
=FLOW THRU LEVEL 4	12.	0.	0.	0.	17.	21.	30.	23.	23.	0.
-RESERVOIR DEMANDS,T	1.	0.	0.	0.	2.	5.	10.	3.	6.	0.
-DEMAND AT LEVEL 4	11.	0.	0.	0.	15.	16.	21.	21.	17.	0.
=FLOW RETURNED,STREAMS,T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
FLOW RETURNED, USERS	8.	0.	0.	0.	9.	10.	0.	10.	11.	0.
+CUTBACKS AND EXCESSES	353.	609.	544.	525.	316.	387.	436.	363.	405.	583.
=FLOW RETURNED,STREAMS,U	361.	609.	544.	525.	325.	397.	436.	374.	417.	583.
+FLOW RETURNED,STREAMS,T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW RETURNED,STREAMS,S	361.	609.	544.	525.	325.	397.	436.	374.	417.	583.
CHECK RESULT	361.	609.	544.	525.	325.	397.	436.	374.	417.	583.

ADVANCED WASTE TREATMENT OPERATION BY YEAR
(IN MILLIONS OF GALLONS)

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
RESERVOIR FLOW	1268.	1265.	1298.	1272.	1299.	1157.	1321.	1229.	1105.	1366.
-SYSTEM LOSSES	310.	290.	329.	306.	333.	321.	311.	273.	317.	340.
=SECONDARY TREATED FLOW	959.	974.	969.	966.	966.	836.	1011.	956.	787.	1026.
-LOCAL WATER	301.	310.	321.	303.	325.	331.	427.	342.	249.	337.
-WATER SOLD	22.	22.	21.	22.	21.	17.	19.	20.	18.	23.
-AGRICULTURE USE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW AVAILABLE AT AWT	636.	642.	626.	641.	620.	487.	564.	593.	521.	667.
-CUTBACKS	636.	642.	626.	641.	620.	447.	564.	543.	451.	667.
=FLOW TO AWT, PASS 1	0.	0.	0.	0.	0.	41.	0.	50.	70.	0.
+FLOW, RECYCLED	0.	0.	0.	0.	0.	84.	0.	88.	141.	0.
=FLOW THRU LEVEL 1	0.	0.	0.	0.	0.	125.	0.	138.	211.	0.
-CONSUMPTION LEVEL 1	0.	0.	0.	0.	0.	4.	0.	4.	6.	0.
-DEMAND AT LEVEL 1	0.	0.	0.	0.	0.	66.	0.	68.	126.	0.
-FLOW RETURNED,STREAMS,T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW THRU LEVEL 2	0.	0.	0.	0.	0.	55.	0.	66.	79.	0.
-CONSUMPTION LEVEL 2	0.	0.	0.	0.	0.	2.	0.	2.	2.	0.
-DEMAND AT LEVEL 2	0.	0.	0.	0.	0.	16.	0.	16.	30.	0.
=FLOW THRU LEVEL 3	0.	0.	0.	0.	0.	37.	0.	48.	46.	0.
-CONSUMPTION LEVEL 3	0.	0.	0.	0.	0.	1.	0.	1.	1.	0.
-DEMAND AT LEVEL 3	0.	0.	0.	0.	0.	3.	0.	3.	5.	0.
=FLOW AVAILABLE LEVEL 4	0.	0.	0.	0.	0.	33.	0.	43.	40.	0.
-RESERVOIR DEMANDS,U	0.	0.	0.	0.	0.	9.	0.	9.	8.	0.
=FLOW THRU LEVEL 4	0.	0.	0.	0.	0.	24.	0.	33.	32.	0.
-RESERVOIR DEMANDS,T	0.	0.	0.	0.	0.	5.	0.	11.	6.	0.
-DEMAND AT LEVEL 4	0.	0.	0.	0.	0.	19.	0.	22.	26.	0.
=FLOW RETURNED,STREAMS,T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
FLOW RETURNED, USERS	0.	0.	0.	0.	0.	0.	0.	0.	8.	0.
+CUTBACKS AND EXCESSES	636.	642.	626.	641.	620.	447.	564.	543.	451.	667.
=FLOW RETURNED,STREAMS,U	636.	642.	626.	641.	620.	447.	564.	543.	459.	667.
+FLOW RETURNED,STREAMS,T	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
=FLOW RETURNED,STREAMS,S	636.	642.	626.	641.	620.	447.	564.	543.	459.	667.
CHECK RESULT	636.	642.	626.	641.	620.	447.	564.	543.	459.	667.

*****INVESTMENT COST SERIES BY YEAR*****
(IN MILLIONS OF DOLLARS)

YEAR	COAGULATION) SEDIMENTATION	FILTRATION	GRANULATED CARB ABSORPTN	ACTIVATED SLUDGE	ION EXCHANGE	TOTAL ALL PROCESSES
1974	0.0	0.0	0.0	0.0	0.0	0.0
1975	0.0	0.0	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0	0.0	0.0
1978	0.0	0.0	0.0	0.0	0.0	0.0
1979	0.0	0.0	0.0	0.0	0.0	0.0
1980	0.0	0.0	0.0	0.0	0.0	0.0
1981	0.0	0.0	0.0	0.0	0.0	0.0
1982	0.0	0.0	0.0	0.0	0.0	0.0
1983	0.0	0.0	0.0	0.0	0.0	0.0
1984	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	0.0	0.0	0.0	0.0	0.0
1986	0.0	0.0	0.0	0.0	0.0	0.0
1987	0.0	0.0	0.0	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.0	0.0	0.0
1989	0.0	0.0	0.0	0.0	0.0	0.0
1990	0.0	0.0	0.0	0.0	0.0	0.0
1991	0.0	0.0	0.0	0.0	0.0	0.0
1992	0.0	0.0	0.0	0.0	0.0	0.0
1993	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0.0	0.0	0.0	0.0
1996	0.0	0.0	0.0	0.0	0.0	0.0
1997	0.0	0.0	0.0	0.0	0.0	0.0
1998	0.0	0.0	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0
2001	0.0	0.0	0.0	0.0	0.0	0.0
2002	.4	0.0	1.7	6.1	.4	8.5
2003	.2	0.0	.3	1.3	.3	2.1
2004	.0	0.0	.5	.5	.3	1.3
2005	0.0	0.0	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0	0.0	0.0
2008	.0	0.0	0.0	.2	0.0	.2
2009	0.0	0.0	0.0	0.0	0.0	0.0
2010	.1	0.0	.3	1.2	.2	1.8
2011	.0	0.0	.0	.1	.0	.1
2012	0.0	0.0	0.0	0.0	0.0	0.0
2013	0.0	0.0	0.0	0.0	0.0	0.0
2014	0.0	0.0	0.0	0.0	0.0	0.0
2015	0.0	0.0	0.0	0.0	0.0	0.0
2016	0.0	0.0	0.0	0.0	0.0	0.0
2017	0.0	0.0	0.0	0.0	0.0	0.0
2018	0.0	0.0	0.0	0.0	0.0	0.0
2019	0.0	0.0	0.0	0.0	0.0	0.0
2020	0.0	0.0	0.0	0.0	0.0	0.0
2021	.1	0.0	.3	1.2	.2	1.8
2022	0.0	0.0	0.0	0.0	0.0	0.0
2023	0.0	0.0	0.0	0.0	0.0	0.0

*****FIXED AND VARIABLE COSTS FOR STREAM,*****
RESERVOIR, WELL, AND PROJECT ADDITIONS
(IN MILLIONS OF DOLLARS)

	FIXED COSTS					VARIABLE COSTS				
YEAR	STREAM	RESERVOIRS	WELL	PROJECTS	TOTAL	STREAM	RESERVOIRS	WELL	PROJECTS	TOTAL
1974	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
1975	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
1976	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
1977	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
1978	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
1979	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
1980	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
1981	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
1982	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
1983	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
1984	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
1985	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
1986	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
1987	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
1988	0.00	0.00	0.00	8.00	8.00	0.000	0.000	0.000	.049	.049
1989	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
1990	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
1991	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
1992	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
1993	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
1994	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
1995	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
1996	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
1997	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
1998	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
1999	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
2000	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
2001	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
2002	6.00	0.00	0.00	0.00	6.00	0.000	0.000	0.000	.049	.049
2003	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
2004	3.00	6.00	0.00	0.00	9.00	0.000	0.000	0.000	.049	.049
2005	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
2006	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
2007	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
2008	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
2009	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
2010	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
2011	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
2012	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
2013	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
2014	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
2015	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
2016	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
2017	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
2018	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
2019	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
2020	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
2021	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
2022	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049
2023	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	.049	.049

PRESENT WORTH OF INVESTMENT COST SERIES
(IN MILLIONS OF DOLLARS)

	CDAGULATION) SEDIMENTATIDN	FILTRATION	GRANULATED CARB ABSORPTN	ACTIVATED SLUDGE	ION EXCHANGE	TOTAL ALL PROCESSES
AT 5.75+	.2	0.0	.5	1.8	.2	2.7
AT 8.00+	.1	0.0	.3	.9	.1	1.4
AT *.00+	.0	0.0	.1	.3	.0	.5

PRESENT WORTH DF FIXED AND VARIABLE COSTS
(IN MILLIONS OF DOLLARS)

	FIXED COSTS					VARIABLE COSTS				
	STREAM	RESERVDIRS	WELL	PROJECTS	TDTAL	STREAM	RESERVOIRS	WELL	PROJECTS	TOTAL
AT 5.75+	1.72	1.06	0.00	3.46	6.23	0.0D	0.00	0.00	.34	.34
AT 8.00+	.92	.55	0.00	2.52	3.99	0.00	0.0D	0.00	.2D	.20
AT *.00+	.31	.18	0.00	1.46	1.95	0.D0	0.00	D.00	.08	.08

PRESENT WORTH OF OPERATION AND MAINTENANCE COSTS
(IN.THOUSANDS.OF.DOLLARS)

	ACTIVATED- SLUDGE	CDAGULATION- SEDIMENTATIN	GRANULATED CARB ABSORP.	ION- EXCHANGE	TOTAL
AT 5.75+	122.	33.	53.	57.	265.
AT 8.00+	58.	16.	25.	27.	125.
AT *.00+	17.	4.	7.	7.	36.

OPERATION AND MAINTENANCE COSTS BY YEAR
(IN.THOUSANDS.OF.DOLLARS)

YEAR	ACTIVATED-SLUDGE	COAGULATION-SEDIMENTATIN	GRANULATED CARB ABSORP.	ION-EXCHANGE	TOTAL COSTS
1974	0.	0.	0.	0.	0.
1975	0.	0.	0.	0.	0.
1976	0.	0.	0.	0.	0.
1977	0.	0.	0.	0.	0.
1978	0.	0.	0.	0.	0.
1979	0.	0.	0.	0.	0.
1980	0.	0.	0.	0.	0.
1981	0.	0.	0.	0.	0.
1982	0.	0.	0.	0.	0.
1983	0.	0.	0.	0.	0.
1984	0.	0.	0.	0.	0.
1985	0.	0.	0.	0.	0.
1986	0.	0.	0.	0.	0.
1987	0.	0.	0.	0.	0.
1988	0.	0.	0.	0.	0.
1989	0.	0.	0.	0.	0.
1990	0.	0.	0.	0.	0.
1991	0.	0.	0.	0.	0.
1992	0.	0.	0.	0.	0.
1993	0.	0.	0.	0.	0.
1994	0.	0.	0.	0.	0.
1995	0.	0.	0.	0.	0.
1996	0.	0.	0.	0.	0.
1997	0.	0.	0.	0.	0.
1998	0.	0.	0.	0.	0.
1999	0.	0.	0.	0.	0.
2000	0.	0.	0.	0.	0.
2001	0.	0.	0.	0.	0.
2002	57.	13.	25.	21.	116.
2003	131.	37.	70.	55.	293.
2004	83.	20.	26.	21.	150.
2005	0.	0.	0.	0.	0.
2006	0.	0.	0.	0.	0.
2007	0.	0.	0.	0.	0.
2008	86.	21.	29.	29.	164.
2009	87.	20.	29.	43.	179.
2010	62.	22.	40.	51.	175.
2011	100.	31.	39.	60.	230.
2012	102.	23.	34.	39.	198.
2013	0.	0.	0.	0.	0.
2014	0.	0.	0.	0.	0.
2015	0.	0.	0.	0.	0.
2016	0.	0.	0.	0.	0.
2017	0.	0.	0.	0.	0.
2018	0.	0.	0.	0.	0.
2019	58.	18.	36.	40.	152.
2020	0.	0.	0.	0.	0.
2021	68.	25.	44.	56.	193.
2022	107.	33.	48.	70.	258.
2023	0.	0.	0.	0.	0.

E V E N T S....

7	1974/ 7	SPILLAGE	134125.14	8511.14	0.00
8	1974/ 8	SPILLAGE	132971.12	7357.12	0.00
18	1975/ 6	SPILLAGE	126417.50	803.50	0.00
19	1975/ 7	SPILLAGE	135638.57	10024.57	0.00
20	1975/ 8	SPILLAGE	134420.35	8806.35	0.00
30	1976/ 6	SPILLAGE	162481.76	36867.76	0.00
31	1976/ 7	SPILLAGE	157686.54	32072.54	0.00
32	1976/ 8	SPILLAGE	137619.10	12005.10	0.00
42	1977/ 6	SPILLAGE	126833.46	1219.46	0.00
43	1977/ 7	SPILLAGE	134086.74	8472.74	0.00
44	1977/ 8	SPILLAGE	131751.40	6137.40	0.00
54	1978/ 6	SPILLAGE	126936.21	1322.21	0.00
55	1978/ 7	SPILLAGE	136200.75	10586.75	0.00
56	1978/ 8	SPILLAGE	127924.63	2310.63	0.00
65	1979/ 5	CO-STANOBY DEMANO MODIFIEO AS SHOWN	301.00	5.00	0.00
66	1979/ 6	SPILLAGE	133225.32	7611.32	0.00
67	1979/ 7	SPILLAGE	138374.57	12760.57	0.00
68	1979/ 8	SPILLAGE	140130.78	14516.78	0.00
78	1980/ 6	SPILLAGE	134275.61	8661.61	0.00
79	1980/ 7	SPILLAGE	143089.71	17475.71	0.00
80	1980/ 8	SPILLAGE	137322.88	11708.88	0.00
91	1981/ 7	SPILLAGE	144150.71	18536.71	0.00
92	1981/ 8	SPILLAGE	126705.20	1091.20	0.00
95	1981/11	CO-STANDBY DEMAND MODIFIED AS SHOWN	302.00	9.00	0.00
128	1984/ 8	SPILLAGE	126728.26	1114.26	0.00
139	1985/ 7	SPILLAGE	136551.61	10937.61	0.00
140	1985/ 8	SPILLAGE	131602.64	5988.64	0.00
144	1986/ 0	CO-STANDBY DEMAND MODIFIED AS SHOWN	303.00	14.00	0.00
152	1986/ 8	SPILLAGE	131390.28	5776.28	0.00
179	1988/11	IMPLEMENTATION OF NEW PROJECT COMPLETED	1.00	900.00	0.00
179	1988/11	IMPLEMENTATION OF NEW PROJECT COMPLETED	2.00	900.00	0.00
179	1988/11	IMPLEMENTATION OF NEW PROJECT COMPLETED	3.00	900.00	0.00
179	1988/11	IMPLEMENTATION OF NEW PROJECT COMPLETED	4.00	900.00	0.00
179	1988/11	IMPLEMENTATION OF NEW PROJECT COMPLETED	5.00	800.00	0.00
179	1988/11	IMPLEMENTATION OF NEW PROJECT COMPLETED	6.00	700.00	0.00
179	1988/11	IMPLEMENTATION OF NEW PROJECT COMPLETED	7.00	600.00	0.00
179	1988/11	IMPLEMENTATION OF NEW PROJECT COMPLETED	8.00	700.00	0.00
179	1988/11	IMPLEMENTATION OF NEW PROJECT COMPLETED	9.00	700.00	0.00
179	1988/11	IMPLEMENTATION OF NEW PROJECT COMPLETED	10.00	800.00	0.00
179	1988/11	IMPLEMENTATION OF NEW PROJECT COMPLETED	11.00	800.00	0.00
179	1988/11	IMPLEMENTATION OF NEW PROJECT COMPLETED	12.00	800.00	0.00
187	1989/ 7	SPILLAGE	131855.60	6241.60	0.00
188	1989/ 8	SPILLAGE	127926.50	2312.50	0.00
199	1990/ 7	SPILLAGE	136569.30	10955.30	0.00
200	1990/ 8	SPILLAGE	132925.55	7311.55	0.00
212	1991/ 8	SPILLAGE	134554.13	8940.13	0.00
247	1994/ 7	SPILLAGE	129236.23	3622.23	0.00
283	1997/ 7	SPILLAGE	141550.29	15936.29	0.00
284	1997/ 8	SPILLAGE	131084.54	5470.54	0.00
296	1998/ 8	SPILLAGE	134179.74	8565.74	0.00
307	1999/ 7	SPILLAGE	128597.96	2983.96	0.00
308	1999/ 8	SPILLAGE	144331.49	18717.49	0.00
340	2002/ 4	ITTERRATION LIMIT EXCEEOED	2.25	0.00	0.00
341	2002/ 5	ITTERRATION LIMIT EXCEEDEO	.00	.63	.77
342	2002/ 6	ITTERRATION LIMIT EXCEEDEO	.00	.00	.00
348	2003/ 0	IMPLEMENTATION OF NEW STREAM COMPLETED	501.00	324.00	0.00
348	2003/ 0	PLAN FILE 5 EXHAUSTED	0.00	0.00	0.00
349	2003/ 1	ITTERRATION LIMIT EXCEEOED	.00	0.00	.00

350	2003/ 2	ITTERRATION LIMIT EXCEEDED	.00	.00	.00
351	2003/ 3	ITTERRATION LIMIT EXCEEDED	.00	.00	.00
352	2003/ 4	ITTERRATION LIMIT EXCEEDED	0.00	.65	.89
353	2003/ 5	ITTERRATION LIMIT EXCEEDED	.00	1.90	1.05
354	2003/ 6	ITTERRATION LIMIT EXCEEDED	.00	.00	0.00
363	2004/ 3	ITTERRATION LIMIT EXCEEDED	.00	1.43	1.02
364	2004/ 4	ITTERRATION LIMIT EXCEEDED	2.24	0.00	0.00
365	2004/ 5	ITTERRATION LIMIT EXCEEDED	.00	2.61	0.00
372	2005/ 0	IMPLEMENTATION OF NEW STREAM COMPLETED	503.00	348.00	0.00
372	2005/ 0	IMPLEMENTATION OF NEW RESERVOIR COMPLETED	505.00	348.00	94388.34
408	2008/ 0	PLAN FILE 5 EXHAUSTED	0.00	0.00	0.00
411	2008/ 3	ITTERRATION LIMIT EXCEEDED	.63	2.41	0.00
412	2008/ 4	ITTERRATION LIMIT EXCEEDED	.00	2.63	0.00
413	2008/ 5	ITTERRATION LIMIT EXCEEDED	.00	.00	.00
414	2008/ 6	ITTERRATION LIMIT EXCEEDED	.00	0.00	.00
423	2009/ 3	ITTERRATION LIMIT EXCEEDED	.00	2.74	0.00
424	2009/ 4	ITTERRATION LIMIT EXCEEDED	1.81	.94	0.00
425	2009/ 5	ITTERRATION LIMIT EXCEEDED	.00	.00	.03
426	2009/ 6	ITTERRATION LIMIT EXCEEDED	.00	.00	.00
437	2010/ 5	ITTERRATION LIMIT EXCEEDED	.00	.00	.00
447	2011/ 3	ITTERRATION LIMIT EXCEEDED	.00	2.86	0.00
448	2011/ 4	ITTERRATION LIMIT EXCEEDED	.48	2.50	0.00
449	2011/ 5	ITTERRATION LIMIT EXCEEDED	.00	.00	.00
458	2012/ 2	ITTERRATION LIMIT EXCEEDED	2.37	0.00	0.00
459	2012/ 3	ITTERRATION LIMIT EXCEEDED	.00	2.39	.29
460	2012/ 4	ITTERRATION LIMIT EXCEEDED	1.08	1.47	0.00
461	2012/ 5	ITTERRATION LIMIT EXCEEDED	.00	0.00	.00
462	2012/ 6	ITTERRATION LIMIT EXCEEDED	0.00	.00	-.00
545	2019/ 5	ITTERRATION LIMIT EXCEEDED	.00	.00	0.00
546	2019/ 6	ITTERRATION LIMIT EXCEEDED	.00	0.00	.00
569	2021/ 5	ITTERRATION LIMIT EXCEEDED	0.00	.00	.00
579	2022/ 3	ITTERRATION LIMIT EXCEEDED	.00	0.00	.82
580	2022/ 4	ITTERRATION LIMIT EXCEEDED	.00	3.43	0.00
581	2022/ 5	ITTERRATION LIMIT EXCEEDED	0.00	0.00	.00

******** DUMP OF THE PLANNING MATRIX ********

FILE NO	NUMBER ENTRYS	FIRST ENTRY	LAST-ENTRY
1	-1	0	0
2	-1	0	0
3	-1	0	0
4	-1	0	0
5	-1	0	0
6	-1	0	0

COLM	PLAN	TIME	LAGS	CODE	ATTR 1	ATTR 2	ATTR 3	SUCCES	PREDCS
1	0	D	D	0	0	0	D	0	0
2	0	0	0	0	D	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	D	0	0	0	0
5	0	0	0	0	0	D	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0
15	D	D	0	0	D	0	0	0	0
16	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	D	0	0
18	D	0	0	0	0	0	0	0	0
19	D	0	0	0	D	0	0	0	0
20	0	0	D	0	0	0	0	0	0
21	0	0	0	0	D	0	0	0	0
22	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0
24	0	D	D	0	0	0	0	D	0
25	0	0	0	D	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0
28	0	0	0	0	D	0	0	0	0
29	0	0	0	0	0	0	0	D	0
30	0	0	0	0	0	0	D	0	0
31	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0
40	0	D	0	0	0	0	0	0	0

COLM	PLAN	TIME	LAGS	CODE	ATTR 1	ATTR 2	ATTR 3	SUCCES	PREDCS
41	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0
49	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0
51	-0	-0	-0	-0	-0	-0	-0	0	0
52	0	0	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	0
57	0	0	0	0	0	0	0	0	0
58	0	0	0	0	0	0	0	0	0
59	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0
61	0	0	0	0	0	0	0	0	0
62	0	0	0	0	0	0	0	0	0
63	0	0	0	0	0	0	0	0	0
64	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0	0
66	0	0	0	0	0	0	0	0	0
67	0	0	0	0	0	0	0	0	0
68	0	0	0	0	0	0	0	0	0
69	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0
71	0	0	0	0	0	0	0	0	0
72	0	0	0	0	0	0	0	0	0
73	0	0	0	0	0	0	0	0	0
74	0	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	0	0
76	0	0	0	0	0	0	0	0	0
77	0	0	0	0	0	0	0	0	0
78	0	0	0	0	0	0	0	0	0
79	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0

APPENDIX D

SOURCE LISTING OF PROGRAMS

Program SORT

```
      PROGRAM SORT(INPUT,OUTPUT,OLDPL,NEWPL, TAPE5=INPUT,TAPE6=OUTPUT,
     *TAPE14=OLDPL,TAPE15=NEWPL)
      INTEGER STA,YR,TAPE1,TAPE2
      DIMENSION S(600,30),Z(12)
      DATA M,TAPE1,TAPE2/0,14,15/
      READ(5,19) N1,NOSTA,YR
19    FORMAT(3H5)
      N2-N1*12
      DO 26 I-1,2
      DO 23 STA=1,NOSTA
      DO 18 K=1,N1
      NS=1+12*(K-1)
      NF=NS+11
      READ(TAPE1)   (S(MO,STA),MO=NS,NF)
      IF(EOF(TAPE1))24,18
18    CONTINUE
23    CONTINUE
24    DO 25 MO=1,12
      WRITE(TAPE2)   (S(MO,STA),STA=1,NOSTA)
25    CONTINUE
26    CONTINUE
      END FILE TAPE2
      REWIND TAPE2
      WRITE(6,35)
35    FORMAT(1H1)
      DO 30 I=1,2
      DO 30 MO=1,N2
      M=M+1
      IF(M .NE. 13) GO TO 27
      M=1
      YR=YR+1
27    READ(TAPE2)   (S(MO,STA),STA=1,NOSTA)
      IF(EOF(TAPE2)) 31,28
28    WRITE (6,29) YR,M,)S(MO,STA),STA=1,NOSTA)
29    FORMAT(1X,14]H/,12,15(1X,F6.1),/8X,15(1X,F6.1))
30    CONTINUE
31    REWIND TAPE2
      STOP
      END
```

Program RINDEX

```
      PROGRAM RINDEX(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      REAL R(600),RBAR(12)
      INTEGER FYR,YR,ADV
      DATA RBAR/12*0.0/,ADV/0/
      READ (5,20) FYR,NOYRS
20    FORMAT (2I2)
      DO 23 YR=1,NOYRS
      NS=(YR-1)*12+1
      NF=NS+11
      READ(5,21)   (R(I),I=NS,NF)
21    FORMAT(8X,12F6.2)
      DO 22 MO=1,12
      J=NS+MO-1
      RBAR(MO)=RBAR(M()+R(J)
22    CONTINUE
23    CONTINUE
      WRITE(6,29)
29    FORMAT(1H1,//15X,2HMO,5X,10HMEAN  RAIN,//)
      DO 24 MO=1,12
      RBAR(MO)=RBAR(MO)/NOYRS
      WRITE(6,30) MO,RBAR(MO)
30    FORMAT(15X,12,5X,F10.4)
24    CONTINUE
      WRITE(6,25)
25    FORMAT(1H1,//15X,5HYR/MO,10X,10HRAIN INDEX,//)
      DO 28 YR=1,NOYRS
      RI=0.0
      NS=(YR-1)*12+1
      DO 27 MO=1,12
      J=NS+MO-1
      RI=RI+R(J)-RBAR(MO)
      WRITE(6,26) FYR,MO,RI
26    FORMAT(15X,12,1H/,12,10X,F10.4)
27    CONTINUE
      FYR=FYR+1
      ADV=ADV+1
      IF(ADV .LT. 4) GO TO 28
      WRITE(6,25)
      ADV=0
28    CONTINUE
      STOP
      END

      DATA GOES HERE. . . . . . . .
```

Program MASD

```
      PROGRAM MASD (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      REAL X(240,20),Y(240,10),XBAR(10),SD(10)
C
C     PART I: INITIALIZATION
C
      NOBS=144
      NEQ=5
      NIV=13
C
      DO 15 I=1,NOBS
      READ(5,10) (X(I,J),J=1,NIV)
C
C     PART II:  FORMAT FOR INPUT DATA
C
   10 FORMAT(10X,7F10.2,/10X,2F10.0,F10.3,3F10.0)
C
C     PART III: REGRESSION EQUATIONS
C
      Y(1,1)=X(I,1)-(-3.05767-0.00708403*X(I,6)-0.559955*X(I,10)+7.28339
     **X(I,11)+0.0000788865*X(1,9)+0.00474522*X(I,12)-0.0286087*X(I,13))
      Y(I,2)=X(I,2)-(-4.85623-0.0586182*X(I,6)+1.04886*X(I,11)+0.0001455
     *38*X(1,9)-0.0405107*X(1,12))
      Y(1,3)=X(I,3)-(1.08962-0.00550472*X(I,7)+0.520728*X(I,11)-0.000201
     *889*X(I,8)+0.00767182*X(I,12))
      Y(I,4)=X(I,4)-(0.283470+2.26120*X(I,11)+0.0200078*X(I,12))
      Y(1,5)=X(I,5)=(0.915658+0.0240205*X(I,12))
   15 CONTINUE
C
      DO 30 J=1,NEQ
      DO 25 I=1,NOBS
      XBAR(J)=XBAR(J)+Y(I,J)
   25 CONTINUE
      XBAR(J)=XBAR(J)/NOBS
   30 CONTINUE
      DO 40 J=1,NEQ
      DO 35 I=1,NOBS
      SD(J)=SD(J)+(Y(I,J)-XBAR(J))**2
   35 CONTINUE
      SD(J)=SD(J)/(NOBS-1)
      SD(J)=SQRT(SD(J))
   40 CONTINUE
      WRITE(6,45)
   45 FORMAT(1H1)
      DO 55 I=1,NOBS
      WRITE(6,50) (Y(I,J),J=1,NEQ)
   50 FORMAT(10X,10F10.2)
   55 CONTINUE
      WRITE(6,45)
      WRITE(6,60)
   60 FORMAT(//10X,3HEQ.,7X,4HMEAN,12X,9HSTD.DEV.,/)
      DO 70 J=1,NEQ
      WRITE(6,65) J,XBAR(J),SD(J)
   65 FORMAT(10X,I2,2(3X,F15.6))
   70 CONTINUE
      STOP
      END
```

MAIN PROGRAM TINKLE

```
      PROGRAM TINKLE(INPUT,OUTPUT,OLDPL,TAPE5=INPUT,TAPE6=OUTPUT,
     *TAPE15=OLDPL,TAPE7,TAPE16,TAPE17)
      COMMON/IODEV/NR,NP,NC,TAPE1,TAPE2,TAPE3
      COMMON/M/T,YR,MO,YRST,NYRPRJ,RLEVEL,RPOFF,RECYCL,OPTN1,OPTN2,
     *IDSNQ,FREQ,GRAPH,NODYS(12),RIMPRT,RLOCAL
      COMMON/P/LEAK,RLMAX,RCPL,PLEVEL,RRON,PROBL,NO,EXPL,FXPR
      COMMON/S/NSTA,NOSTA,N1,NAS,STNO(40),SNAME(40,5),TYPE(40),
     *NOCUTS(40),PC(40),SEAS1(40,3),SEAS2(40,3),CMIN(40,3),CMAX(40,3),
     *H(60,5),IYR,WELLS(12),PROJCT(12),SKIP
      COMMON/RV/MINQ(40,12),MINQR(12),EVAP(12)
      COMMON/D/PG,EG,DPRICC,DPRII,DEFCC,DEFOMC,PRICEF,PRICEI,PRICEM,
     *PRICEC,PRICEA,POP,EMPLOY,RAIN,RAINAV(12)
      COMMON/AWT/CD(35),DIST(35),ICD(35),ICIST(35),LCD(35),LDIST(35),
     *LDR1,LDR2,LDR3,LDR4,LL(5),NOCD,NCDS,CA(12),PLTQ(12),PLSTQ,PT1,
     *PT2,PT3,PRL,RITL,WQR
      COMMON/OUT/SWD(50,37),SSS(50,5),SAWT(5,5),DATES(10),AWTO(32,50),
     *INVC(50,6),OC(50,5),R(3),OTHRC(50,10)
      COMMON/TMP/IT,NT,TEMP1,TEMP2,X(60)
      REAL     LEAK
      REAL     MINQ,MINQR
      REAL     LDR1,LDR2,LDR3,LDR4,LL
      REAL     INVC
      REAL     SNQ(40),SQ(40),RQIN(2),VC(4,5),AITW(5),AITP(5),AITR(5)
      REAL     QOUT(2)
      INTEGER  TAPE1,TAPE2,TAPE3
      INTEGER  T,YR,MO,YRST,RECYCL,OPTN1,OPTN2,IDSNQ,FREQ,GRAPH
      INTEGER  STNO,TYPE,SEAS1,SEAS2,SKIP
      INTEGER  PT1,PT2,PT3,RITL
      INTEGER  DATES
      INTEGER  XPLN(7),CODE,STA,OFF,ON
      EQUIVALENCE (XPLN(4),CODE)
      DATA SQ12,SQA,AUSE,RQIN,IS,OFF,ON/5*0.0,0,9,1/
      DATA NATW,NATP,NATR,IW,IP,VC/5*0,20*0.0/
      CALL INPUTINCFILE)
      IF(SKIP .EQ. 0)GO TO 33
      NN=SKIP*12
      DO 37 I=1,NN
      READ(TAPE1) RAIN,(SQ(STA),STA=1,NOSTA)
   37 CONTINUE
   38 NN=NYRPRJ*12
      DO 82 T=1,NN
      MO=MO+1
      IF(MO .GT. 12)MO=1
      IF(MO .NE. 1)GO TO 39
      YR=YR+1
   39 READ(TAPE1) RAIN,(SQ(STA),STA=1,NOSTA)
      IF(EOF(TAPE1))83,42
   42 RAIN=RAIN/100.0
      RQIN(1)=WELLS(MO)+PROJCT(MO)
      RQIN(2)=0.0
C     ------------------------------------------------------------------
C     ****** STREAMS
C     REDUCTION OF STREAM FLOWS TO COMPLY WITH
C     1.  WATER LAWS
C     2.  SEASONAL VARIATIONS IN AGRICULTURE
C     3.  PIPELINE CONSTRAINTS
C     4.  UPDATE HISTORICAL DATA ON STREAM FLOWS
C     ------------------------------------------------------------------
      DO 51 STA=1,NSTA
      IT=TYPE(STA)
      NT=NOCUTS(STA)
```

```
      SNQ(STA)=0.0                                                      TNKL062
      DO 50 K=1,NT                                                      TNKL063
      IF(MO .LT. SEAS1(STA,K) .OR. MO .GT. SEAS2(STA,K))GO TO 50        TNKL064
      IF(SQ(STA) .LE. CMIN(STA,K))GO TO 50                              TNKL065
      SNQ(STA)=SNQ(STA)+SQ(STA)-CMIN(STA,K)                             TNKL066
      IF(SQ(STA) .LE. CMAX(STA,K))GO TO 50                              TNKL067
      SNQ(STA)=SNQ(STA)-SQ(STA)+CMAX(STA,K)                             TNKL068
   50 CONTINUE                                                          TNKL069
      IF(SNQ(STA) .GE. PC(STA))SNQ(STA)=PC(STA)                         TNKL070
      RQIN(IT)=RQIN(IT)+SNQ(STA)*1.98346*NODYS(MO)                      TNKL071
   51 CONTINUE                                                          TNKL072
      IF(IDSNQ .EQ. 0)GO TO 53                                          TNKL073
      WRITE(TAPE2) (SNQ(STA),STA=1,NOSTA)                               TNKL074
   53 IF(OPTNI .EQ. 0)GO TO 62                                          TNKL075
      DO 54 STA=1,NSTA                                                  TNKL076
      H(IYR,1)=H(IYR,1)+SQ(STA)                                         TNKL077
   54 CONTINUE                                                          TNKL078
      IF(NI .GT. NOSTA)GO TO 57                                         TNKL079
      DO 55 STA=NI,NOSTA                                                TNKL080
      I=STA-NI+2                                                        TNKL081
      H(IYR,I)=H(IYR,I)+SQ(STA)                                         TNKL082
   55 CONTINUE                                                          TNKL083
   57 DO 56 STA=1,NSTA                                                  TNKL084
      SQA=SQA+SQ(STA)                                                   TNKL085
   56 CONTINUE                                                          TNKL086
C     ------------------------------------------------------------------ TNKL087
C     ******RESERVOIR   ACCOUNTING                                      TNKL088
C                                                                       TNKL089
C     1.  DETERMINE WHETHER TO RECYCLE                                  TNKL090
C     2.  CALCULATE LEAKAGE AND EVAPORATION FROM RESERVOIR              TNKL091
C     3.  PROJECT CURRENT WATER DEMANDS                                 TNKL092
C     4.  CALCULATE NET FLOW FROM RESERVOIRS                            TNKL093
C     5.  EVALUATE NEW RESERVOIR  LEVEL                                 TNKL094
C     6.  CHECK FOR SPILLAGE, DIP INTO CONSERVATION POOL,*RESERVOIR OPY TNKL095
C     ------------------------------------------------------------------ TNKL096
      IF(RLEVEL-PLEVEL)60,62,61                                         TNKL097
   60 IF(RLEVEL .GT. RRON)GO TO 62                                      TNKL098
      IF(RECYCL .LT. 0)RECYCL=0                                         TNKL099
      IF(RECYCL .EQ. OFF)RECYCL=ON                                      TNKL100
      NO=NO+1                                                           TNKL101
      GO TO 62                                                          TNKL102
   61 IF(RLEVEL .LT. RROFF)GO TO 62                                     TNKL103
      IF(RECYCL .EQ. 0)RECYCL=-1                                        TNKL104
      IF(RECYCL .EQ. ON)RECYCL=OFF                                      TNKL105
      NO=0                                                              TNKL106
   62 RLEAK=LEAK*1.98346*NODYS(MO)                                      TNKL107
      REVAP=EVAP(MO)*RLEVEL                                             TNKL108
      PLSTQ=RLOCAL/RLEVEL                                               TNKL109
      CALL DEMAND(QOUT,NOFILE)                                          TNKL110
      QOUT(1)=QOUT(1)*3.07*NODYS(MO)                                    TNKL111
      QOUT(2)=QOUT(2)*3.07*NODYS(MO)                                    TNKL112
      AUSE=AUSE+QOUT(1)+QOUT(2)                                         TNKL113
      PLEVEL=RLEVEL                                                     TNKL114
      RLOCAL=RLOCAL-PLSTQ*(RLEAK+REVAP)+(RQIN(1)-QOUT(1))               TNKL115
      RIMPRT=RIMPRT-(1.0-PLSTQ)*(RLEAK+REVAP)-MINOR(MO)+(RQIN(2)-QOUT(2) TNKL116
     *)                                                                 TNKL117
      IF(RLOCAL .LE. 0.0)RLOCAL=0.0                                     TNKL118
      IF(RIMPRT .LE. 0.0)RIMPRT=0.0                                     TNKL119
      RLEVEL=RLOCAL+RIMPRT                                              TNKL120
      RLMIN=AMIN1(RLMIN,RLEVEL)                                         TNKL121
      IF(RLEVEL .LE. RLMAX)GO TO 63                                     TNKL122
```

```
      TEMP1=RLEVEL-RLMAX                                                TNKL123
      CALL INTRPT(T,1,RLEVEL,TEMP1,0.0)                                 TNKL124
      RLEVEL=RLMAX                                                      TNKL125
      TEMP1=RLOCAL/(RLOCAL+RIMPRT)                                      TNKL126
      RLOCAL=TEMP1*RLEVEL                                               TNKL127
      RIMPRT=RLEVEL-RLOCAL                                              TNKL128
      GO TO 64                                                          TNKL129
   63 IF(RLEVEL .GT. RCPL)GO TO 64                                      TNKL130
      CALL INTRPT(T,2,RLEVEL,RCPL,0.0)                                  TNKL131
      IF(RLEVEL .GT. 0.0)GO TO 64                                       TNKL132
      CALL INTRPT(T,3,RLEVEL,0.0,0.0)                                   TNKL133
      GO TO 83                                                          TNKL134
C     ------------------------------------------------------------------ TNKL135
C     ****** EXPANSION   SCHEDULED COMPLETION OF PLAN                   TNKL136
C                                                                       TNKL137
C     1.IS A RESERVOIR OR STREAM ADDITION SCHEDULED FOR COMPLETION      TNKL138
C     2.  IF SO, PERFORM APPROPRIATE UPDATING                           TNKL139
C     ------------------------------------------------------------------ TNKL140
   64 CALL EXPAND(L,T,XPLN,IR)                                          TNKL141
      IF(IR .EQ. 0)GO TO 77                                             TNKL142
      TEMP1=XPLN(1)                                                     TNKL143
      TEMP2=T-XPLN(3)                                                   TNKL144
      GO TO (71,73,74,75,76,84,85,86,87),CODE                           TNKL145
C     ------------------------------------------------------------------ TNKL146
C     ******STREAM EXPANSION                                            TNKL147
C     ------------------------------------------------------------------ TNKL148
   71 NSTA=NSTA+XPLN(5)                                                 TNKL149
      IT=NAS                                                            TNKL150
      NAS=NAS+XPLN(5)                                                   TNKL151
      NT=NAS-1                                                          TNKL152
      DO 72 K=IT,NT                                                     TNKL153
      DO 72 I=1,12                                                      TNKL154
      MINQR(I)=MINQR(I)+MINQ(K,I)                                       TNKL155
   72 CONTINUE                                                          TNKL156
      IS=IS+1                                                           TNKL157
      DATES(IS)=T                                                       TNKL158
      CALL INTRPT(T,5,TEMP1,TEMP2,0.0)                                  TNKL159
      GO TO 64                                                          TNKL160
C     ------------------------------------------------------------------ TNKL161
C     ******RESERVOIR EXPANSION                                         TNKL162
C     ------------------------------------------------------------------ TNKL163
   73 PLEVEL=RLEVEL                                                     TNKL164
      RLEVEL=RLEVEL+XPLN(5)                                             TNKL165
      RLMAX=RLMAX+XPLN(5)                                               TNKL166
      RIMPRT=RIMPRT+XPLN(5)                                             TNKL167
      RRON=XPLN(6)                                                      TNKL168
      RROFF=XPLN(7)                                                     TNKL169
      CALL INTRPT(T,6,TEMP1,TEMP2,RLEVEL)                               TNKL170
      NATR=NATR+1                                                       TNKL171
      AITR(NATR)=XPLN(5)                                                TNKL172
      GO TO 64                                                          TNKL173
C     ------------------------------------------------------------------ TNKL174
C     ******INCREASE IN WELL FLOWS                                      TNKL175
C     ------------------------------------------------------------------ TNKL176
   74 IT=XPLN(5)                                                        TNKL177
      WELLS(IT)=WELLS(IT)+XPLN(6)                                       TNKL178
      IW=IW+1                                                           TNKL179
      IF(IW .EQ. 1)NATW=NATW+1                                          TNKL180
      AITW(NATW)=AITW(NATW)+XPLN(6)                                     TNKL181
      IF(IW .GE. 12)IW=0                                                TNKL182
      TEMP1=XPLN(5)                                                     TNKL183
```

```
      TEMP2=XPLN(6)                                                     TNKL184
      CALL INTRPT(T,7,TEMP1,TEMP2,0.0)                                  TNKL185
      GO TO 64                                                          TNKL186
C     ------------------------------------------------------------------ TNKL187
C     ******INCREASE IN PROJECT FLOWS                                   TNKL188
C     ------------------------------------------------------------------ TNKL189
   75 IT=XPLN(5)                                                        TNKL190
      PROJCT(IT)=PROJCT(IT)+XPLN(6)                                     TNKL191
      IP=IP+1                                                           TNKL192
      IF(IP .EQ. 1)NATP=NATP+1                                          TNKL193
      AITP(NATP)=AITP(NATP)+XPLN(6)                                     TNKL194
      IF(IP .GE. 12)IP=0                                                TNKL195
      TEMP1=XPLN(5)                                                     TNKL196
      TEMP2=XPLN(6)                                                     TNKL197
      CALL INTRPT(T,8,TEMP1,TEMP2,0.0)                                  TNKL198
      GO TO 64                                                          TNKL199
C     ------------------------------------------------------------------ TNKL200
C     ******FUTURE IMPLEMENTATION OF RECYCLING                          TNKL201
C     ------------------------------------------------------------------ TNKL202
   76 OPTN1=XPLN(5)                                                     TNKL203
      RRON=XPLN(6)                                                      TNKL204
      RROFF=XPLN(7)                                                     TNKL205
      TEMP1=OPTN1                                                       TNKL206
      CALL INTRPT(T,9,TEMP1,RRON,RROFF)                                 TNKL207
      GO TO 64                                                          TNKL208
C     ------------------------------------------------------------------ TNKL209
C     ******CALCULATE FIXED COSTS ON STREAMS, RESERVOIRS, WELLS, AND    TNKL210
C           PROJECTS                                                    TNKL211
C     ------------------------------------------------------------------ TNKL212
   84 IT=NAS-1                                                          TNKL213
      VC(1,IT)=XPLN(6)/100.0                                            TNKL214
      GO TO 88                                                          TNKL215
   85 VC(2,NATR)=XPLN(6)/100.0                                          TNKL216
      GO TO 88                                                          TNKL217
   86 VC(3,NATW)=XPLN(6)/100.0                                          TNKL218
      GO TO 88                                                          TNKL219
   87 VC(4,NATP)=XPLN(6)/100.0                                          TNKL220
   88 IT=CODE-5                                                         TNKL221
      OTHRC(YR,IT)=OTHRC(YR,IT)+XPLN(5)                                 TNKL222
      GO TO 64                                                          TNKL223
C     ------------------------------------------------------------------ TNKL224
C     ******CALCULATE VARIABLE COSTS FOR STREAMS                        TNKL225
C     ------------------------------------------------------------------ TNKL226
   77 IF(NAS .EQ. 1)GO TO 91                                            TNKL227
      K=NAS-1                                                           TNKL228
      IT=NSTA-(K-1)                                                     TNKL229
      DO 90 J=1,K                                                       TNKL230
      IF(VC(1,J) .LE. 0.0)GO TO 90                                      TNKL231
      NT=(IT+(J-1)                                                      TNKL232
      OTHRC(YR,6)=OTHRC(YR,6)+VC(1,J)*SNG(NT)                           TNKL233
   90 CONTINUE                                                          TNKL234
C     ------------------------------------------------------------------ TNKL235
C     ******COLLECT STATISTICS ON ANNUAL SUPPLY IN STORAGE              TNKL236
C     ------------------------------------------------------------------ TNKL237
   91 IF(MO .NE. 12)GO TO 82                                            TNKL238
      SSS(YR,1)=RLEVEL                                                  TNKL239
      SSS(YR,2)=RLEVEL/RLMAX                                            TNKL240
      IF(AUSE .GT. 0.0)SSS(YR,3)=RLMAX/AUSE                             TNKL241
      SSS(YR,4)=SQA                                                     TNKL242
      DO 78 I=1,IYR                                                     TNKL243
      X(I)=0.0                                                          TNKL244
```

```
      DO 78 J=1,NAS                                                     TNKL245
      X(I)=X(I)+H(I,J)                                                  TNKL246
   78 CONTINUE                                                          TNKL247
      NT=IYR-1                                                          TNKL248
      DO 79 I=1,NT                                                      TNKL249
      IT=I+1                                                            TNKL250
      DO 79 J=IT,IYR                                                    TNKL251
      IF(X(J) .LE. X(I))GO TO 79                                        TNKL252
      TEMP1=X(I)                                                        TNKL253
      X(I)=X(J)                                                         TNKL254
      X(J)=TEMP1                                                        TNKL255
   79 CONTINUE                                                          TNKL256
      DO 80 I=1,IYR                                                     TNKL257
      IF(X(I) .GT. SQA)GO TO 80                                         TNKL258
      TEMP1=I-1                                                         TNKL259
      TEMP2=1.0-TEMP1/IYR                                               TNKL260
      GO TO 81                                                          TNKL261
   80 CONTINUE                                                          TNKL262
   81 SSS(YR,5)=TEMP2                                                   TNKL263
C     ---------------------------------------------------               TNKL264
C     ************EXPANSION,DECISION FOR ***************               TNKL265
C     ---------------------------------------------------               TNKL266
      TEMP1=0.0                                                         TNKL267
      IF(RLEVEL.GT.EXPL)GO TO 66                                        TNKL268
      IF(AUSE.GT.0.0)TEMP1=RLMIN/AUSE                                   TNKL269
      IF(TEMP1.GT.EXPR)GO TO 66                                         TNKL270
      IF(TEMP2.LE.PROBL) GO TO 66                                       TNKL271
      CALL SEARCH(T,IFOUND)                                             TNKL272
      IF (IFOUND.EQ.1)GO TO 66                                          TNKL273
   65 CALL EXPAND(5,T,XPLN,IR)                                          TNKL274
      IF(IR.LT.0)GO TO 65                                               TNKL275
   66 RLMIN= 1000000.0                                                  TNKL276
      IYR=IYR+1                                                         TNKL277
      SQA=0.0                                                           TNKL278
      AUSE=0.0                                                          TNKL279
C     ------------------------------------------------------------------ TNKL280
C     ******CALCULATE VARIABLE COSTS FOR RESERVOIRS                      TNKL281
C     ------------------------------------------------------------------ TNKL282
      IF(NATR .EQ. 0)GO TO 93                                           TNKL283
      DO 92 J=1,NATR                                                    TNKL284
      IF(VC(2,J) .LE. 0.0)GO TO 92                                      TNKL285
      OTHRC(YR,7)=OTHRC(YR,7)+VC(2,J)*AITR(J)                           TNKL286
   92 CONTINUE                                                          TNKL287
C     ------------------------------------------------------------------ TNKL288
C     ******CALCULATE VARIABLE COSTS FOR WELLS                           TNKL289
   93 IF(NATW .EQ. 0)GO TO 95                                           TNKL290
      DO 94 J=1,NATW                                                    TNKL291
      IF(VC(3,J) .LE. 0.0)GO TO 94                                      TNKL292
      OTHRC(YR,8)=OTHRC(YR,8)+VC(3,J)*AITW(J)                           TNKL293
   94 CONTINUE                                                          TNKL294
C     ------------------------------------------------------------------ TNKL295
C     ******CALCULATE VARIABLE COSTS FOR PROJECTS                        TNKL296
C     ------------------------------------------------------------------ TNKL297
   95 IF(NATP .EQ. 0)GO TO 82                                           TNKL298
      DO 96 J=1,NATP                                                    TNKL299
      IF(VC(4,J) .LE. 0.0)GO TO 96                                      TNKL300
      OTHRC(YR,9)=OTHRC(YR,9)+VC(4,J)*AITP(J)                           TNKL301
   96 CONTINUE                                                          TNKL302
   82 CONTINUE                                                          TNKL303
   83 CALL OUTPUT(NOFILE)                                               TNKL304
      REWIND TAPE1                                                      TNKL305
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      STOP                                                              TNKL306
      END                                                               TNKL307
      SUBROUTINE DEMAND(QOUT,NOFILE)                                    DMND001
      COMMON/IODEV/NR,NP,NC,TAPEI,TAPE2,TAPE3                           DMND002
      COMMON/M/T,YR,MO,YRST,NYRPRJ,RLEVEL,RRCFF,RECYCL,OPTN1,OPTN2,     DMND003
     *IDSNQ,FREQ,GRAPH,NODYS(12),RIMPRT,RLCCAL                          DMND004
      COMMON/D/PG,EG,DPRIDC,DPRII,DEFCC,DEFDMC,PRICED,PRICEI,PRICEM,    DMND005
     *PRICEC,PRICEN,POP,EMPLOY,RAIN,RAINAVI12)                          DMND006
      COMMON/AWT/CD(35),DIST(35),ICD(35),ICIST(35),LCD(35),LDIST(35),   DMND007
     *LDR1,LDR2,LDR3,LDR4,LL(5),NOCD,NCDS,QA(12),PLTQ(12),PLSTQ,PT1,    DMND008
     *PT2,PT3,PRL,RITL,WQR                                              DMND009
      COMMON/OUT/SWD(50,37),SSS(50,5),SAWT(5,5),DATES(10),AWIO(32,50),  DMND010
     *INVC(50,6),OC(50,5),R(3),DTHRC(50,10)                             DMND011
      COMMON/TMP/IT,NT,TEMP1,TEMP2,X(60)                                DMND012
      REAL     LDR1,LDR2,LDR3,LDR4,LL                                   DMND013
      REAL     INVC                                                     DMND014
      REAL     PEQ1(6),PEQ2(5),PEQ3(5),PEQ4(4),PEQ5(3),MEAN(5),SD(5)    DMND015
      REAL     DL(5),DT(7),Z(19),QOUT(2),Q(4),JANQ,KO                   DMND016
      INTEGER TAPEI,TAPE2,TAPE3                                         DMND017
      INTEGER T,YR,MO,YRST,RECYCL,OPTN1,OPTN2,IDSNQ,FREQ,GRAPH          DMND018
      INTEGER PT1,PT2,PT3,RITL                                          DMND019
      INTEGER DATES                                                     DMND020
      INTEGER XPLN(7),NPS(4),CCDF,CFF,HTC,SW1,SW2,SW3                   DMND021
      EQUIVALENCE  (Z(1),CN1),(Z(2),CN2),(Z(3),CN3),(Z(4),CN4),         DMND022
     *             (Z(5),QR1),(Z(6),QR2),(Z(7),QR3),(Z(8),QR4),         DMND023
     *             (Z(9),QU1),(Z(10),QU2),(Z(11),QU3),(Z(12),QU4),      DMND024
     *             (Z(13),CN1I,(Z(14),CN2I,(Z(15),CN3),(Z(16),QN4),     DMND025
     *             (Z(17),CNRI,(Z(18),QUR),(Z(19),TQIR)                 DMND026
      EQUIVALENCE (XPLN(4),CODE),(COL,STQ,CS,CONS,QN)                   DMND027
      DATA PEQ1/-3.05767,-0.708403,-0.559955,7.288339,0.00007888,       DMND028
     *0.00474522/                                                       DMND029
      DATA PEQ2/-4.85623,-5.86187,1.04886,0.000145533,-0.0405107/       DMND030
      DATA PEQ3/1.08962,-0.550472,0.520728,0.000201889,0.0076718Z/      DMND031
      DATA PEQ4/0.28347,0.0,7.26120,0.0200078/                          DMND032
      DATA PEQ5/0.915658,0.00,0.0240205/                                DMND033
      DATA MEAN/0.000007,0.000048,-0.000003,-0.000005,-0.000004/        DMND034
      DATA SD/2.607066,2.91100),0.385583,1.312117,3.320815/             DMND035
      DATA RINDEX,OFF,KO,HTC/0.0,9,250.0,264/                           DMND036
      SW1=0                                                             DMND037
      SW2=0                                                             DMND038
      QRR=0.0                                                           DMND039
      QOUT(1)=0.0                                                       DMND040
      QOUT(2)=0.0                                                       DMND041
      EXCESS=0.0                                                        DMND042
      VOLR=RLEVEL                                                       DMND043
      DO 2 I=1,4                                                        DMND044
      NPS(I)=0                                                          DMND045
      Q(I)=0.0                                                          DMND046
    2 CONTINUE                                                          DMND047
      DO 63 I=1,19                                                      DMND048
      Z(I)=0.0                                                          DMND049
   63 CONTINUE                                                          DMND050
C     ------------------------------------------------------------------ DMND051
C     ******PROJECT THE INDEPENDENT VARIABLES FOR DEMAND EQS.           DMND052
C     ------------------------------------------------------------------ DMND053
    9 CALL EXPAND(4,T,XPLN,IR)                                          DMND054
      IF(IR .EQ. 0)GO TO 17                                             DMND055
      GO TO (10,11,12,13,14,15,16),CODE                                 DMND056
   10 PRICED=XPLN(5)/1000.0                                             DMND057
      GO TO 9                                                           DMND058
   11 PRICEI=XPLN(5)/1000.0                                             DMND059
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      GO TO 9                                                           DMND060
   12 PRICEM=XPLN(5)/1000.0                                             DMND061
      GO TO 9                                                           DMND062
   13 PRICEC=XPLN(5)/1000.0                                             DMND063
      GO TO 9                                                           DMND064
   14 PRICEN=XPLN(5)/1000.0                                             DMND065
      GO TO 9                                                           DMND066
   15 EG=XPLN(5)/10000.0                                                DMND067
      GO TO 9                                                           DMND068
   16 PG=XPLN(5)/10000.0                                                DMND069
      GO TO 9                                                           DMND070
   17 EMPLOY=(1.0+EG)*EMPLOY                                            DMND071
      POP=(1.0+PG)*POP                                                  DMND072
      SEASON=0                                                          DMND073
      IF(MO .LE. 4 .OR. MO .GE. 10)GO TO 18                             DMND074
      SEASON=1                                                          DMND075
      PRICE1=DPRIDC*PRICEC                                              DMND076
      PRICE2=DPRII*PRICEI                                               DMND077
      SWD(YR,6)=AMAX1(SWD(YR,6),PRICE1)                                 DMND078
      SWD(YR,14)=AMAX1(SWD(YR,14),PRICE2)                               DMND079
      GO TO 19                                                          DMND080
   18 PRICE1=PRICEC                                                     DMND081
      PRICE2=PRICEI                                                     DMND082
      SWD(YR,5)=AMAX1(SWD(YR,5),PRICE1)                                 DMND083
      SWD(YR,13)=AMAX1(SWD(YR,13),PRICE2)                               DMND084
   19 IF(MO .EQ. 1)RINDEX=0.0                                           DMND085
      RINDEX=RINDEX+RAIN-RAINAV(MO)                                     DMND086
      SWD(YR,3)=AMAX1(SWD(YR,3),POP)                                    DMND087
      SWD(YR,7)=SWD(YR,7)+RAIN                                          DMND088
      SWD(YR,11)=AMAX1(SWD(YR,11),EMPLOY)                               DMND089
      SWD(YR,24)=AMAX1(SWD(YR,24),PRICEM)                               DMND090
      SWD(YR,28)=AMAX1(SWD(YR,28),PRICEC)                               DMND091
      SWD(YR,32)=AMAX1(SWD(YR,32),PRICEN)                               DMND092
C     ------------------------------------------------------------------ DMND093
C     ******MODIFY AGGREGRATE WATER DEMANDS   INDUSTRIAL                DMND094
C     ------------------------------------------------------------------ DMND095
      CALL EXPAND(2,T,XPLN,IR)                                          DMND096
      IF(IR .EQ. 0)GO TO 20                                             DMND097
      PEQ3(1)=PEQ3(1)+XPLN(5)                                           DMND098
      X5=XPLN(1)                                                        DMND099
      CALL INTRPT(T,16,X5,PEQ3(1),0.0)                                  DMND100
C     ------------------------------------------------------------------ DMND101
C     ******MODIFY DISTRIBUTION                                         DMND102
C     ------------------------------------------------------------------ DMND103
   20 IF(OPTN1 .EQ. 0)GO TO 30                                          DMND104
   21 CALL EXPAND(3,T,XPLN,IR)                                          DMND105
      IF(IR .EQ. 0)GO TO 30                                             DMND106
      IF(CODE .NE. 1)GO TO 8                                            DMND107
   22 DO 23 I=1,NODS                                                    DMND108
      IF(IDIST(I) .NE. XPLN(5))GO TO 23                                 DMND109
      IF(LDIST(I) .NE. XPLN(6))GO TO 23                                 DMND110
      DIST(I)=XPLN(7)/1000.0                                            DMND111
      GO TO 21                                                          DMND112
   23 CONTINUE                                                          DMND113
      X5=XPLN(5)                                                        DMND114
      X6=XPLN(6)                                                        DMND115
      X7=XPLN(7)/1000.0                                                 DMND116
      CALL INTRPT(T,13,X5,X6,X7)                                        DMND117
C     ------------------------------------------------------------------ DMND118
C     ******MODIFY CONTINUOUS DEMANDS                                   DMND119
C     ------------------------------------------------------------------ DMND120
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   24 CALL EXPAND(3,T,XPLN,IR)                                          DMND121
      IF(IR .EQ. 0)GO TO 30                                             DMND122
    8 GO TO (22,25,27),CODE                                             DMND123
   25 DO 26 I=1,NOCD                                                    DMND124
      IF(ICD(I) .NE. XPLN(5))GO TO 26                                   DMND125
      IF(LCD(I) .NE. XPLN(6))GO TO 26                                   DMND126
      CD(I)=CD(I)+XPLN(7)/100.0                                         DMND127
      X5=XPLN(1)                                                        DMND128
      CALL INTRPT(T,17,X5,CD(I),0.0)                                    DMND129
      GO TO 24                                                          DMND130
   26 CONTINUE                                                          DMND131
      X5=XPLN(5)                                                        DMND132
      X6=XPLN(6)                                                        DMND133
      X7=XPLN(7)                                                        DMND134
      CALL INTRPT(T,14,X5,X6,X7)                                        DMND135
      GO TO 30                                                          DMND136
   27 NOCD=NOCD+1                                                       DMND137
      IF(NOCD .EQ. 1)RECYCL=-1                                          DMND138
      IF(NOCD .LE. 35)GO TO 28                                          DMND139
      X5=NOCD                                                           DMND140
      CALL INTRPT(T,15,X5,0.0,0.0)                                      DMND141
      GO TO 30                                                          DMND142
   28 ICD(NOCD)=XPLN(5)                                                 DMND143
      LCD(NOCD)=XPLN(6)                                                 DMND144
      CD(NOCD)=XPLN(7)/100.0                                            DMND145
      X5=XPLN(1)                                                        DMND146
      CALL INTRPT(T,18,X5,CD(NOCD),0.0)                                 DMND147
      GO TO 24                                                          DMND148
C     ------------------------------------------------------------------ DMND149
C     ******PROJECT AGGREGATE WATER DEMANDS                              DMND150
C     ------------------------------------------------------------------ DMND151
   30 DT(1)=PEQ1(1)+PEQ1(2)*PRICE1+PEQ1(3)*RINCEX+PEQ1(4)*SEASON        DMND152
     *       +PEQ1(5)*POP+PEQ1(6)*(T+HTC)+RNORM(MEAN(1),SD(1))          DMND153
      DT(2)=PEQ2(1)+PEQ2(2)*PRICE1+PEQ2(3)*SEASON+PEQ2(4)*POP           DMND154
     *       +PEQ2(5)*(T+HTC)+RNORM(MEAN(2),SD(2))                      DMND155
      DT(3)=PEQ3(1)+PEQ3(2)*PRICE2+PEQ3(3)*SEASON+PEQ3(4)*EMPLOY        DMND156
     *       +PEQ3(5)*(T+HTC)+RNORM(MEAN(3),SD(3))                      DMND157
      DT(4)=PEQ4(1)+PEQ4(2)*PRICEM+PEQ4(3)*SEASON+PEQ4(4)*(T+HTC)       DMND158
     *       +RNORM(MEAN(4),SD(4))                                      DMND159
      DT(5)=PEQ5(1)+PEQ5(2)*PRICEC+PEQ5(3)*(T+HTC)+RNORM(MEAN(5),SD(5)) DMND160
      DT(6)=0.0                                                         DMND161
      DT(7)=0.0                                                         DMND162
      DT(7)=((RROFF-RLEVEL)/NODYS(MO))*0.326                            DMND163
      IF(DT(7) .LE. 0.0)DT(7)=0.0                                       DMND164
      IF(RECYCL .EQ. -1)DT(7)=0.0                                       DMND165
      IF(OPTN1 .EQ. 1)GO TO 48                                          DMND166
C     ------------------------------------------------------------------ DMND167
C     ******RATIONING ROUTINE                                            DMND168
C     ------------------------------------------------------------------ DMND169
      IF(DT(7) .LE. 0.0001)GO TO 51                                     DMND170
      TEMP1=DT(1)+DT(2)+DT(3)+DT(4)+DT(5)+DT(6)+DT(7)                   DMND171
      RATION=DT(7)/TEMP1                                                DMND172
      IF(RATION .LT. PRL)GO TO 46                                       DMND173
      CALL INTRPT(T,10,RATION,PRL,0.0)                                  DMND174
      RATION=PRL                                                        DMND175
   46 SWD(YR,1)=AMAX1(SWD(YR,1),RATION)                                 DMND176
      SWD(YR,9)=SWD(YR,9)+RATION*PRICEC*DT(1)*1000.0*NODYS(MO)          DMND177
      SWD(YR,16)=SWD(YR,16)+RATION*PRICEI*DT(3)*1000.0*NODYS(MO)        DMND178
      SWD(YR,22)=SWD(YR,22)+RATION*PRICEC*DT(2)*1000.0*NODYS(MO)        DMND179
      SWD(YR,26)=SWD(YR,26)+RATION*PRICEM*DT(4)*1000.0*NODYS(MO)        DMND180
      SWD(YR,30)=SWD(YR,30)+RATION*PRICEC*DT(5)*1000.0*NODYS(MO)        DMND181
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      DO 47 I=1,5                                                       DMND182
      DT(I)=(1.0-RATION)*DT(I)                                          DMND183
   47 CONTINUE                                                          DMND184
      DL(1)=DT(6)+DT(7)                                                 DMND185
      GO TO 51                                                          DMND186
   48 DO 49 L=1,5                                                       DMND187
      DL(L)=0.0                                                         DMND188
   49 CONTINUE                                                          DMND189
      IF(RECYCL .EQ. OFF)GO TO 51                                       DMND190
      IF(RECYCL .LT. 0)GO TO 51                                         DMND191
C     ------------------------------------------------------------------ DMND192
C     ******DISTRIBUTE DEMANDS                                          DMND193
C     ------------------------------------------------------------------ DMND194
      DO 50 I=1,NODS                                                    DMND195
      IT=IDIST(I)                                                       DMND196
      L=LDIST(I)                                                        DMND197
      DL(L)=DL(L)+DIST(I)*DT(IT)                                        DMND198
   50 CONTINUE                                                          DMND199
      IF(DL(5) .GT. 0.0)SW1=1                                           DMND200
      GO TO 53                                                          DMND201
C     ------------------------------------------------------------------ DMND202
C     ******NON DISTRIBUTED DEMANDS                                     DMND203
C     ------------------------------------------------------------------ DMND204
   51 DO 52 IT=1,5                                                      DMND205
      DL(1)=DL(1)+DT(IT)                                                DMND206
   52 CONTINUE                                                          DMND207
C     ------------------------------------------------------------------ DMND208
C     ******CALCULATE FLOW AVAILABLE TO AWT                              DMND209
C     ------------------------------------------------------------------ DMND210
   53 IF(MO .EQ. 1)JANQ=QL(1)                                           DMND211
      QOL=PLTO(MO)*JANQ                                                 DMND212
      QOUT(1)=QOUT(1)+PLSTO*QOL                                         DMND213
      AWTO(2,YR)=AWTO(2,YR)+QOL                                         DMND214
      STO=DL(1)-QOL                                                     DMND215
      AWTO(3,YR)=AWTO(3,YR)+STO                                         DMND216
      QL=PLSTO*STO                                                      DMND217
      QOUT(1)=QOUT(1)+QL                                                DMND218
      AWTO(4,YR)=AWTO(4,YR)+QL                                          DMND219
      QI=STO-QL                                                         DMND220
      QS=0.033*QI                                                       DMND221
      IF(QI .LE. 0.001)GO TO 74                                         DMND222
      AWTO(5,YR)=AWTO(5,YR)+QS                                          DMND223
      QI=QI-QS-QA(MO)                                                   DMND224
      AWTO(6,YR)=AWTO(6,YR)+QA(MO)                                      DMND225
      AWTO(7,YR)=AWTO(7,YR)+QI                                          DMND226
      IF(DPTN1 .EQ. 0)GO TO 74                                          DMND227
      IF(RECYCL .EQ. OFF)GO TO 74                                       DMND228
      IF(RECYCL .GT. 0)GO TO 59                                         DMND229
C     ------------------------------------------------------------------ DMND230
C     ******ADD IN CONTINUOUS STANDBY DEMANDS                           DMND231
C     ------------------------------------------------------------------ DMND232
      DO 55 I=1,NCCD                                                    DMND233
      IT=ICD(I)                                                         DMND234
      L=LCD(I)                                                          DMND235
      DL(L)=DL(L)+CD(I)                                                 DMND236
      DT(6)=DT(6)+CD(I)                                                 DMND237
   55 CONTINUE                                                          DMND238
      IF(DL(5) .GT. 0.0)SW1=1                                           DMND239
C     ------------------------------------------------------------------ DMND240
C     ******CUTBACKS FOR EFFICIENCY AND SETUP FOR AWT                   DMND241
C     1.  MORE THAN ENOUGH IN ONE PASS                                  DMND242
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C     2.  LESS THAN OR JUST ENOUGH IN ONE PASS                          DMND243
C     ----------------------------------------------------------------- DMND244
   59 TEMP1=DL(5)+DL(4)+(1.0-LL(PT3))*DL(3)+(1.0-LL(PT3))*(1.0-LL(PT2))* DMND245
     *DL(2)+DT(7)                                                       DMND246
      IF(TEMP1 .GT. 0.0)GO TO 60                                        DMND247
      CALL INTRPT(T,11,TEMP1,0.0,0.0)                                   DMND248
   60 TEMP1=TEMP1/((1.0-LL(PT3))*(1.0-LL(PT2))*(1.0-LL(PT1)))           DMND249
      IF(QI .LE. TEMP1)GO TO 61                                         DMND250
      QIR=TEMP1                                                         DMND251
      QI=QI-QIR                                                         DMND252
      AWTO(8,YR)=AWTO(8,YR)+QI                                          DMND253
      AWTO(9,YR)=AWTO(9,YR)+QIR                                         DMND254
      GO TO 62                                                          DMND255
   61 QIR=QI                                                            DMND256
      QI=0.0                                                            DMND257
      AWTO(8,YR)=AWTO(8,YR)+QI                                          DMND258
      AWTO(9,YR)=AWTO(9,YR)+QIR                                         DMND259
   62 TEMP1=DL(3)+DL(4)+DL(5)+DT(7)                                     DMND260
      TEMP2=TEMP1-DL(3)                                                 DMND261
      NT=1                                                              DMND262
      GO TO 70                                                          DMND263
C     ----------------------------------------------------------------- DMND264
C     ******LEVEL 1 WATER                                               DMND265
C     ----------------------------------------------------------------- DMND266
   68 NT=NT+1                                                           DMND267
      EXCESS=0.0                                                        DMND268
      IF(NT .LE. RITL)GO TO 69                                          DMND269
      CALL INTRPT(T,12,QR1,QR2,QR3)                                     DMND270
   65 IF(QRR .GT. 0.0)QRR=QRR-1.0                                       DMND271
      GO TO 74                                                          DMND272
   69 QIR=QR1+QR2+QR3+QR4                                               DMND273
      IF(QIR .LE. 0.01)GO TO 65                                         DMND274
      DO 80 I=5,8                                                       DMND275
      Z(I)=0.0                                                          DMND276
   80 CONTINUE                                                          DMND277
      TQIR=TQIR+QIR                                                     DMND278
   70 AWTO(11,YR)=AWTO(11,YR)+QIR                                       DMND279
      SW3=0                                                             DMND280
      QM1=AMAX1(QM1,QIR)                                                DMND281
      CONS=LL(PT1)*QIR                                                  DMND282
      AWTO(12,YR)=AWTO(12,YR)+CONS                                      DMND283
      QG=QIR-CONS                                                       DMND284
      QU1=QU1+QG                                                        DMND285
      QN1=QU1-DL(2)-CN1                                                 DMND286
      IF(QN1 .GE. -0.009)GO TO 100                                      DMND287
      QN1=0.0                                                           DMND288
      SW3=1                                                             DMND289
  100 CN1=CN1+QN1                                                       DMND290
      QR1=LDR1*(QG-QN1)                                                 DMND291
      AWTO(13,YR)=AWTO(13,YR)+QG-QN1                                    DMND292
      NPS(1)=NPS(1)+1                                                   DMND293
      Q(1)=Q(1)+QIR                                                     DMND294
      IF(SW3 .EQ. 1)GO TO 68                                            DMND295
      EXCESS=QN1                                                        DMND296
C     ----------------------------------------------------------------- DMND297
C     ******LEVEL 2 WATER                                               DMND298
C     ----------------------------------------------------------------- DMND299
      IF(TEMP1 .LE. 0.0)GO TO 73                                        DMND300
      EXCESS=0.0                                                        DMND301
      IF(QN1 .LE. 0.0)GO TO 68                                          DMND302
      SW3=0                                                             DMND303
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      AWTO(15,YR)=AWTO(15,YR)+QN1                                       DMND304
      QM2=AMAX1(QM2,QN1)                                                DMND305
      CONS=LL(PT2)*QN1                                                  DMND306
      AWTO(16,YR)=AWTO(16,YR)+CONS                                      DMND307
      QG=QN1-CONS                                                       DMND308
      QU2=QU2+QG                                                        DMND309
      QN2=QU2-DL(3)-CN2                                                 DMND310
      IF(QN2 .GE. -0.009)GO TO 101                                      DMND311
      QN2=0.0                                                           DMND312
      SW3=1                                                             DMND313
  101 CN2=CN2+QN2                                                       DMND314
      QR2=LDR2*(QG-QN2)                                                 DMND315
      AWTO(17,YR)=AWTO(17,YR)+QG-QN2                                    DMND316
      NPS(2)=NPS(2)+1                                                   DMND317
      Q(2)=Q(2)+QN1                                                     DMND318
      IF(SW3 .EQ. 1)GO TO 68                                            DMND319
      EXCESS=QN2                                                        DMND320
C     ------------------------------------------------------------------ DMND321
C     ******LEVEL 3 WATER                                               DMND322
C     ------------------------------------------------------------------ DMND323
      IF(TEMP2 .LE. 0.0)GO TO 73                                        DMND324
      EXCESS=0.0                                                        DMND325
      IF(QN2 .LE. 0.0)GO TO 68                                          DMND326
      SW3=0                                                             DMND327
      AWTO(18,YR)=AWTO(18,YR)+QN2                                       DMND328
      QM3=AMAX1(QM3,QN2)                                                DMND329
      CONS=LL(PT3)*QN2                                                  DMND330
      AWTO(19,YR)=AWTO(19,YR)+CONS                                      DMND331
      QG=QN2-CONS                                                       DMND332
      QU3=QU3+QG                                                        DMND333
      QN3=QU3-DL(4)-CN3                                                 DMND334
      IF(QN3 .GE. -0.009)GO TO 102                                      DMND335
      QN3=0.0                                                           DMND336
      SW3=1                                                             DMND337
  102 CN3=CN3+QN3                                                       DMND338
      QR3=LDR3*(QG-QN3)                                                 DMND339
      AWTO(20,YR)=AWTO(20,YR)+QG-QN3                                    DMND340
      NPS(3)=NPS(3)+1                                                   DMND341
      Q(3)=Q(3)+QN2                                                     DMND342
      IF(SW3 .EQ. 1)GO TO 68                                            DMND343
C     ------------------------------------------------------------------ DMND344
C     ******LEVEL 4 WATER                                               DMND345
C     ------------------------------------------------------------------ DMND346
      IF(DL(5)+DT(7) .LE. 0.0)GO TO 73                                  DMND347
      IF(QN3 .LE. 0.0)GO TO 68                                          DMND348
      QG=QN3                                                            DMND349
      AWTO(21,YR)=AWTO(21,YR)+QN3                                       DMND350
      IF(SW1 .EQ. 1)GO TO 79                                            DMND351
      QRR=QRR+QG                                                        DMND352
      IF(SW2 .NE. 0)GO TO 79                                            DMND353
      QRR=QRR+1.0                                                       DMND354
      SW2=1                                                             DMND355
   79 SW3=0                                                             DMND356
      QUR=QUR+QG                                                        DMND357
      QNR=QUR-QRR-CNR                                                   DMND358
      IF(QNR .GE. -0.009)GO TO 103                                      DMND359
      QNR=0.0                                                           DMND360
      SW3=1                                                             DMND361
  103 CNR=CNR+QNR                                                       DMND362
      QN=QG-QNR                                                         DMND363
      IF(QN .LE. 0.0)GO TO 76                                           DMND364
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      TEST=WQR*VOLR+(WQR+KO)*QN*3.07*NCDYS(MO)                          DMND365
      TEST=TEST/(VOLR+QN*3.07*NODYS(MO))                                DMND366
      VOLR=VOLR+QN*3.07*NCDYS(MO)                                       DMND367
      IF(TEST .LE. 500.0)GC TO 71                                       DMND368
C     ------------------------------------------------------------------ DMND369
C     ******RESERVOIR, TREATED                                          DMND370
C     ------------------------------------------------------------------ DMND371
      WQR=0.95*TEST                                                     DMND372
      QM4=AMAX1(QM4,QN3)                                                DMND373
      NPS(4)=NPS(4)+1                                                   DMND374
      Q(4)=Q(4)+QN3                                                     DMND375
      AWTO(23,YR)=AWTO(23,YR)+QN                                        DMND376
      AWTO(24,YR)=AWTO(24,YR)+QN                                        DMND377
      GO TO 72                                                          DMND378
C     ------------------------------------------------------------------ DMND379
C     ******RESERVOIR, NOT TREATED                                      DMND380
C     ------------------------------------------------------------------ DMND381
   71 WQR=TEST                                                          DMND382
      AWTO(22,YR)=AWTO(22,YR)+CN                                        DMND383
   72 IF(SW3 .EQ. 1)GO TO 68                                            DMND384
C     ------------------------------------------------------------------ DMND385
C     ******PORTABLE, TREATED                                           DMND386
C     ------------------------------------------------------------------ DMND387
   76 EXCESS=QNR                                                        DMND388
      IF(DL(5) .LE. 0.0)GC TC 74                                        DMND389
      EXCESS=0.0                                                        DMND390
      IF(QNR .LE. C.0)GO TC 6P                                          DMND391
      SW3=0                                                             DMND392
      QG=QNR                                                            DMND393
      AWTO(23,YR)=AWTO(23,YR)+CNR                                       DMND394
      QM4=AMAX1(QM4,QNR)                                                DMND395
      QU4=QU4+QG                                                        DMND396
      QN4=QU4-DL(5)-CN4                                                 DMND397
      IF(QN4 .GE. -0.009)GC TO 104                                      DMND398
      QN4=0.0                                                           DMND399
      SW3=1                                                             DMND400
  104 CN4=CN4+QN4                                                       DMND401
      QR4=LDR4*(QG-QN4)                                                 DMND402
      AWTO(25,YR)=AWTO(25,YR)+QG-QN4                                    DMND403
      NPS(4)=NPS(4)+1                                                   DMND404
      Q(4)=Q(4)+QNR                                                     DMND405
      IF(SW3 .EQ. 1)GO TO 6P                                            DMND406
      IF(DT(7) .LE. 0.0)GO TO 105                                       DMND407
      QRR=QRR+QN4                                                       DMND408
      AWTO(24,YR)=AWTO(24,YR)+QN4                                       DMND409
      VOLR=VOLR+QN4*3.07*NCDYS(MO)                                      DMND410
      QN4=0.0                                                           DMND411
  105 SW1=0                                                             DMND412
      IF(DT(7)-QRR .GT. 0.C)GO TO 68                                    DMND413
      AWTO(26,YR)=AWTO(26,YR)+QN4                                       DMND414
      IF(QRR .GT. 0.0)QRR=QRR-1.0                                       DMND415
      GO TO 74                                                          DMND416
   73 QRR=0.0                                                           DMND417
   74 IF(DPTN2 .NE. 0)GO TC 75                                          DMND418
C     ------------------------------------------------------------------ DMND419
C     ******NO ADDITIONAL PASS TO CLEAN EFFLUENT BEFORE DISCHARGING     DMND420
C           INTO STREAMS                                                DMND421
C     ------------------------------------------------------------------ DMND422
      IF(RECYCL .EC. OFF)AWTO(8,YR)=AWTO(8,YR)+QI                       DMND423
      IF(EXCESS .LE. 0.009)EXCESS=0.0                                   DMND424
      AWTO(28,YR)=AWTO(28,YR)+QI+EXCESS                                 DMND425
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      AWTO(27,YR)=AWTO(27,YR)+CR1+CR2+CR3+CR4                           DMND426
      QI=QI+QR1+QR2+QR3+QR4+EXCESS                                      DMND427
      AWTO(29,YR)=AWTO(29,YR)+QI                                        DMND428
      AWTO(30,YR)=AWTO(26,YR)                                           DMND429
      QI=QI+QN4                                                         DMND430
      AWTO(31,YR)=AWTO(31,YR)+QI                                        DMND431
      GO TO 77                                                          DMND432
C     ------------------------------------------------------------------ DMND433
C     ******ADDITIONAL PASS TO CLEAN EFFLUENT BEFORE DISCHARGING        DMND434
C           INTO STREAMS                                                DMND435
C     ------------------------------------------------------------------ DMND436
   75 AWTO(8,YR)=AWTO(8,YR)-QI                                          DMND437
      QI=QI+QR1+QR2+QR3+CR4                                             DMND438
      AWTO(10,YR)=AWTO(10,YR)+QI                                        DMND439
      AWTO(11,YR)=AWTO(11,YR)+CI                                        DMND440
      QM1=AMAX1(QM1,CI)                                                 DMND441
      IF(QI .GT. 0.0)OC(YR,1)=OC(YR,1)+DEFOMC*COST(PT1,Q()              DMND442
      CONS=LL(PT1)*QI                                                   DMND443
      AWTO(12,YR)=AWTO(12,YR)+CONS                                      DMND444
      QI=QI-CONS                                                        DMND445
      AWTO(14,YR)=AWTO(14,YR)+QI                                        DMND446
      QI=QI+CN4                                                         DMND447
      AWTO(31,YR)=AWTO(31,YR)+CI                                        DMND448
      AWTO(30,YR)=AWTO(30,YR)+CI                                        DMND449
C     ------------------------------------------------------------------ DMND450
C     ******COLLECT THE REMAINNING AWT OPERATION STATISTICS             DMND451
C     ------------------------------------------------------------------ DMND452
   77 QOUT(2)=DL(1)-QOUT(1)-QRR                                         DMND453
      AWTO(1,YR)=AWTO(1,YR)+DL(1)                                       DMND454
      AWTO(10,YR)=AWTO(10,YR)+TCIR                                      DMND455
      IF(PT1 .NE. 5 .AND. C(1) .GT. 0.0)OC(YR,1)=OC(YR,1)+DEFOMC*COST(PT DMND462
     *1,Q(1))*Q(1)*NODYS(MO)                                            DMND463
      IF(PT2 .NE. 5 .AND. C(2) .GT. 0.0)OC(YR,2)=OC(YR,2)+DEFOMC*COST(PT DMND464
     *2,Q(2))*Q(2)*NODYS(MO)                                            DMND465
      IF(PT3 .NE. 5 .AND. C(3) .GT. 0.0)OC(YR,3)=OC(YR,3)+DEFOMC*COST(PT DMND466
     *3,Q(3))*Q(3)*NODYS(MO)                                            DMND467
      IF(Q(4) .GT. 0.0)OC(YR,4)=OC(YR,4)+DEFOMC*COST(5,Q(4))*Q(4)*NODYS( DMND468
     *MO)                                                               DMND469
C     ------------------------------------------------------------------ DMND470
C     ******COLLECT STATISTICS ON WATER DEMAND                          DMND471
C     ------------------------------------------------------------------ DMND472
      SWD(YR,2)=SWD(YR,2)+DT(1)*NODYS(MO)                               DMND473
      SWD(YR,10)=SWD(YR,10)+DT(3)*NODYS(MO)                             DMND474
      SWD(YR,17)=SWD(YR,17)+DT(2)*NODYS(MO)                             DMND475
      SWD(YR,23)=SWD(YR,23)+DT(4)*NODYS(MO)                             DMND476
      SWD(YR,27)=SWD(YR,27)+DT(5)*NODYS(MO)                             DMND477
      SWD(YR,31)=SWD(YR,31)+DT(6)*NODYS(MO)                             DMND478
      SWD(YR,8)=SWD(YR,8)+PRICED*DT(1)*1000.0*NODYS(MO)                 DMND479
      SWD(YR,15)=SWD(YR,15)+PRICEI*DT(3)*1000.0*NODYS(MO)               DMND480
      SWD(YR,21)=SWD(YR,21)+PRICED*DT(2)*1000.0*NODYS(MO)               DMND481
      SWD(YR,25)=SWD(YR,25)+PRICEM*DT(4)*1000.0*NODYS(MO)               DMND482
      SWD(YR,29)=SWD(YR,29)+PRICEC*DT(5)*1000.0*NODYS(MO)               DMND483
      SWD(YR,33)=SWD(YR,33)+PRICEN*DT(6)*1000.0*NODYS(MO)               DMND484
C     ------------------------------------------------------------------ DMND485
C     ******COLLECT INVESTMENT COST STATISTICS                          DMND486
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C     ------------------------------------------------------------------ DMND487
      IF(PT1 .NE. 5)INVC(YR,PT1)=AMAX1(INVC(YR,PT1),QM1)                 DMND488
      IF(PT2 .NE. 5)INVC(YR,PT2)=AMAX1(INVC(YR,PT2),QM2)                 DMND489
      IF(PT3 .NE. 5)INVC(YR,P(3)=AMAX1(INVC(YR,PT3),CM3)                 DMND490
      INVC(YR,5)=AMAX1(INVC(YR,5),CM4)                                   DMND491
      RETURN                                                             DMND492
      END                                                                DMND493
      BLOCK DATA                                                         BLKD001
      COMMON/HD/TITLE(9)                                                 BLKD002
      COMMON/IODEV/NR,NP,NC,TAPE1,TAPE2,TAPE3                            BLKD003
      COMMON/M/T,YR,MO,YRST,NYRPRJ,RLEVEL,RRCFF,RECYCL,OPTN1,OPTN2,      BLKD004
     *IDSNO,FREQ,GRAPH,NODYS(12),RIMPRT,RLOCAL                           BLKD005
      COMMON/P/LEAK,RLMAX,RCPL,PLEVEL,RRON,PROBL,NO,EXPL,EXPR            BLKD006
      COMMON/S/NSTA,NOSTA,NI,NAS,STNO(40),SNAME(40,5),TYPE(40),          BLKD007
     *NOCUTS(40),PC(40),SEAS1(40,3),SEAS2(40,3),CMIN(40,3),CMAX(40,3),   BLKD008
     *H(60,5),IYR,WELLS(12),PROJCT(12),SKIP                              BLKD009
      COMMON/RV/MINQ(40,12),MINCR(12),EVAP(12)                           BLKD010
      COMMON/D/PG,EG,DPRIDC,DPRII,DEFCC,DEFOMC,PRICED,PRICEI,PRICEM,     BLKD011
     *PRICEC,PRICEN,POP,EMPLOY,RAIN,RAINAV(12)                           BLKD012
      COMMON/AWT/CD(35),DIST(35),ICD(35),IDIST(35),LCD(35),LDIST(35),    BLKD013
     *LDR1,LDR2,LDR3,LDR4,LL(5),NOCD,NODS,CA(12),PLTQ(12),PLSTQ,PT1,     BLKD014
     *PT2,PT3,PRL,RITL,WQR                                               BLKD015
      COMMON/OUT/SWD(50,37),SSS(50,5),SAWT(5,5),DATES(10),AWTO(32,50),   BLKD016
     *INVC(50,6),QC(50,5),R(3),DTHRC(50,10)                              BLKD017
      COMMON/TMP/IT,NT,TEMP1,TEMP2,X(60)                                 BLKD018
      REAL     TITLE                                                     BLKD019
      REAL     LEAK                                                      BLKD020
      REAL     MINQ,MINCR                                                BLKD021
      REAL     LDR1,LDR2,LDR3,LDR4,LL                                    BLKD022
      REAL     INVC                                                      BLKD023
      INTEGER TAPE1,TAPE2,TAPE3                                          BLKD024
      INTEGER T,YR,MO,YRST,RECYCL,OPTN1,OPTN2,IDSNO,FREQ,GRAPH           BLKD025
      INTEGER STNO,TYPE,SEAS1,SEAS2,SKIP                                 BLKD026
      INTEGER PT1,PT2,PT3,PITL                                           BLKD027
      INTEGER DATES                                                      BLKD028
      DATA TITLE/9*8H        /                                           BLKD029
      DATA NR,NP,NC,TAPE1,TAPE2,TAPE3/5,6,7,15,16,17/                    BLKD030
      DATA MO,YRST,NYRPRJ,RLEVEL,RRCFF/0,1972,50,66743.0,42667.0/        BLKD031
      DATA RECYCL,OPTN1,OPTN2,IDSNO,FREQ,GRAPH/1,1,0,0,5,0/              BLKD032
      DATA NODYS/31,29,31,30,31,30,31,31,30,31,30,31/                    BLKD033
      DATA LEAK,RLMAX,RCPL,PLEVEL,PRON/10.0,125614.0,3375.0,65704.0,     BLKD034
     *30000.0/                                                           BLKD035
      DATA RLOCAL/33371.5/                                               BLKD036
      DATA WELLS,PROJCT,SKIP/12*0.0,12*0.0,0/                            BLKD037
      DATA PROBL,NO/0.70,67,EXPL,EXPR/2*0.0/                             BLKD038
      DATA NSTA,NOSTA,IYR/28,30,10/                                      BLKD039
      DATA PG,EG,DPRIDC,DPRII,DEFCC,DEFOMC/2*0.0045,4*1.0/               BLKD040
      DATA PRICED,PRICEI,PRICEM,PRICEC,PRICEN/0.717,0.40,0.65,0.00,0.27/ BLKD041
      DATA POP,EMPLOY/150000.0,7240.0/                                   BLKD042
      DATA LDR1,LDR2,LDR3,LDR4,LL/4*0.00,4*0.00,0.00001/                 BLKD043
      DATA NOCD,NODS,PT1,PT2,PT3,PRL,RITL,WQR/0,0,4,1,3,0.30,30,70.0/    BLKD044
      DATA PLTQ/2*0.35,2*0.25,4*0.15,3*0.30,0.35/                        BLKD045
      DATA R/0.04,0.065,0.08/                                            BLKD046
      END                                                                BLKD047
      SUBROUTINE INPUT(NOFILE)                                           NPUT001
      COMMON/HD/TITLE(9)                                                 NPUT002
      COMMON/IODEV/NR,NP,NC,TAPE1,TAPE2,TAPE3                            NPUT003
      COMMON/M/T,YR,MO,YRST,NYRPRJ,RLEVEL,RRCFF,RECYCL,OPTN1,OPTN2,      NPUT004
     *IDSNO,FREQ,GRAPH,NODYS(12),RIMPRT,RLOCAL                           NPUT005
      COMMON/P/LEAK,RLMAX,RCPL,PLEVEL,RRON,PROBL,NO,EXPL,EXPR            NPUT006
      COMMON/S/NSTA,NOSTA,NI,NAS,STNO(40),SNAME(40,5),TYPE(40),          NPUT007
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     *NOCUTS(40),PC(40),SEAS1(40,3),SEAS2(40,3),CMIN(40,3),CMAX(40,3),   NPUT008
     *H(60,5),IYR,WELLS(12),PROJCT(12),SKIP                              NPUT009
      COMMON/RV/MINQ(40,12),MINQR(12),EVAP(12)                           NPUT010
      COMMON/D/PG,EG,DPRIDC,DPRII,DEFCC,DEFOMC,PRICED,PRICEI,PRICEM,     NPUT011
     *PRICEC,PRICEN,POP,EMPLOY,RAIN,RAINAV(12)                           NPUT012
      COMMON/AWT/CD(35),DIST(35),ICD(35),IDIST(35),LCD(35),LDIST(35),    NPUT013
     *LDR1,LDR2,LDR3,LDR4,LL(5),NOCD,NCDS,CAI(12),PLTQ(12),PLSTQ,PT1,    NPUT014
     *PT2,PT3,PRL,RITL,WQR                                               NPUT015
      COMMON/OUT/SWD(50,37),SSS(50,5),SAWT(5,5),DATES(10),AWTO(32,50),   NPUT016
     *INVC(50,6),DC(50,5),R(3),OTHRC(50,10)                              NPUT017
      COMMON/TMP/IT,NT,TEMP1,TEMP2,X(60)                                 NPUT018
      REAL     TITLE                                                     NPUT019
      REAL     LEAK                                                      NPUT020
      REAL     MINQ,MINQR                                                NPUT021
      REAL     LDR1,LDR2,LDR3,LDR4,LL                                    NPUT022
      REAL     INVC                                                      NPUT023
      INTEGER  TAPE1,TAPE2,TAPE3                                         NPUT024
      INTEGER  T,YR,MO,YRST,RECYCL,OPTN1,OPTN2,IDSNQ,FREQ,GRAPH          NPUT025
      INTEGER  STNO,TYPE,SEAS1,SEAS2,SKIP                                NPUT026
      INTEGER  PT1,PT2,PT3,RITL                                          NPUT027
      INTEGER  DATES                                                     NPUT028
      INTEGER  DCII,DCIII,DCIV,DCV,DCVI,DCVII,DCVIII,DCIX,DCX,DCXI,DCXII NPUT029
      INTEGER  STA                                                       NPUT030
      NAMELIST/PARAM/NYRPRJ,YRST,NOSTA,NSTA,YR,IYR,SKIP,LEAK,RLMAX,RCPL, NPUT031
     *RLEVEL,PLEVEL,WQR,PROBL,OPTN1,RECYCL,RRCN,RROFF,NOFILE,NCDS,NOCD,  NPUT032
     *EG,PG,EMPLOY,POP,PRICED,PRICEI,PRICEM,PRICEC,PRICEN,DPRIDC,RLOCAL, NPUT033
     *DPRII,DEFCC,DEFOMC,OPTN2,RITL,PT1,PT2,LDR1,LDR2,LDR3,LDR4,LL,R,    NPUT034
     *IDSNQ,FREQ,DCII,DCIII,DCIV,DCV,DCVI,DCVII,DCVIII,DCIX,DCX,DCXI,    NPUT035
     *DCXII,GRAPH,EXPL,EXPR                                              NPUT036
      DATA DCII,DCIII,DCIV,DCV,DCVI,DCVII,DCVIII,DCIX,DCX/9*1/           NPUT037
      DATA DCXI,DCXII/2*1/                                               NPUT038
C     ------------------------------------------------------------------ NPUT039
C     ******TITLE CARD                                                   NPUT040
C     ------------------------------------------------------------------ NPUT041
      REWIND TAPE2                                                       NPUT042
      REWIND TAPE3                                                       NPUT043
      CALL HEADNG(-1)                                                    NPUT044
      READ(NR,10) TITLE                                                  NPUT045
   10 FORMAT(9A8)                                                        NPUT046
C     ------------------------------------------------------------------ NPUT047
C     ******PARAMETERS   DATA CARD TYPE I                                NPUT048
C     ------------------------------------------------------------------ NPUT049
      READ(NR,PARAM)                                                     NPUT050
      CALL HEADNG(1)                                                     NPUT051
      WRITE(NP,14)                                                       NPUT052
   14 FORMAT(//48X,24H*****PARAMETER LIST*****,                          NPUT053
     *//25X,51HITEM    VARIABLE              DESCRIPTION            ,3X, NPUT054
     *5HVALUE)                                                           NPUT055
      WRITE(NP,15) NYRPRJ,YRST,NOSTA,NSTA,YR,IYR,SKIP                    NPUT056
   15 FORMAT(1H0,                                                        NPUT057
     * 24X,51HTIME      NYRPRJ NUMBER OF YEARS IN SIMULATION.....,I12,  NPUT058
     */25X,51H          YRST   SIMULATION BEGINS IN ............,I12,  NPUT059
     *2(/),                                                              NPUT060
     * 25X,51HSTREAMS   NOSTA  TOTAL NUMBER OF STREAMS............,I12, NPUT061
     */25X,51H          NSTA   BEGINNING NUMBER OF STREAMS........,I12, NPUT062
     */25X,51H          YR     HISTORICAL DATA BEGINS IN..........,I12, NPUT063
     */25X,51H          IYR    NUMBER OF YEARS OF HISTORICAL DATA,I12,  NPUT064
     */25X,51H          SKIP   NUMBER OF YRS OF STREAM DATA SKIP.,I12)  NPUT065
      WRITE(NP,16) LEAK,RLMAX,RCPL,RLEVEL,PLEVEL,RLOCAL,WQR,PROBL,EXPL,  NPUT066
     *EXPR                                                               NPUT067
   16 FORMAT(1H0,                                                        NPUT068
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 * 24X,51HRESERVOIR LEAK  LEAKAGE CONSTANT...................,F12.4,  NPUT069
 */25X,51H          RLMAX  MAXIMUM CAPACITY...................,F12.4,  NPUT070
 */25X,51H          RCPL   CONSERVATION POOL LEVEL............,F12.4,  NPUT071
 */25X,51H          RLEVEL CURRENT LEVEL......................,F12.4,  NPUT072
 */25X,51H          PLEVEL PREVIOUS LEVEL.....................,F12.4,  NPUT073
 */25X,51H          RLOCAL LOCAL WATER LEVEL..................,F12.4,  NPUT074
 */25X,51H          WQR    CURRENT WATER QUALITY.............,F12.4,  NPUT075
 */25X,51H          PRCRL  PROBABILITY LIMIT FOR EXPANSION...,F12.4,  NPUT076
 */25X,51H          EXPL   RESERVOIR LEVEL FOR EXPANSION.....,F12.4,  NPUT077
 */25X,51H          EXPR   STORAGE FACTOR RATIO FOR EXPANSION,F12.4)  NPUT078
  WRITE(NP,17) OPTN1,RECYCL,RRCN,RROFF,NCFILE                          NPUT079
17 FORMAT(1H0,                                                         NPUT080
 * 24X,51HRECYCLE   OPTN1  RECYCLE (0=NO, 1=YES)..............,I12,  NPUT081
 */25X,51H          RECYCL STARTING POSITION .................,I12,  NPUT082
 */25X,51H          RRCN   RECYCLE ON LEVEL...................,F12.4,  NPUT083
 */25X,51H          RROFF  RECYCLE OFF LEVEL..................,F12.4,  NPUT084
 *2(/),                                                                NPUT085
 * 25X,51HPLANS     NOFILE NUMBER OF PLANNING FILES...........,I12)  NPUT086
  WRITE(NP,18) NODS,NCCD,EG,PG,EMPLOY,POP,PRICED,PRICEI,PRICEM,        NPUT087
 *PRICEC,PRICEN,DPRIDC,UPRII,DEFCC,DEFOMC                              NPUT088
18 FORMAT(1H0,                                                         NPUT089
 * 24X,51HDEMANDS   NODS   NUMBER OF DISTRIBUTION SUBDIVISION,I12,    NPUT090
 */25X,51H          NCCD   NUMBER OF STANDBY DEMANDS..........,I12,  NPUT091
 */25X,51H          EG     GROWTH RATE OF EMPLOYMENT..........,F12.4,  NPUT092
 */25X,51H          PG     GROWTH RATE OF POPULATION..........,F12.4,  NPUT093
 */25X,51H          EMPLOY STARTING EMPLOYMENT................,F12.4,  NPUT094
 */25X,51H          POP    STARTING POPULATION................,F12.4,  NPUT095
 */25X,51H          PRICED STARTING PRICE, DOMESTIC AND COMM.,F12.4,  NPUT096
 */25X,51H          PRICEI STARTING PRICE, INDUSTRIAL.........,F12.4,  NPUT097
 */25X,51H          PRICEM STARTING PRICE, MILITARY...........,F12.4,  NPUT098
 */25X,51H          PRICEC STARTING PRICE, MUNICIPAL..........,F12.4,  NPUT099
 */25X,51H          PRICEN STARTING PRICE, NON-POTABLE........,F12.4,  NPUT100
 */25X,51H          DPRIDC SUMMER PRICE INCREASE, DOM ) COM...,F12.4,  NPUT101
 */25X,51H          DPRII  SUMMER PRICE INCREASE, INDUSTRIAL..,F12.4,  NPUT102
 */25X,51H          DEFCC  DEFLATOR, CONSTRUCTION COSTS.......,F12.4,  NPUT103
 */25X,51H          DEFOMC DEFLATOR, OPER. ) MAIN. COSTS......,F12.4)  NPUT104
  WRITE(NP,19) OPTN2,RITL,PT1,PT2,PT3,LDR1,LDR2,LDR3,LDR4,             NPUT105
 *(LL(I),I=1,4)                                                        NPUT106
19 FORMAT(1H0,                                                         NPUT107
 * 24X,51HAWT       OPTN2  TREAT EFFLUENT (0=NO, 1=YES).......,I12,  NPUT108
 */25X,51H          RITL   RECYCLE ITTERATION LIMIT...........,I12,  NPUT109
 */25X,51H          PT1    PROCESS TYPE, LEVEL 1..............,I12,  NPUT110
 */25X,51H          PT2    PROCESS TYPE, LEVEL 2..............,I12,  NPUT111
 */25X,51H          PT3    PROCESS TYPE, LEVEL 3..............,I12,  NPUT112
 */25X,51H          LDR1   PERCENT DEMAND RETURNED, LEVEL 1..,F12.4,  NPUT113
 */25X,51H          LDR2   PERCENT DEMAND RETURNED, LEVEL 2..,F12.4,  NPUT114
 */25X,51H          LDR3   PERCENT DEMAND RETURNED, LEVEL 3..,F12.4,  NPUT115
 */25X,51H          LDR4   PERCENT DEMAND RETURNED, LEVEL 4..,F12.4,  NPUT116
 */25X,51H          LL(1)  PERCENT CONSUMPTION, COAG ) SED...,F12.4,  NPUT117
 */25X,51H          LL(2)  PERCENT CONSUMPTION, FILTRATION...,F12.4,  NPUT118
 */25X,51H          LL(3)  PERCENT CONSUMPTION, G. CARB. A. ..,F12.4,  NPUT119
 */25X,51H          LL(4)  PERCENT CONSUMPTION, ACT. SLUDGE..,F12.4)  NPUT120
  CALL HEADNG(1)                                                       NPUT121
  WRITE(NP,14)                                                         NPUT122
  WRITE(NP,20) (R(I),I=1,3)                                            NPUT123
20 FORMAT(1H0,                                                         NPUT124
 * 24X,51HOTHER     R(1)   INTEREST RATE 1....................,F12.4,  NPUT125
 */25X,51H          R(2)   INTEREST RATE 2....................,F12.4,  NPUT126
 */25X,51H          R(3)   INTEREST RATE 3....................,F12.4)  NPUT127
  WRITE(NP,21) IDSNO,FREC,DCII,DCIII,DCIV,DCV,DCVI,DCVII,DCVIII,DCIX   NPUT128
 *,DCX,DCXI,DCXII,GRAPH                                                NPUT129
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   21 FORMAT(1H0,                                                       NPUT130
     * 24X,51HEDIT      IDSNO  INTERMEDIATE DATA, STREAM NET FLOW,I12,  NPUT131
     */25X,51H          FREQ   FREQUENCY OF IDSNO PRINTOUT .......,I2,  NPUT132
     */25X,51H          DCII   DATA CARD TYPE II   PRINTOUT.......,I12, NPUT133
     */25X,51H          DCIII  DATA CARD TYPE III  PRINTOUT.......,I12, NPUT134
     */25X,51H          DCIV   DATA CARD TYPE IV   PRINTOUT.......,I12, NPUT135
     */25X,51H          DCV    DATA CARD TYPE V    PRINTOUT.......,I12, NPUT136
     */25X,51H          DCVI   DATA CARD TYPE VI   PRINTOUT.......,I12, NPUT137
     */25X,51H          DCVII  DATA CARD TYPE VII  PRINTOUT.......,I12, NPUT138
     */25X,51H          DCVIII DATA CARD TYPE VIII PRINTOUT.......,I12, NPUT139
     */25X,51H          DCIX   DATA CARD TYPE IX   PRINTOUT.......,I12, NPUT140
     */25X,51H          DCX    DATA CARD TYPE  X   PRINTOUT.......,I12, NPUT141
     */25X,51H          DCXI   DATA CARD TYPE  XI  PRINTOUT.......,I12, NPUT142
     */25X,51H          DCXII  DATA CARD TYPE  XII PRINTOUT.......,I12, NPUT143
     */25X,51H          GRAPH  PUNCH DATA FOR GRAPH PROGRAM.......,I12I NPUT144
      N1=NSTA+1                                                         NPUT145
      NAS=1                                                             NPUT146
      RIMPRT=RLEVEL-RLOCAL                                              NPUT147
C     ------------------------------------------------------------------ NPUT148
C     ******STREAM FLOW CONSTRAINT DATA   DATA CARD TYPE II             NPUT149
C     ------------------------------------------------------------------ NPUT150
      DO 42 STA=1,NOSTA                                                 NPUT151
      READ (NR,40) STNO(STA),(SNAME(STA,K),K=1,5),TYPE(STA),NOCUTS(STA), NPUT152
     *PC(STA),SEAS1(STA,1),SEAS2(STA,1),CMIN(STA,1),CMAX(STA,1),        NPUT153
     *        SEAS1(STA,2),SEAS2(STA,2),CMIN(STA,2),CMAX(STA,2),        NPUT154
     *        SEAS1(STA,3),SEAS2(STA,3),CMIN(STA,3),CMAX(STA,3)         NPUT155
   40 FORMAT(I3,5A4,2(1,F6.2,1X,3(2(2,2F6.2))                           NPUT156
      IF(PC(STA) .LE. 0.0)PC(STA)=999.99                                NPUT157
      NT=NOCUTS(STA)                                                    NPUT158
      DO 41 K=1,NT                                                      NPUT159
      IF(SEAS1(STA,K) .LE. 0)SEAS1(STA,K)=1                             NPUT160
      IF(SEAS2(STA,K) .LE. 0)SEAS2(STA,K)=12                            NPUT161
      IF(SEAS1(STA,K) .GT. 0 .AND. CMAX(STA,K) .LE. 0.0)CMAX(STA,K)=999. NPUT162
     *99                                                                NPUT163
   41 CONTINUE                                                          NPUT164
   42 CONTINUE                                                          NPUT165
      IF(DCII .EQ. 0)GO TO 12                                           NPUT166
      CALL HEADNG(1)                                                    NPUT167
      WRITE(NP,43)                                                      NPUT168
   43 FORMAT(///40X,41H******** STREAM FLOW CONSTRAINTS ********,       NPUT169
     */50X,20H(DATA CARD TYPE  (I))                                     NPUT170
      WRITE(NP,44) (J,J=1,3),(K,K=1,3)                                  NPUT171
   44 FORMAT(///2X,7HSTATION,1X,20H----STREAM  NAME----,2X,5HTYPE-,     NPUT172
     *3X,2HNO,4X,8HPIPELINE,1X,3(2X,13H-----CUT NO. ,(1,5H-----),       NPUT173
     */2X,7HNUMBER ,23X,5HWATER,2X,4HCUTS,2X,10HCONSTRAINT,             NPUT174
     *3(2X,4HSEAS,I1,14H MIN OF MAX OF),//)                             NPUT175
      DO 47 STA=1,NOSTA                                                 NPUT176
      NT=NOCUTS(STA)                                                    NPUT177
      WRITE(NP,45) STNO(STA),(SNAME(STA,K),K=1,5),TYPE(STA),NOCUTS(STA), NPUT178
     *PC(STA),(SEAS1(STA,J),SEAS2(STA,J),CMIN(STA,J),CMAX(STA,J),J=1,NT) NPUT179
   45 FORMAT(4X,I3,3X,5A4,4X,I1,5X,I2,5X,F6.2,2X,3(2X,I2,1H-,I2,2(1X,F6. NPUT180
     *2)))                                                              NPUT181
      IF(STA .EQ. NSTA)WRITE(NP,46)                                     NPUT182
   46 FORMAT(1H0)                                                       NPUT183
   47 CONTINUE                                                          NPUT184
C     ------------------------------------------------------------------ NPUT185
C     ******HISTORICAL ANNUAL STREAM FLOW DATA   DATA CARD TYPE III     NPUT186
C     ------------------------------------------------------------------ NPUT187
   12 IF(OPTN1 .EQ. 0)GO TO 30                                          NPUT188
      JX=YR-1                                                           NPUT189
      DO 57 I=1,IYR,9                                                   NPUT190
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      IT=I                                                              NPUT191
      NT=IT+8                                                           NPUT192
      IF(NT .GT. IYR)NT=IYR                                             NPUT193
      IF(DCIII .EQ. 0)GO TO 49                                          NPUT194
      CALL HEADNG(1)                                                    NPUT195
      IX=JX+1                                                           NPUT196
      JX=IX+8                                                           NPUT197
      IF(JX .GT. YR+9)JX=YR+9                                           NPUT198
      WRITE(NP,48) (J,J=IX,JX)                                          NPUT199
   48 FORMAT(///34X,52H******** HISTORICAL ANNUAL STREAM FLOW DATA ***** NPUT200
     ****,                                                              NPUT201
     */50X,20HDATA CARD TYPE (III),                                     NPUT202
     *///13X,3HSTA,3X,9(2X,I4,4X))                                      NPUT203
      WRITE(NP,46)                                                      NPUT204
   49 K=1                                                               NPUT205
      DO 25 STA=1,NOSTA                                                 NPUT206
      IF(STA .GT. NSTA)K=K+1                                            NPUT207
      READ(NR,50) (X(J),J=IT,NT)                                        NPUT208
   50 FORMAT(8X,9F8.2)                                                  NPUT209
      IF(DCIII .EQ. 0)GO TO 52                                          NPUT210
      WRITE(NP,51) STNO(STA),(X(J),J=IT,NT)                             NPUT211
   51 FORMAT(13X,I3,3X,9(F8.2,2X))                                      NPUT212
   52 IF(STA .GT. NSTA)GO TO 55                                         NPUT213
      DO 53 J=IT,NT                                                     NPUT214
      H(J,1)=H(J,1)+X(J)                                                NPUT215
   53 CONTINUE                                                          NPUT216
      IF(DCIII .EQ. 0)GO TO 25                                          NPUT217
      IF(STA .NE. NSTA)GO TO 25                                         NPUT218
      WRITE(NP,54) (H(J,1),J=IT,NT)                                     NPUT219
   54 FORMAT(//13X,5HTOTAL,1X,9(F8.2,2X))                               NPUT220
      GO TO 25                                                          NPUT221
   55 DO 56 J=IT,NT                                                     NPUT222
      H(J,K)=X(J)                                                       NPUT223
   56 CONTINUE                                                          NPUT224
   25 CONTINUE                                                          NPUT225
   57 CONTINUE                                                          NPUT226
   30 YR=0                                                              NPUT227
C     ---------------------------------------------------------------- NPUT228
C     ******RESERVOIR LOSSES DATA   DATA CARD TYPE IV                  NPUT229
C     ---------------------------------------------------------------- NPUT230
      IF(DCIV .EQ. 0)GO TO 61                                           NPUT231
      CALL HEADNG(1)                                                    NPUT232
      WRITE(NP,59)                                                      NPUT233
   59 FORMAT(///29X,62H******** RESERVOIR LOSSES   MINIMUM REQUIRED OUTF NPUT234
     *LOWS ********,/50X,20H(DATA CARD TYPE  IV))                       NPUT235
      WRITE(NP,60) (K,K=1,12)                                           NPUT236
   60 FORMAT(///1X,7HSTATION,1X,20H----STREAM  NAME----,26X,1HM,6X,1HO, NPUT237
     *6X,1HN,6X,1HT,6X,1HH,6X,1HS,                                      NPUT238
     */1X,7HNUMBER ,21X,12(3X,I2,2X),//)                                NPUT239
   61 I=1                                                               NPUT240
      DO 70 STA=1,NOSTA                                                 NPUT241
      IF(STA .GT. NSTA)I=I+1                                            NPUT242
      READ(NR,62) (MINQ(I,J),J=1,12)                                    NPUT243
   62 FORMAT(8X,12F6.2)                                                 NPUT244
      IF(OCIV .EQ. 0)GO TO 64                                           NPUT245
      WRITE(NP,63) STNO(STA),(SNAME(STA,K),K=1,5),(MINQ(I,J),J=1,12)    NPUT246
   63 FORMAT(3X,I3,3X,5A4,I2(1X,F6.2),4H CFS)                           NPUT247
   64 DO 65 J=1,12                                                      NPUT248
      MINQ(I,J)=MINQ(I,J)*1.98346*NODYS(J)                              NPUT249
   65 CONTINUE                                                          NPUT250
      IF(OCIV .EQ. 0)GO TO 67                                           NPUT251
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      WRITE(NP,66) (MINQ(I,J),J=1,12)                                   NPUT252
   66 FORMAT(29X,12(1X,   F6.2),6H AF/MO)                               NPUT253
      IF(STA .NE. 24)GO TO 67                                           NPUT254
      CALL HEADNG(1)                                                    NPUT255
      WRITE(NP,59)                                                      NPUT256
      WRITE(NP,60) (K,K=1,12)                                           NPUT257
   67 IF(STA .GT. NSTA)GO TO 70                                         NPUT258
      DO 68 J=1,12                                                      NPUT259
      MINQR(J)=MINQR(J)+MINQ(I,J)                                       NPUT260
   68 CONTINUE                                                          NPUT261
      IF(DCIV .EQ. 0)GO TO 70                                           NPUT262
      IF(STA .NE. NSTA)GO TO 70                                         NPUT263
      WRITE(NP,69) NSTA,(MINQR(J),J=1,12)                               NPUT264
   69 FORMAT(//9X,10HTOTAL FOR ,I2,8H STREAMS,12(1X,-3PF6.2),7H TAF/MO, NPUT265
     */)                                                                NPUT266
   70 CONTINUE                                                          NPUT267
C     *****RESERVOIR  EVAPORATION CONSTANTS   DATA CARD TYPE V          NPUT269
C     ------------------------------------------------------------------ NPUT268
C     ------------------------------------------------------------------ NPUT270
      READ(NR,71) (EVAP(J),J=1,12)                                      NPUT271
   71 FORMAT(8X,12F6.4)                                                 NPUT272
      IF(DCV .EQ. 0)GO TO 73                                            NPUT273
      WRITE(NP,72) (J,J=1,12),(EVAP(I),I=1,12)                          NPUT274
   72 FORMAT(//35X,49H******** RESERVOIR EVAPORATION CONSTANTS ********, NPUT275
     */50X,20H(DATA CARD TYPE  V ),                                     NPUT276
     *//18X,12(2X,I2,3X),                                               NPUT277
     */18X,12(F6.4,1X))                                                 NPUT278
   73 CONTINUE                                                          NPUT279
C     ------------------------------------------------------------------ NPUT280
C     ******PLANNING DATA   DATA CARD TYPE VI                            NPUT281
C     ------------------------------------------------------------------ NPUT282
      CALL SETPLN(NOFILE,DCVI)                                          NPUT283
C     ------------------------------------------------------------------ NPUT284
C     ******DISTRIBUTION DATA FOR RECYCLING UNDER PERIODS OF WATER       NPUT285
C           RATIONNING   DATA CARD TYPE VII                             NPUT286
C     ------------------------------------------------------------------ NPUT287
      IF(NODS .EQ. 0)GO TO 75                                           NPUT288
      READ(NR,74) (IDIST(I),LDIST(I),DIST(I),I=1,NODS)                  NPUT289
   74 FORMAT(11X,I1,1X,I1,1X,F5.3,1X,I1,1X,I1,1X,F5.3,1X,I1,1X,I1,1X,   NPUT290
     *F5.3,1X,I1,1X,I1,1X,F5.3,1X,I1,1X,I1,1X,F5.3,1X,I1,1X,I1,1X,F5.3, NPUT291
     *1X,I1,1X,I1,1X,F5.3)                                              NPUT292
C     ------------------------------------------------------------------ NPUT293
C     ******CONTINUOUS DEMANDS FOR RECYCLED WATER DATA                  NPUT294
C           DATA CARD TYPE VIII                                         NPUT295
C     ------------------------------------------------------------------ NPUT296
   75 IF(NOCD .EQ. 0)GO TO 77                                           NPUT297
      READ(NR,76) (ICD(I),LCD(I),CD(I),I=1,NOCD)                        NPUT298
   76 FORMAT(11X,I1,1X,I1,1X,F5.0,1X,I1,1X,I1,1X,F5.0,1X,I1,1X,I1,1X,   NPUT299
     *F5.0,1X,I1,1X,I1,1X,F5.0,1X,I1,1X,I1,1X,F5.0,1X,I1,1X,I1,1X,F5.0, NPUT300
     *1X,I1,1X,I1,1X,F5.0)                                              NPUT301
   77 IX=DCVII-DCVIII                                                   NPUT302
      IF(IX)94,78,87                                                    NPUT303
   78 IF(DCVII+DCVIII .NE. 2)GO TO 99                                   NPUT304
      CALL HEADNG(1)                                                    NPUT305
      WRITE(NP,79)                                                      NPUT306
   79 FORMAT(//18X,33H DISTRIBUTION DATA FOR RECYCLING ,18X,            NPUT307
     *33H CONTINUOUS DEMANDS FOR RECYCLED ,                             NPUT308
     */17X,35HDURING PERIODS OF WATER RESTRICTION,17X,33H          WATE NPUT309
     *R  DATA          ,                                               NPUT310
     */18X,33H       (DATA CARD TYPE VII )       ,18X,33H       (DATA CARD NPUT311
     *TYPE VIII)       ,///)                                           NPUT312
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      WRITE(NP,80)                                                      NPUT313
   80 FORMAT(19X,4HUSER,6X,5HLEVEL,5X,10HPERCENTAGE,21X,4HUSER,6X,      NPUT314
     *5HLEVEL,7X,6HAMOUNT,//)                                           NPUT315
      DO 86 I=1,35                                                      NPUT316
      WRITE(NP,81) IDIST(I),LDIST(I),DIST(I),ICD(I),LCD(I),CD(I)        NPUT317
   81 FORMAT(21X,2(I1,9X),F7.4,24X,2(I1,9X),F7.0)                       NPUT318
      IF(DIST(I) .GT. 5)WRITE(NP,82)                                    NPUT319
      IF(LDIST(I) .GT. 4)WRITE(NP,83)                                   NPUT320
      IF(ICD(I) .GT. 5)WRITE(NP,84)                                     NPUT321
      IF(LCD(I) .GT. 4)WRITE(NP,85)                                     NPUT322
   82 FORMAT(1H+,21X,8H-INVALID)                                        NPUT323
   83 FORMAT(1H+,31X,8H-INVALID)                                        NPUT324
   84 FORMAT(1H+,72X,8H-INVALID)                                        NPUT325
   85 FORMAT(1H+,82X,8H-INVALID)                                        NPUT326
   86 CONTINUE                                                          NPUT327
      GO TO 99                                                          NPUT328
   87 CALL HEADNG(1)                                                    NPUT329
      WRITE(NP,88)                                                      NPUT330
   88 FORMAT(//43X,33H DISTRIBUTION DATA FOR RECYCLING ,                NPUT331
     */42X,35HDURING PERIODS OF WATER RESTRICTION,                      NPUT332
     */43X,33H       (DATA CARD TYPE VII )       ,///)                  NPUT333
      WRITE(NP,89)                                                      NPUT334
   89 FORMAT(44X,4HUSER,6X,5HLEVEL,5X,10HPERCENTAGE,//)                 NPUT335
      DO 93 I=1,35                                                      NPUT336
      WRITE(NP,90) IDIST(I),LDIST(I),DIST(I)                            NPUT337
   90 FORMAT(46X,2(I1,9X),F7.4)                                         NPUT338
      IF(IDIST(I) .GT. 5)WRITE(NP,91)                                   NPUT339
      IF(LDIST(I) .GT. 4)WRITE(NP,92)                                   NPUT340
   91 FORMAT(1H+,46X,8H-INVALID)                                        NPUT341
   92 FORMAT(1H+,56X,8H-INVALID)                                        NPUT342
   93 CONTINUE                                                          NPUT343
      GO TO 99                                                          NPUT344
   94 CALL HEADNG(1)                                                    NPUT345
      WRITE(NP,95)                                                      NPUT346
   95 FORMAT(//43X,33H CONTINUOUS DEMANDS FOR RECYCLED ,                NPUT347
     */43X,33H            WATER DATA             ,                     NPUT348
     */43X,33H       (DATA CARD TYPE VIII)       ,///)                 NPUT349
      WRITE(NP,96)                                                      NPUT350
   96 FORMAT(44X,4HUSER,6X,5HLEVEL,7X,6HAMOUNT,//)                      NPUT351
      DO 98 I=1,35                                                      NPUT352
      WRITE(NP,97) ICD(I),LCD(I),CD(I)                                  NPUT353
   97 FORMAT(46X,2(I1,9X),F7.0)                                         NPUT354
      IF(ICD(I) .GT. 5)WRITE(NP,91)                                     NPUT355
      IF(LCD(I) .GT. 4)WRITE(NP,92)                                     NPUT356
   98 CONTINUE                                                          NPUT357
   99 IF(NODS .EQ. 0)GO TO 101                                          NPUT358
      DO 100 I=1,NODS                                                   NPUT359
      LDIST(I)=LDIST(I)+1                                               NPUT360
  100 CONTINUE                                                          NPUT361
  101 IF(NOCD .EQ. 0)GO TO 103                                          NPUT362
      DO 102 I=1,NOCD                                                   NPUT363
      LCD(I)=LCD(I)+1                                                   NPUT364
  102 CONTINUE                                                          NPUT365
C     ------------------------------------------------------------------ NPUT366
C     ******AVERAGE MONTHLY RAINFALL DATA   DATA CARD TYPE IX           NPUT367
C     ------------------------------------------------------------------ NPUT368
  103 READ(NR,104) (RAINAV(I),I=1,12)                                   NPUT369
  104 FORMAT(8X,12F6.3)                                                 NPUT370
      IF(OCIX .EQ. 0)GO TO 107                                          NPUT371
      WRITE(NP,105) (J,J=1,12)                                          NPUT372
  105 FORMAT(///40X,39H******AVERAGE MONTHLY RAINFALL DATA******,       NPUT373
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     */50X,20H(DATA CARD TYPE IX ),                                     NPUT374
     *//13X,12(2X,I2,4X))                                               NPUT375
      WRITE(NP,106) (RAINAV(I),I=1,12)                                  NPUT376
  106 FORMAT(13X,12(F6.3,2X))                                           NPUT377
C     ------------------------------------------------------------------ NPUT378
C     ******AGRICULTURE DEMAND DATA   DATA CARD TYPE X                  NPUT379
C     ------------------------------------------------------------------ NPUT380
  107 READ(NR,108) (QA(I),I=1,12)                                       NPUT381
  108 FORMAT(8X,12F6.0)                                                 NPUT382
      IF(DCX .EQ. 0)GO TO 111                                           NPUT383
      CALL HEADNG(1)                                                    NPUT384
      WRITE(NP,109) (J,J=1,12)                                          NPUT385
  109 FORMAT(///43X,33H*****AGRICULTURE DEMAND DATA*****,               NPUT386
     */50X,20H(DATA CARD TYPE X  ),                                     NPUT387
     *//13X,12(2X,I2,4X))                                               NPUT388
      WRITE(NP,110) (QA(I),I=1,12)                                      NPUT389
  110 FORMAT(13X,12(F6.0,2X))                                           NPUT390
C     ------------------------------------------------------------------ NPUT391
C     ******MONTHLY WELL FLOW DATA   DATA CARD TYPE XI                  NPUT392
C     ------------------------------------------------------------------ NPUT393
  111 READ(NR,108) (WELLS(I),I=1,12)                                    NPUT394
      IF(DCXI .EQ. 0)GO TO 113                                          NPUT395
      WRITE(NP,112) (J,J=1,12)                                          NPUT396
  112 FORMAT(///43X,32H*****MONTHLY WELL FLOW DATA*****,                NPUT397
     */50X,20H(DATA CARD TYPE XI ),                                     NPUT398
     *//13X,12(2X,I2,4X))                                               NPUT399
      WRITE(NP,110) (WELLS(I),I=1,12)                                   NPUT400
C     ------------------------------------------------------------------ NPUT401
C     ******MONTHLY PROJECT FLOW DATA   DATA CARD TYPE XII              NPUT402
C     ------------------------------------------------------------------ NPUT403
  113 READ(NR,108) (PROJCT(I),I=1,12)                                   NPUT404
      IF(DCXII .EQ. 0)GO TO 115                                         NPUT405
      WRITE(NP,114) (J,J=1,12)                                          NPUT406
  114 FORMAT(///42X,35H*****MONTHLY PROJECT FLOW DATA*****,             NPUT407
     */50X,20H(DATA CARD TYPE XII),                                     NPUT408
     *//13X,12(2X,I2,4X))                                               NPUT409
      WRITE(NP,110) (PROJCT(I),I=1,12)                                  NPUT410
  115 RETURN                                                            NPUT411
      END                                                               NPUT412
      SUBROUTINE OUTPUT(NCFILE)                                         OUTP001
      COMMON/IODEV/NR,NP,NC,TAPE1,TAPE2,TAPE3                           OUTP002
      COMMON/M/T,YR,MO,YRST,NYRPRJ,RLEVEL,RROFF,RECYCL,OPTN1,OPTN2,     OUTP003
     *IDSNQ,FREQ,GRAPH,NODYS(12),RIMPR1,RLOCAL                          OUTP004
      COMMON/S/NSTA,NCSTA,N1,NAS,STNO(40),SNAME(40,5),TYPE(40),         OUTP005
     *NOCUTS(40),PC(40),SEAS1(40,3),SEAS2(40,3),CMIN(40,3),CMAX(40,3),  OUTP006
     *H(60,5),IYR,WELLS(12),PROJCT(12),SKIP                             OUTP007
      COMMON/D/PG,EG,DPR10C,DPRII,DFFCC,DEFOMC,PRICED,PRICEI,PRICEM,    OUTP008
     *PRICEC,PRICEN,PCP,EMPLOY,RAIN,RAINAV(12)                          OUTP009
      COMMON/AWT/CD(35),DIST(35),ICD(35),IDIST(35),LCD(35),LDIST(35),   OUTP010
     *LDR1,LDR2,LDR3,LDR4,LL(5),NOCD,NCDS,QA(12),PLTQ(12),PLSTO,PT1,    OUTP011
     *PT2,PT3,PPL,RITL,WCR                                              OUTP012
      COMMON/OUT/SWD(50,37),SSS(50,5),SAWT(5,5),DATES(10),AWTD(32,50),  OUTP013
     *INVC(50,6),OC(50,5),R(3),OTHRC(50,10)                             OUTP014
      REAL     LAB(32,3)                                                OUTP015
      REAL     LDR1,LDR2,LDR3,LDR4,LL                                   OUTP016
      REAL     INVC                                                     OUTP017
      REAL     PROC(10,3),PW(3,71),X(40,12),SNQ(40)                     OUTP018
      INTEGER TAPE1,TAPE2,TAPE3                                         OUTP019
      INTEGER T,YR,MO,YRST,RECYCL,OPTN1,OPTN2,IDSNQ,FREQ,GRAPH          OUTP020
      INTEGER STNO,TYPE,SEAS1,SEAS2,SKIP                                OUTP021
      INTEGER PT1,PT2,PT3,RITL                                          OUTP022
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      INTEGER DATES                                                     OUTP023
      INTEGER Z(10),LYR(50),STA                                         OUTP024
      DATA LAB/8H RESERVO,8H-SYSTEM ,8H=SECONDA,8H-LOCAL W,8H-WATER S,  OUTP025
     *8H-AGRICUL,8H=FLOW AV,8H-CUTBACK,8H=FLOW TO,8H+FLOW, R,8H=FLOW TH, OUTP026
     *8H-CONSUMP,8H-DEMAND ,8H-FLOW RE,8H=FLOW TH,8H-CONSUMP,8H-DEMAND , OUTP027
     *8H=FLOW TH,8H-CONSUMP,8H-DEMAND ,8H=FLOW AV,8H-RESERVO,8H=FLOW TH, OUTP028
     *8H-RESERVO,8H-DEMAND ,8H=FLOW RE,8H FLOW RE,8H+CUTBACK,8H=FLOW RE, OUTP029
     *8H+FLOW RE,8H=FLOW RE,8H CHECK R,8HIR FLOW ,8HLOSSES  ,8HRY TREAT, OUTP030
     *8HATER    ,8HOLD     ,8HTURE USE,8HAILABLE ,8HS        ,8H AWT, PA, OUTP031
     *8HECYCLED ,8HRU LEVEL,8HTION LEV,8HAT LEVEL,8HTURNED,S,8HRU LEVEL, OUTP032
     *8HTION LEV,8HAT LEVEL,8HRU LEVEL,8HTION LEV,8HAT LEVEL,8HAILABLE , OUTP033
     *8HIR DEMAN,8HRU LEVEL,8HIR DEMAN,8HAT LEVEL,8HTURNED,S,8HTURNED, , OUTP034
     *8HS AND EX,3*8HTURNED,S,8HFSULT   ,2*8H         ,                 OUTP035
     *8HED FLOW ,3*8H         ,8HAT AWT  ,8H         ,8HSS 1    ,        OUTP036
     *8H        ,8H 1       ,8HEL I    ,8H I       ,8HTREAMS,T,8H 2      , OUTP037
     *8HEL 2    ,8H 2       ,8H 3      ,8HEL 3     ,8H 3       ,8HLEVEL 4 , OUTP038
     *8HDS,U    ,8H 4       ,8HDS,T    ,8H 4       ,8HTREAMS,T,8HUSERS   , OUTP039
     *8HCESSES  ,8HTREAMS,U,8HTREAMS,T,8HTREAMS,S,8H        /            OUTP040
      DATA PROC/4HCOAG,4H FIL,4H GRA,4H ACT,4H----,4HSEDI,4H    ,        OUTP041
     *4HCARB,4H   S,4H    ,4HULAT,4HTRAT,4HNULA,4HIVAT,4HNONF,4HMFNT,   OUTP042
     *4H    ,4H ABS,4HLUUG,4H    ,4HION-,4HION ,4HTED ,4HED- ,4H----,   OUTP043
     *4HATIN,4H    ,4HORP.,4HE   ,4H    /                               OUTP044
      DATA Z/3,7,9,11,15,18,21,23,26,32/                                OUTP045
      IF(T .GT. NYRPRJ*12)GO TO 4                                       OUTP046
      NYRPRJ=T/12                                                       OUTP047
      NDEC=NYRPRJ/10+1                                                  OUTP048
      IF(NDEC .GT. 5)NDEC=5                                             OUTP049
      GO TO 3                                                           OUTP050
    4 NDEC=NYRPRJ/10                                                    OUTP051
    3 DO 5 I=1,NYRPRJ                                                   OUTP052
      LYR(I)=YRST+(I-1)                                                 OUTP053
    5 CONTINUE                                                          OUTP054
C     ------------------------------------------------------------------ OUTP055
C     ******PREPARE THE REMAINNING OUTPUT DATA                          OUTP056
C     ------------------------------------------------------------------ OUTP057
      DO 10 I=1,NYRPRJ                                                  OUTP058
      SWD(I,35)=SWD(I,2)+SWD(I,10)+SWD(I,17)+SWD(I,23)+SWD(I,27)+       OUTP059
     *SWD(I,31)                                                         OUTP060
      SWD(I,36)=SWD(I,8)+SWD(I,15)+SWD(I,21)+SWD(I,25)+SWD(I,29)+       OUTP061
     *SWD(I,33)                                                         OUTP062
      SWD(I,37)=SWD(I,9)+SWD(I,16)+SWD(I,22)+SWD(I,26)+SWD(I,30)+       OUTP063
     *SWD(I,34)                                                         OUTP064
      SWD(I,19)=SWD(I,5)                                                OUTP065
      SWD(I,20)=SWD(I,6)                                                OUTP066
      IF(SWD(I,3) .LE. 0.0)GO TO 10                                     OUTP067
      SWD(I,4)=(SWD(I,2)/SWD(I,3))*1000.0                               OUTP068
      SWD(I,18)=(SWD(I,17)/SWD(I,3))*1000.0                             OUTP069
      IF(SWD(I,11) .LE. 0.0)GO TO 10                                    OUTP070
      SWD(I,12)=(SWD(I,10)/SWD(I,11))*1000.0                            OUTP071
   10 CONTINUE                                                          OUTP072
      DO 15 I=1,NDEC                                                    OUTP073
      IX=1+(I-1)*10                                                     OUTP074
      IT=IX+9                                                           OUTP075
      IF(IT .GT. NYRPRJ)IT=NYRPRJ                                       OUTP076
      DO 15 J=1,5                                                       OUTP077
      DO 15 K=IX,IT                                                     OUTP078
      SAWT(I,J)=AMAX1(SAWT(I,J),INVC(K,J))                              OUTP079
   15 CONTINUE                                                          OUTP080
      DO 20 I=1,NYRPRJ                                                  OUTP081
      AWTO(32,I)=AWTO(1,I)-AWTO(2,I)-AWTO(4,I)-AWTO(5,I)-AWTO(6,I)      OUTP082
     *-AWTO(8,I)+AWTO(10,I)-AWTO(12,I)-AWTO(13,I)-AWTO(14,I)-AWTO(16,I) OUTP083
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     *-AWTO(17,I)-AWTO(19,I)-AWTO(20,I)-AWTO(22,I)-AWTO(24,I)-AWTO(25,I) OUTP084
     *+AWTO(27,I)+AWTO(28,I)+AWTO(14,I)-(AWTO(28,I)-AWTO(8,I))          OUTP085
   20 CONTINUE                                                          OUTP086
      DO 21 I=1,NYRPRJ                                                  OUTP087
      DO 21 J=1,5                                                       OUTP088
      INVC(I,J)=CCOST(J,INVC(I,J))*DEFCC                                OUTP089
      INVC(I,6)=INVC(I,6)+INVC(I,J)                                     OUTP090
   21 CONTINUE                                                          OUTP091
      DO 25 J=1,6                                                       OUTP092
      K=0                                                               OUTP093
      SUM=0.0                                                           OUTP094
      PW(1,J)=0.0                                                       OUTP095
      PW(2,J)=0.0                                                       OUTP096
      PW(3,J)=0.0                                                       OUTP097
      DO 25 I=1,NYRPRJ                                                  OUTP098
      IF(INVC(I,J) .LE. 0.0)GO TO 25                                    OUTP099
      IF(K .NE. 0)GO TO 22                                              OUTP100
      K=1                                                               OUTP101
      GO TO 24                                                          OUTP102
   22 INVC(I,J)=INVC(I,J)-SUM                                           OUTP103
      IF(INVC(I,J))23,25,24                                             OUTP104
   23 INVC(I,J)=0.0                                                     OUTP105
      GO TO 25                                                          OUTP106
   24 SUM=SUM+INVC(I,J)                                                 OUTP107
      PW(1,J)=PW(1,J)+INVC(I,J)*1.0/(1.0+R(1))**I                       OUTP108
      PW(2,J)=PW(2,J)+INVC(I,J)*1.0/(1.0+R(2))**I                       OUTP109
      PW(3,J)=PW(3,J)+INVC(I,J)*1.0/(1.0+R(3))**I                       OUTP110
   25 CONTINUE                                                          OUTP111
      DO 30 I=1,NYRPRJ                                                  OUTP112
      DO 30 J=1,4                                                       OUTP113
      OC(I,5)=OC(I,5)+OC(I,J)                                           OUTP114
   30 CONTINUE                                                          OUTP115
      DO 50 I=1,NYRPRJ                                                  OUTP116
      DO 52 J=6,9                                                       OUTP117
      OTHRC(I,J)=OTHRC(I,J)/1000000.0                                   OUTP118
   52 CONTINUE                                                          OUTP119
      OTHRC(I,5)=OTHRC(I,1)+OTHRC(I,2)+OTHRC(I,3)+OTHRC(I,4)            OUTP120
      OTHRC(I,10)=OTHRC(I,6)+OTHRC(I,7)+OTHRC(I,8)+OTHRC(I,9)           OUTP121
   50 CONTINUE                                                          OUTP122
      DO 51 J=7,16                                                      OUTP123
      PW(1,J)=0.0                                                       OUTP124
      PW(2,J)=0.0                                                       OUTP125
      PW(3,J)=0.0                                                       OUTP126
      DO 51 I=1,NYRPRJ                                                  OUTP127
      IF(OTHRC(I,J-6) .LE. 0.0)GO TO 51                                 OUTP128
      PW(1,J)=PW(1,J)+OTHRC(I,J-6)*1.0/(1.0+R(1))**I                    OUTP129
      PW(2,J)=PW(2,J)+OTHRC(I,J-6)*1.0/(1.0+R(2))**I                    OUTP130
      PW(3,J)=PW(3,J)+OTHRC(I,J-6)*1.0/(1.0+R(3))**I                    OUTP131
   51 CONTINUE                                                          OUTP132
      DO 53 J=17,21                                                     OUTP133
      PW(1,J)=0.0                                                       OUTP134
      PW(2,J)=0.0                                                       OUTP135
      PW(3,J)=0.0                                                       OUTP136
      DO 53 I=1,NYRPRJ                                                  OUTP137
      PW(1,J)=PW(1,J)+OC(I,J-16)*1.0/(1.0+R(1))**(                      OUTP138
      PW(2,J)=PW(2,J)+OC(I,J-16)*1.0/(1.0+R(2))**I                      OUTP139
      PW(3,J)=PW(3,J)+OC(I,J-16)*1.0/(1.0+R(3))**I                      OUTP140
   53 CONTINUE                                                          OUTP141
C     ------------------------------------------------------------------ OUTP142
C     ******INTERMEDIATE NET STREAM FLOW OUTPUT                          OUTP143
C     ------------------------------------------------------------------ OUTP144
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      IF(IDSNO .EQ. 0)GO TO 99                                          OUTP145
      IFRQ=0                                                            OUTP146
      END FILE TAPE2                                                    OUTP147
      REWIND TAPE2                                                      OUTP148
      DO 45 I=1,NYRPRJ                                                  OUTP149
      DO 41 J=1,12                                                      OUTP150
      READ(TAPE2) (SNO(STA),STA=1,NOSTA)                                OUTP151
      IF(EOF(TAPE2))99,35                                               OUTP152
   35 DO 41 STA=1,NOSTA                                                 OUTP153
      X(STA,J)=SNO(STA)                                                 OUTP154
   41 CONTINUE                                                          OUTP155
      IFRQ=IFRQ+1                                                       OUTP156
      IF(IFRQ .NE. FREQ)GO TO 45                                        OUTP157
      IFRQ=0                                                            OUTP158
      CALL HEADNG(1)                                                    OUTP159
      WRITE(NP,42) LYR(I),(N,N=1,12)                                    OUTP160
   42 FORMAT(///36X,38H*****INTERMEDIATE NET STREAM FLOW DATA ,I4,      OUTP161
     *5H*****,//5X,3HSTA,3X,12(2X,I2,5X))                               OUTP162
      DO 44 STA=1,NOSTA                                                 OUTP163
      WRITE(NP,43) STNO(STA),(X(STA,N),N=1,12)                          OUTP164
   43 FORMAT(5X,I3,1213X,F6.3)1                                         OUTP165
   44 CONTINUE                                                          OUTP166
   45 CONTINUE                                                          OUTP167
C     ------------------------------------------------------------------ OUTP168
C     ******ANNUAL SUMMARY OF WATER DEMAND BY ALL USERS                 OUTP169
C     ------------------------------------------------------------------ OUTP170
   99 CALL HEADNG(1)                                                    OUTP171
      WRITE(NP,100)                                                     OUTP172
  100 FORMAT(///38X,43HANNUAL SUMMARY OF WATER DEMAND BY ALL USERS,///) OUTP173
      WRITE(NP,101)                                                     OUTP174
  101 FORMAT(17X,25(1H-),17H D O M E S T I C ,26(1H-),2X,19(1H-),14H I N OUTP175
     * D U S T R,/8X,7HPERCENT,5X,5HTOTAL,3X,10HPOPULATION,1X,10HPER CAP OUTP176
     *ITA,                                                              OUTP177
     *2(7H PRICE ),7H RAIN- ,7H TOTAL ,8H REVENUE,5X,5HTOTAL,3X,        OUTP178
     *23HEMPLOYMENT PER CAPITA L,                                       OUTP179
     */1X,26HYEAR RESTRICTIN WATER  USE,12X,31HWATER  USE WINTER SUMMER OUTP180
     *FALLS ,27HREVENUE LOST/RS  WATER  USE,12X,12HWATER  USE L,        OUTP181
     */6X,10HOF  DEMAND,4X,4H(MG),4X,9HTHOUSANDS,5X,4H (G),4X,          OUTP182
     *2(7H$/1000 ),1X,1HIN    1000$,5X,1H$,8X,4H(MG),4X,9HTHOUSANDS,    OUTP183
     *5X,9H (G)    L,//)                                                OUTP184
      DO 103 I=L,NYRPRJ                                                 OUTP185
      WRITE(NP,102) LYR(I),(SWD(I,J),J=1,12)                            OUTP186
  102 FORMAT(1X,I4,4X,2PF4.1,6X, 0PF6.0,5X,-3PF6.0,5X, 0PF6.0,3X,       OUTP187
     *2(0PF6.3,1X),0PF5.1,1X,-3PF7.1,1X,0PF7.1,4X, 0PF6.0,5X,-3PF6.0,   OUTP188
     *5X, 0PF6.0)                                                       OUTP189
  103 CONTINUE                                                          OUTP190
      CALL HEADNG(1)                                                    OUTP191
      WRITE(NP,100)                                                     OUTP192
      WRITE(NP,104)                                                     OUTP193
  104 FORMAT(1X,7H I N D U ,22(1H-),2X,15(1H-),21H C O M M E R C I A L ,OUTP194
     *15(1H-),2X,8(1H-),17H M I L I T A R Y ,8(1H-),                    OUTP195
     */1X,2(7HPRICE  ),15H TOTAL  REVENUE,5X,5HTOTAL,3X,10HPER CAPITA,  OUTP196
     *21(7H PRICE ),2X,5HTOTAL,2X,7HREVENUE,5X,5HTOTAL,3X,5HPRICE,3X,   OUTP197
     *5HTOTAL,2X,9HREVENUE L,                                           OUTP198
     */1X,52HWINTER SUMMER REVENUE LOST/RS  WATER  USE WATER  USE,      OUTP199
     *43H WINTER SUMMER REVENUE LOST/RS  WATER  USE ,7X,17HREVENUE LOST/ OUTP200
     *RS L,                                                             OUTP201
     */1X,2(7H$/1000 ),8H 1000$  ,3X,1H$,8X,4H(MG),7X,4H (G),4X,        OUTP202
     *2(7H$/1000 ),8H 1000$  ,3X,1H$,8X,4H(MG),4X,7H$/1000 ,8H 1000$  , OUTP203
     *3X,1H$,4X,1HL,//)                                                 OUTP204
      DO 106 I=1,NYRPRJ                                                 OUTP205
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      WRITE(NP,105) (SWD(I,J),J=13,26)                                  OUTP206
  105 FORMAT(1X,2(0PF6.3,1X),-3PF7.1,1X,0PF7.1,2X,2(2X, 0PF6.0,3X),     OUTP207
     *2(0PF6.3,1X),                                                     OUTP208
     *-3PF7.1,1X,0PF7.1,4X, 0PF6.0,3X,0PF6.3,1X,-3PF7.1,1X,0PF7.1)      OUTP209
  106 CONTINUE                                                          OUTP210
      CALL HEADNG(1)                                                    OUTP211
      WRITE(NP,100)                                                     OUTP212
      WRITE(NP,107)                                                     OUTP213
  107 FORMAT(1X,7(1H-),19H M U N I C I P A L ,7(1H-),2X,5(1H-),23H N O N OUTP214
     *   P O T A B L E ,5(1H-),                                         OUTP215
     */1X,2(35H   TOTAL   PRICE   TOTAL  REVENUE  ),1X,8HCOMBINED,1X,   OUTP216
     *2(1X,8HCOMBINED),                                                 OUTP217
     */1X,2(10HWATER  USE,8X,15HREVENUE LOST/RS,2X),10HWATER  USE,1X,   OUTP218
     *22HREVENUES LOST/RES YEAR,                                        OUTP219
     */1X,2(3X,4H(MG),4X,14H$/1000  1000$ ,4X,1H$,5X),3X,4H(MG),5X,     OUTP220
     *5H1000$,7X,1H$,//)                                                OUTP221
      DO 109 I=1,NYRPRJ                                                 OUTP222
      WRITE(NP,108) (SWD(I,J),J=27,37),LYR(I)                           OUTP223
  108 FORMAT(1X,2(2X, 0PF6.0,3X,0PF6.3,1X,-3PF7.1,1X,0PF7.1,2X),1X,     OUTP224
     * 0PF7.0,4X,-3PF7.0,2X,0PF7.0,1X,I4)                                OUTP225
  109 CONTINUE                                                          OUTP226
C     ------------------------------------------------------------------ OUTP227
C     ******ANNUAL SUMMARY OF SUPPLY IN STORAGE                         OUTP228
C     ------------------------------------------------------------------ OUTP229
      CALL HEADNG(1)                                                    OUTP230
      WRITE(NP,110)                                                     OUTP231
  110 FORMAT(///42X,35HANNUAL SUMMARY OF SUPPLY IN STORAGE,///)         OUTP232
      WRITE(NP,111)                                                     OUTP233
  111 FORMAT(33X,9HRESERVOIR,3X,11HPERCENT MAX,3X,12HMAX CAPACITY,3X,   OUTP234
     *8H  TOTAL ,3X,11HPROBABILITY                                      OUTP235
     */76X,4HYEAR,3X,9H  LEVEL  ,3X,11HCAPACITY ON,3X,12H 10  ANNUAL ,  OUTP236
     *3X,8H  FLOW  ,3X,11H OF  TOTAL ,                                  OUTP237
     */33X,9H(000)  AF,3X,11H   JAN 1   ,3X,12H WATER  USE ,3X,         OUTP238
     *8H C.F.S. ,3X,1)H   FLOW    ,//)                                  OUTP239
      DO 113 I=1,NYRPRJ                                                 OUTP240
      WRITE(NP,112) LYR(I),(SSSI(I,J),J=1,5)                            OUTP241
  112 FORMAT(26X,I4,5X,-3PF5.0,9X,2PF3.0,10X,0PF5.2,7X, 0PF6.0,7X,0PF5.3 OUTP242
     *)                                                                 OUTP243
  113 CONTINUE                                                          OUTP244
C     ------------------------------------------------------------------ OUTP245
C     ******SUMMARY OF ADVANCED WASTE TREATMENT BY DECADE               OUTP246
C     ------------------------------------------------------------------ OUTP247
      CALL HEADNG(1)                                                    OUTP248
      WRITE(NP,114)                                                     OUTP249
  114 FORMAT(///35X,50HSUMMARY OF ADVANCED WASTE TREATMENT(AWT) BY DECAD OUTP250
     *E,/48X,24H(IN MILLIONS OF GALLONS),///)                           OUTP251
      WRITE(NP,115)                                                     OUTP252
  115 FORMAT(18X,6HDECADE,3X,13HCOAGULATION ),3X,13H FILTRATION  ,      OUTP253
     *3X,13H GRANULATED  ,3X,13H  ACTIVATED  ,3X,13H     ION     ,      OUTP254
     */27X,13HSEDIMENTATION,19X,13HCARB ABSORPTN,3X,13H   SLUDGE        OUTP255
     *4X,13H  EXCHANGE   ,//)                                           OUTP256
      DO 117 I=1,NDEC                                                   OUTP257
      WRITE(NP,116) I,(SAWT(I,J),J=1,5)                                 OUTP258
  116 FORMAT(20X,I2,5X,5(3X,0PF7.1,6X))                                 OUTP259
  117 CONTINUE                                                          OUTP260
C     ------------------------------------------------------------------ OUTP261
C     ******STREAM ADDITIONS                                            OUTP262
C     ------------------------------------------------------------------ OUTP263
      CALL HEADNG(1)                                                    OUTP264
      WRITE(NP,118)                                                     OUTP265
  118 FORMAT(///47X,26H*****STREAM ADDITIONS*****,///)                  OUTP266
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      WRITE(NP,119)
  119 FORMAT(39X,5HDATES,4X,3HSTA,7X,12HSTREAM  NAME,7X,4HTYPE,//)
      NAS=NAS-1
      IF(NAS .EQ. 0)GO TO 128
      DO 121 I=1,NAS
      IX=DATES(I)/12
      IT=DATES(I)-IX*12
      IX=YRST+IX
      J=NSTA-NAS+I
      WRITE(NP,120) IX,IT,STNO(J),(SNAME(J,K),K=1,5),TYPE(J)
  120 FORMAT(38X,I4,1H/,I2,3X,I3,3X,5A4,4X,I2)
  121 CONTINUE
C     ------------------------------------------------------------------
C     ******ADVANCED WASTE TREATMENT OPERATION BY YEAR
C     ------------------------------------------------------------------
  128 DO 127 I=1,NDEC
      CALL HEADNG(1)
      WRITE(NP,122)
  122 FORMAT(///39X,42HADVANCED WASTE TREATMENT OPERATION BY YEAR,
     */48X,24H(IN MILLIONS OF GALLONS),///)
      IX=1+(I-1)*10
      IT=IX+9
      IF(IT .GT. NYRPRJ)IT=NYPPRJ
      WRITE(NP,123) (LYR(J),J=IX,IT)
  123 FORMAT(33X,10(IX,I4,3X))
      WRITE(NP,124)
  124 FORMAT(1H0)
      K=1
      DO 127 L=1,32
      IF(L .NE. Z(K))GO TO 125
      WRITE(NP,124)
      K=K+1
  125 WRITE(NP,126) (LAB(L,J),J=1,3),(AWTO(L,N),N=IX,IT)
  126 FORMAT(9X,3A8,10(2X,F6.0))
  127 CONTINUE
C     ------------------------------------------------------------------
C     ******INVESTMENT COSTS AND PRESENT WORTH
C     ------------------------------------------------------------------
      CALL HEADNG(1)
      WRITE(NP,130)
  130 FORMAT(///40X,40H*****INVESTMENT COST SERIES BY YEAR*****,
     */48X,24H(IN MILLIONS OF DOLLARS),//)
      WRITE(NP,131)
  131 FORMAT(10X,6H YEAR ,3X,13HCOAGULATION ),3X,13H FILTRATION  ,
     *3X,13H GRANULATED  ,3X,13H  ACTIVATED  ,3X,13H     ION     ,
     *3X,13H  TOTAL ALL  ,
     */19X,13HSEDIMENTATION,19X,13HCARB ABSORPTN,3X,13H   SLUDGE
     *4X,13H  EXCHANGE   ,2X,13H  PROCESSES  ,//)
      DO 133 I=1,NYRPRJ
      WRITE(NP,132) LYR(I),(INVC(I,J),J=1,6)
  132 FORMAT(11X,I4,3X,6(3X,F7.1,6X))
  133 CONTINUE
C     ------------------------------------------------------------------
C     ******FIXED AND VARIABLE COSTS FOR STREAM, RESERVOIR, WELL AND PRJ
C     ------------------------------------------------------------------
      CALL HEADNG(1)
      WRITE(NP,160)
  160 FORMAT(//37X,46H*****FIXED AND VARIABLE COSTS FOR STREAM,*****,
     */41X,38HRESERVOIR, WELL, AND PROJECT ADDITIONS,
     */48X,24H(IN MILLIONS OF DOLLARS),
     *//7X,16(1H-),22H F I X E D  C O S T S ,17(1H-),1X,13(1H-),
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     *28H V A R I A B L E  C O S T S ,14(1H-),                          OUTP328
     */3X,4HYEAR,2(1X,10H  STREAM  ,1X,10HRESERVOIRS,1X,10H   WELL   ,1X OUTP329
     *,10H PROJECTS ,1X,10H   TOTAL  ),//)                              OUTP330
      DO 162 I=1,NYRPRJ                                                 OUTP331
      WRITE(NP,161) LYR(I),(OTHRC(I,J),J=1,10)                          OUTP332
  161 FORMAT(3X,I4,5(1X,F10.2),1X,5(F10.3,1X))                          OUTP333
  162 CONTINUE                                                          OUTP334
C     ------------------------------------------------------------------ OUTP335
C     ******PRESENT WORTH SERIES                                        OUTP336
C     ------------------------------------------------------------------ OUTP337
      CALL HEADNG(1)                                                    OUTP338
      WRITE(NP,134)                                                     OUTP339
  134 FORMAT(///40X,39HPRESENT WORTH OF INVESTMENT COST SERIES,         OUTP340
     */48X,24H(IN MILLIONS OF DOLLARS),//)                              OUTP341
      WRITE(NP,137)                                                     OUTP342
  137 FORMAT(//19X,13HCOAGULATION ),3X,13H FILTRATION  ,                OUTP343
     *3X,13H GRANULATED  ,3X,13H  ACTIVATED  ,3X,13H     ION            OUTP344
     *3X,13H  TOTAL ALL  ,                                              OUTP345
     */19X,13HSEDIMENTATION,19X,13HCARB ABSORPTN,3X,13H   SLUDGE    ,   OUTP346
     *4X,13H  EXCHANGE   ,2X,13H  PROCESSES  ,//)                       OUTP347
      DO 136 I=1,3                                                      OUTP348
      WRITE(NP,135) R(I),(PW(I,J),J=1,6)                                OUTP349
  135 FORMAT(9X,3HAT ,2PF4.2,2H+ ,6(3X,0PF7.1,6X))                      OUTP350
  136 CONTINUE                                                          OUTP351
      WRITE(NP,170)                                                     OUTP352
  170 FORMAT(///40X,41HPRESENT WORTH OF FIXED AND VARIABLE COSTS,       OUTP353
     */48X,24H(IN MILLIONS OF DOLLARS),                                 OUTP354
     *//9X,16(1H-),22H F I X E D  C O S T S ,17(1H-),1X,13(1H-),        OUTP355
     *28H V A R I A B L E  C O S T S ,14(1H-),                          OUTP356
     */9X,2(1X,10H  STREAM  ,1X,10HRESERVOIRS,1X,10H   WELL   ,1X,10H PR OUTP357
     *OJECTS ,1X,10H   TOTAL  ),//)                                    OUTP358
      DO 172 I=1,3                                                      OUTP359
      WRITE(NP,171) R(I),(PW(I,J),J=7,16)                               OUTP360
  171 FORMAT(1X,3HAT ,2PF4.2,1H+,10(1X,0PF10.2))                        OUTP361
  172 CONTINUE                                                          OUTP362
      WRITE(NP,180)                                                     OUTP363
  180 FORMAT(///36X,48HPRESENT WORTH OF OPERATION AND MAINTENANCE COSTS, OUTP364
     */48X,25H(IN.THOUSANDS.OF.DOLLARS),//)                             OUTP365
      WRITE(NP,181) (PROC(PT1,J),J=1,3),(PROC(PT2,K),K=1,3),(PROC(PT3,L) OUTP366
     *,L=1,3)                                                           OUTP367
  181 FORMAT(25X,3(3X,3A4),3X,12H    ION-    ,3X,12H   TOTAL    )      OUTP368
      WRITE(NP,182) (PROC(PT1+5,J),J=1,3),(PROC(PT2+5,K),K=1,3),(PROC(PT OUTP369
     *3+5,L),L=1,3)                                                     OUTP370
  182 FORMAT(28X,3(3X,3A4),12H  EXCHANGE  ,//)                          OUTP371
      DO 184 I=1,3                                                      OUTP372
      WRITE(NP,183) R(I),(PW(I,J),J=17,21)                              OUTP373
  183 FORMAT(18X,3HAT ,2PF4.2,1H+,2X,5(2X,-3PF8.0,5X))                  OUTP374
  184 CONTINUE                                                          OUTP375
C     ------------------------------------------------------------------ OUTP376
C     ******OPERATION AND MAINTENANCE COSTS                             OUTP377
C     ------------------------------------------------------------------ OUTP378
      CALL HEADNG(1)                                                    OUTP379
      WRITE(NP,140)                                                     OUTP380
  140 FORMAT(///40X,39HOPERATION AND MAINTENANCE COSTS BY YEAR,         OUTP381
     */48X,25H(IN.THOUSANDS.OF.DOLLARS),//)                             OUTP382
      WRITE(NP,141) (PROC(PT1,J),J=1,3),(PROC(PT2,K),K=1,3),(PROC(PT3,L) OUTP383
     *,L=1,3)                                                           OUTP384
  141 FORMAT(21X,4HYEAR,3(3X,3A4),3X,12H    ION-    ,3X,12H   TOTAL    ) OUTP385
      WRITE(NP,143) (PROC(PT1+5,J),J=1,3),(PROC(PT2+5,K),K=1,3),(PROC(PT OUTP386
     *3+5,L),L=1,3)                                                     OUTP387
  143 FORMAT(28X,3(3A4,3X),12H  EXCHANGE  ,3X,12H   COSTS    ,//)       OUTP388
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      DO 146 I=1,NYRPRJ                                                 OUTP389
      WRITE(NP,145) LYR(I),(OC(I,J),J=1,5)                              OUTP390
  145 FORMAT(21X,I4,3X,5(2X,-3PF8.0,5X))                                OUTP391
  146 CONTINUE                                                          OUTP392
C     ------------------------------------------------------------------ OUTP393
C     ******LIST THE INTERRUPTS                                         OUTP394
C     ------------------------------------------------------------------ OUTP395
      CALL INTRPT(YRST,0.0,0.0,0.0,0.0)                                 OUTP396
C     ------------------------------------------------------------------ OUTP397
C     ******DUMP THE PLANNING MATRIX                                    OUTP398
C     ------------------------------------------------------------------ OUTP399
      CALL DUMP(NOFILE)                                                 OUTP400
C     ------------------------------------------------------------------ OUTP401
C     ******PUNCH DATA FOR GRAPH PROGRAM                                OUTP402
C     ------------------------------------------------------------------ OUTP403
      IF(GRAPH .EQ. 0)RETURN                                            OUTP404
      WRITE(NC,150)                                                     OUTP405
  150 FORMAT(10HPOPULATION)                                             OUTP406
      WRITE(NC,151) (SWD(YR,3),YR=1,NYRPRJ)                             OUTP407
  151 FORMAT(8F10.0)                                                    OUTP408
      WRITE(NC,152)                                                     OUTP409
  152 FORMAT(10HEMPLOYMENT)                                             OUTP410
      WRITE(NC,151) (SWD(YR,11),YR=1,NYRPRJ)                            OUTP411
      WRITE(NC,153)                                                     OUTP412
  153 FORMAT(30HPER CAPITA WATER USE  DOMESTIC)                         OUTP413
      WRITE(NC,151) (SWD(YR,4),YR=1,NYRPRJ)                             OUTP414
      WRITE(NC,154)                                                     OUTP415
  154 FORMAT(32HPER CAPITA WATER USE  COMMERCIAL)                       OUTP416
      WRITE(NC,151) (SWD(YR,18),YR=1,NYRPRJ)                            OUTP417
      WRITE(NC,156)                                                     OUTP418
  156 FORMAT(29HPERCENT CAPACITY OF RESERVOIR)                          OUTP419
      WRITE(NC,157) (SSS(YR,2),YR=1,NYRPRJ)                             OUTP420
  157 FORMAT(8F10.5)                                                    OUTP421
      WRITE(NC,158)                                                     OUTP422
  158 FORMAT(21HTOTAL WATER USE IN MG)                                  OUTP423
      WRITE(NC,151) (SWD(YR,35),YR=1,NYRPRJ)                            OUTP424
      WRITE(NC,159)                                                     OUTP425
  159 FORMAT(13HRANK OF FLOWS)                                          OUTP426
      WRITE(NC,157) (SSS(YR,5),YR=1,NYRPRJ)                             OUTP427
      RETURN                                                            OUTP428
      END                                                               OUTP429
      SUBROUTINE INTRPT(IT,CODE,VALUE1,VALUE2,VALUE3)                   NTRPT01
      COMMON/TOOFV/NR,NP,NC,TAPE1,TAPE2,TAPE3                           NTRPT02
      REAL    MESS(18,6)                                                NTRPT03
      INTEGER TAPE1,TAPE2,TAPE3                                         NTRPT04
      INTEGER T,CODE                                                    NTRPT05
      DATA MESS/8HSPILLAGE,8HLEVEL BE,8HRESERVOI,8HPLAN FIL,8HIMPLEMEN, NTRPT06
     *8HIMPLEMEN,8HIMPLEMEN,8HIMPLEMEN,8HRECYCLIN,8HPERCENTA,8HLEVELS I, NTRPT07
     *8HITTERRAT,8HDISTRIBU,8HCO-STAND,8HCO-STAND,8HINDUSTRI,8HCO-STAND, NTRPT08
     *8HCO-STAND,8H        ,8HLOW CONS,8HR EMPTY ,8HE 5 EXPA,8HTATION O, NTRPT09
     *8HTATION O,8HTATION O,8HTATION O,8HG IMPLEM,8HGE RATIO,8H THRU 4 , NTRPT10
     *8HION LIMI,8HTION MOD,8HBY DEMAN,8HBY DEMAN,8HAL EQUAT,8HBY DEMAN, NTRPT11
     *8HBY DEMAN,8H        ,8HERVATION,8H        ,8HUSTED  ,8HE NEW ST, NTRPT12
     *8HE NEW RE,8HE NEW WE,8HE NEW PR,8HENTED   ,8HNNING EX,8HSUM TO Z, NTRPT13
     *8HT EXCEED,8HIFICATIO,8HD MODIFI,8HD MODIFI,8HION CONS,8HD MODIFI, NTRPT14
     *8HD ADDED ,8H        ,8H POOL  ,8H        ,8H        ,8HREAM CHM, NTRPT15
     *8HSERVICR ,8HLL COMPL,8HOJECT CO,8H        ,8HCEEDS LI,8HERO     , NTRPT16
     *8HED      ,8HN REQUES,8HCATION R,8HCATION R,8HTANT INC,8HEO AS SH, NTRPT17
     *8HAS SHOWN,8H        ,8H        ,8H        ,8HPLETED  , NTRPT18
     *8HCOMPLETE,8HETED    ,8HMPLETED ,8H        ,8HMIT     ,8H        , NTRPT19
     *8H        ,8HT INVALI,8HEQUESI I,8HEQUEST I,8HREASED  ,8HOWN    , NTRPT20
```

```
     *6*8H         ,8HD        ,6*8H         ,8HC        ,8HNVALID-A,        NTRPT21
     *8HNVALID-B,3*8H         /                                              NTRPT22
      IF(CODE .EQ. 0)GO TO 20                                                NTRPT23
      WRITE(TAPE3) T,CODE,VALUE1,VALUE2,VALUE3                               NTRPT24
      RETURN                                                                 NTRPT25
   20 END FILE TAPE3                                                         NTRPT26
      REWIND TAPE3                                                           NTRPT27
      IYR=T                                                                  NTRPT28
      CALL HEADNG(1)                                                         NTRPT29
      WRITE(NP,22)                                                           NTRPT30
   22 FORMAT(///,13X,15HE V E N T S....,//)                                  NTRPT31
   24 READ(TAPE3) NT,N,V1,V2,V3                                              NTRPT32
      IF(EOF(TAPE3))26,25                                                    NTRPT33
   25 IX=NT/12                                                               NTRPT34
      IT=NT-IX*12                                                            NTRPT35
      IX=IYR+IX                                                              NTRPT36
      WRITE(NP,23) NT,IX,IT,(MESS(N,L),L=1,6),V1,V2,V3                       NTRPT37
   23 FORMAT(13X,I3,2X,I4,1H/,I2,2X,6A8,2X,3F10.2)                           NTRPT38
      GO TO 24                                                               NTRPT39
   26 RETURN                                                                 NTRPT40
      END                                                                    NTRPT41
      SUBROUTINE EXPAND(FNO,T,XPLN,IR)                                       XPND001
      COMMON/PLANS/FE(6),LE(6),NE(6),PLN(9,80)                               XPND002
      INTEGER FE,LE,NE,PLN,XPLN(7),FNO,T                                     XPND003
      DATA IBOF,IEOF,IS,IP/7777,9999,8,9/                                    XPND004
C     ------------------------------------------------------------------- XPND005
C     THIS ROUTINE PERFORMS THE FILE MANAGEMENT OF THE VARIOUS PLANS        XPND006
C     THAT ARE TO BE IMPLEMENTED                                            XPND007
C                                                                           XPND008
C    VARIABLE              DESCRIPTION                                      XPND009
C     NAME                                                                  XPND010
C                                                                           XPND011
C     FE      FIRST ENTRY POINTER                                           XPND012
C     FNO     FILE NUMBER                                                   XPND013
C     IBOF    BEGINNING OF FILE CODE                                        XPND014
C     IEOF    END OF FILE CODE                                              XPND015
C     IP      PREDECESSOR POINTER                                           XPND016
C     IPT     POINTERS                                                      XPND017
C     IR      RETURN OF PLAN INDICATOR                                      XPND018
C     IS      SUCCESSOR POINTER                                             XPND019
C     LE      LAST ENTRY POINTER                                            XPND020
C     NE      NUMBER OF ENTRIES                                             XPND021
C     PLN     THE VARIOUS PLANS TO BE IMPLEMENTED                           XPND022
C             PLN(1,IPT) = PLAN NUMBER                                      XPND023
C             PLN(2,IPT) = START TIME/END TIME                              XPND024
C             PLN(3,IPT) = LAG TIME                                         XPND025
C             PLN(4,IPT) = CODE                                             XPND026
C             PLN(5,IPT) = ATTRIBUTES 1 THRU 3                              XPND027
C     XPLN    THE PLAN REMOVED AND TO BE IMPLEMENTED AT TIME T              XPND028
C                                                                           XPND029
C     ------------------------------------------------------------------- XPND030
      GO TO (20,20,20,20,49,49),FNO                                          XPND031
C     ------------------------------------------------------------------- XPND032
C     IF THE TIME IS APPROPRIATE, REMOVE THE PLAN AT THE TOP OF FILE        XPND033
C     NUMBER 1 AND ADJUST THE POINTERS                                      XPND034
C     ------------------------------------------------------------------- XPND035
   20 IR=0                                                                   XPND036
      IF(NE(FNO) .GT. 0)GO TO 24                                             XPND037
      IF(NE(FNO) .LT. 0)RETURN                                               XPND038
      NE(FNO)=-1                                                             XPND039
      RETURN                                                                 XPND040
```

```
   24 IPT=FE(FNO)                                                       XPND041
      IF(T .NE. PLN(2,IPT))RETURN                                       XPND042
      IR=1                                                              XPND043
      DO 21 I=1,7                                                       XPND044
      XPLN(I)=PLN(I,IPT)                                                XPND045
   21 CONTINUE                                                          XPND046
      IF(PLN(IS,IPT) .EQ. IEOF)GO TO 22                                 XPND047
      FE(FNO)=PLN(IS,IPT)                                               XPND048
      IX=FE(FNO)                                                        XPND049
      PLN(IP,IX)=IEOF                                                   XPND050
   22 NE(FNO)=NE(FNO)-1                                                 XPND051
      DO 23 I=1,IP                                                      XPND052
      PLN(I,IPT)=0                                                      XPND053
   23 CONTINUE                                                          XPND054
      IF(NE(FNO) .NE. 0)RETURN                                          XPND055
      LE(FNO)=0                                                         XPND056
      FE(FNO)=0                                                         XPND057
      RETURN                                                            XPND058
C     ------------------------------------------------------------------ XPND059
C     REMOVE THE PLAN AT THE TOP OF FILE FNO AND INSERT IT IN FILE NUMBER XPND060
C     1 RANKED ON TIME (LVF).  ADJUST POINTERS APPROPRIATELY.           XPND061
C     ------------------------------------------------------------------ XPND062
   49 IF(NE(FNO) .GT. 0)GO TO 50                                        XPND063
      IF(NE(FNO) .LT. 0)RETURN                                          XPND064
      CALL INTRPT(T,4,0.0,0.0,0.0,0.0)                                  XPND065
      NE(FNO)=-1                                                        XPND066
      RETURN                                                            XPND067
   50 IPT2=FE(FNO)                                                      XPND068
      IR=0                                                              XPND069
      IF(PLN(2,IPT2).GT.0)IR=-1                                         XPND070
      KEY=PLN(3,IPT2)+T                                                 XPND071
      PLN(2,IPT2)=KEY                                                   XPND072
      IPT=PLN(IS,IPT2)                                                  XPND073
      IPT1=FE(1)                                                        XPND074
      IF (NE(1).GT.0)GO TO 51                                           XPND074A
      FE(1)=IPT2                                                        XPND075
      LE(1)=IPT2                                                        XPND076
      NE(1)=1                                                           XPND077
      PLN(IS,IPT2)=IEOF                                                 XPND078
      PLN(IP,IPT2)=IEOF                                                 XPND079
      GO TO 56                                                          XPND080
   51 IF(KEY .LT. PLN(2,IPT1))GO TO 53                                  XPND081
      IF(PLN(IS,IPT1) .EQ. IEOF)GO TO 52                                XPND082
      IPT1=PLN(IS,IPT1)                                                 XPND083
      GO TO 51                                                          XPND084
   52 PLN(IS,IPT2)=IEOF                                                 XPND085
      PLN(IP,IPT2)=LE(1)                                                XPND086
      PLN(IS,IPT1)=IPT2                                                 XPND087
      LE(1)=IPT2                                                        XPND088
      GO TO 55                                                          XPND089
   53 IF(PLN(IP,IPT1) .NE. IEOF)GO TO 54                                XPND090
      PLN(IS,IPT2)=FE(1)                                                XPND091
      PLN(IP,IPT1)=IPT2                                                 XPND092
      FE(1)=IPT2                                                        XPND093
      GO TO 55                                                          XPND094
   54 PLN(IS,IPT2)=IPT1                                                 XPND095
      PLN(IP,IPT2)=PLN(IP,IPT1)                                         XPND096
      IX=PLN(IP,IPT1)                                                   XPND097
      PLN(IS,IX)=IPT2                                                   XPND098
      PLN(IP,IPT1)=IPT2                                                 XPND099
   55 NE(1)=NE(1)+1                                                     XPND094
```

```
   56 NE(FNO)=NE(FNO)-1                                                 XPND095
      IF(NE(FNO).LE.0)GO TO 57                                          XPND95A
      IF(IPT.EQ.IEOF)GO TO 57                                           XPND95B
      FE(FNO)=IPT                                                       XPND096
      PLN(IP,IPT)=IHOF                                                  XPND097
      RETURN                                                            XPND098
   57 FE(FNO)=0                                                         XPND98A
      LE(FNO)=0                                                         XPND98B
      CALL INTRPT(T,4,0.0,0.0,0.0)                                      XPND98C
      RETURN                                                            XPND98D
      END                                                               XPND099
      SUBROUTINE SEARCH(I,IFOUND)                                       SRCH001
      COMMON/PLANS/FE(6),LE(6),NE(6),PLN(9,80)                          SRCH002
      INTEGER FE,LE,NE,PLN,T                                            SRCH003
      DATA IS/8/                                                        SRCH004
      T24=T+24                                                          SRCH005
      IFOUND=0                                                          SRCH006
      IF(NE(I).LE.0)GO TO 22                                            SRCH007
      N=NE(I)                                                           SRCH008
      IPT=FE(I)                                                         SRCH009
      DO 21 I=1,N                                                       SRCH010
      IF(PLN(4,IPT).EQ.5)GO TO 20                                       SRCH011
      SUBROUTINE DUMP NOFILE                                            DUMP0
      COMMON/IODEV/NR,NP,NC,TAPE1,TAPE2,TAPE3                           DUMP0
      COMMON/PLANS/FE 6 ,LE 6 ,NE 6 ,PLN 9,80                           DUMP0
      INTEGER TAPE1,TAPE2,TAPE3                                         DUMP0
      INTEGER FE,LE,NE,PLN                                              DUMP0
C     ------------------------------------------------------------------ DUMP0
C     ******THIS ROUTINE DUMPS THE PLANNING MATRIX                      DUMP0
C     ------------------------------------------------------------------ DUMP0
      CALL HEADNG 1                                                     DUMP0
      WRITE NP,20                                                       DUMP0
   20 FORMAT ///37X,45H******** DUMP OF THE PLANNING MATRIX ********,   DUMP0
     *///49X,23HFILE NUMBER FIRST LAST-,                                DUMP0
     */49X,23H NO  ENTRYS ENTRY ENTRY,//                                DUMP0
      DO 22 I 1,6                                                       DUMP0
      WRITE NP,21  I,NE I ,FE I ,LE I                                   DUMP0
   21 FORMAT 50X,I2,2X,4 I5,1X                                          DUMP0
   22 CONTINUE                                                          DUMP0
      WRITE NP,23   K,K 1,3                                             DUMP0
   23 FORMAT ///16X,6H CULM ,3X,6H PLAN ,3X,6H TIME ,3X,6H LAGS ,3X,    DUMP0
     *6H CODE ,3 3X,5HATTR ,I1 ,3X,6HSUCCES,3X,6HPREDCS,//              DUMP0
      DO 25 I 1,80                                                      DUMP0
      WRITE NP,24  I, PLN K,I ,K 1,9                                    DUMP0
   24 FORMAT 16X,10 I6,3X                                               DUMP0
      IF I .NE. 40 GO TO 25                                             DUMP0
      CALL HEADNG 1                                                     DUMP0
      WRITE NP,23   K,K 1,3                                             DUMP0
   25 CONTINUE                                                          DUMP0
      RETURN                                                            DUMP0
      END                                                               DUMP0
      SUBROUTINE HEADNG SW                                              HEADNG0
      COMMON/HD/TITLE 9                                                 HEADNG0
      COMMON/IODEV/NR,NP,NC,TAPE1,TAPE2,TAPE3                           HEADNG0
      REAL    TITLE                                                     HEADNG0
      INTEGER TAPE1,TAPE2,TAPE3                                         HEADNG0
      INTEGER PAGE,SW,DATE                                              HEADNG0
C     ------------------------------------------------------------------ HEADNG0
C     THIS ROUTINE PRINTS A HEADING AT THE TOP OF EACH PAGE OF THE      HEADNG0
C     OUTPUT.  SINCE IT USES SUBROUTINE INFO, IT IS MACHINE DEPENDENT.  HEADNG0
C                                                                       HEADNG0
```

```
C     IBM 360 SERIES                                                    HEADNGO
C     REAL *8 TITLE,ADATE,ATIME                                         HEADNGO
C     CALL INFO ADATE,ATIME                                             HEADNGO
C     WRITE NP,23   TITLE I ,I 1,9 ,ADATE,ATIME,PAGE                    HEADNGO
C  23 FORMAT 1H1,9A8,6X,6HDATE  ,1A8,2X,6HTIME  ,1A8,2X,5HPAGE ,I3      HEADNGO
C                                                                       HEADNGO
C     CDC 6000 SERIES                                                   HEADNGO
C     ----------------------------------------------------------------- HEADNGO
      IF SW 21,20,22                                                    HEADNGO
   20 RETURN                                                            HEADNGO
   21 PAGE 0                                                            HEADNGO
      CALL INFO DATE,IHR,MIN,ISEC                                       HEADNGO
      RETURN                                                            HEADNGO
   22 PAGE PAGE+1                                                       HEADNGO
      WRITE NP,23   TITLE I ,I 1,9 ,DATE,IHR,MIN,ISEC,PAGE              HEADNGO
   23 FORMAT 1H1,9A8,6X,6HDATE  ,A10,6HTIME  ,I2,1H ,I2,1H ,I2,2X,      HEADNGO
     *5HPAGE ,I3                                                        HEADNGO
      RETURN                                                            HEADNGO
      END                                                               HEADNGO
      SUBROUTINE INFO DATE,IHR,MIN,ISEC                                 INFOO
      INTEGER DATE                                                      INFOO
C     ----------------------------------------------------------------- INFOO
C     THIS ROUTINE OBTAINS THE DATE AND THE TIME OF DAY.  IT IS MACHINE INFOO
C     DEPENDENT AND THE USER SHOULD CONSULT THE STAFF AT THE COMPUTER   INFOO
C     FACILITY AT WHICH THE PROGRAM WILL BE RUN.                        INFOO
C                                                                       INFOO
C     IBM 360 SERIES  SUPPORTING TIME AND DATE SUBROUTINES              INFOO
C     SUBROUTINE INFO ADATE,ATIME                                       INFOO
C     REAL *8 ADATE,ATIME                                               INFOO
C     CALL TIME ATIME                                                   INFOO
C     CALL DATE ADATE                                                   INFOO
C     RETURN                                                            INFOO
C     END                                                               INFOO
C                                                                       INFOO
C     CDC 6000 SERIES  SUPPORTING CLOCK AND SDATE SUBROUTINES           INFOO
C     ----------------------------------------------------------------- INFOO
      IX CLOCK IHR,MIN,ISEC                                             INFOO
      CALL SDATE DATE                                                   INFOO
      RETURN                                                            INFOO
      END                                                               INFOO
      FUNCTION COST PT,Q                                                COSTO
      INTEGER PT                                                        COSTO
      GO TO 10,20,30,40,50 ,PT                                          COSTO
   10 COST 44.0/Q**0.01746                                              COSTO
      RETURN                                                            COSTO
   20 COST 90.0/Q**0.36397                                              COSTO
      RETURN                                                            COSTO
   30 COST 136.0/Q**0.19438                                             COSTO
      RETURN                                                            COSTO
   40 COST 150.0/Q**0.26795                                             COSTO
      RETURN                                                            COSTO
   50 COST 110.0                                                        COSTO
      RETURN                                                            COSTO
      END                                                               COSTO
      FUNCTION CCOST PT,C                                               CCOSTO
      INTEGER PT                                                        CCOSTO
      GO TO  10,20,30,40,50 ,PT                                         CCOSTO
   10 CCOST 0.075*Q**0.90040                                            CCOSTO
      RETURN                                                            CCOSTO
   20 CCOST 0.106*Q**0.64941                                            CCOSTO
      RETURN                                                            CCOSTO
```

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30 CCOST 0.560*Q**0.62487                                          CCOST0
   RETURN                                                          CCOST0
40 CCOST 0.700*Q**0.80978                                          CCOST0
   RETURN                                                          CCOST0
50 CCOST 0.085*Q                                                   CCOST0
   RETURN                                                          CCOST0
   END                                                             CCOST0
   FUNCTION RNORM MEAN,SD                                          RNORM0
   REAL MEAN                                                       RNORM0
   DATA I/0/                                                       RNORM0
   IF I .NE. 0 GO TO 10                                            RNORM0
   I 1                                                             RNORM0
   CALL RANSET 9753.0                                              RNORM0
10 RA RANF DUMMY                                                   RNORM0
   RB RANF DUMMY                                                   RNORM0
   V  -2.0*ALOG RA  **0.5*COS 6.283*RB                             RNORM0
   RNORM V*SD+MEAN                                                 RNORM0
   RETURN                                                          RNORM0
   END                                                             RNORM0
```

APPENDIX E

INTERRUPT CODES AND MESSAGES

During a simulation, the execution of program TINKLE may be interrupted at various points for the purpose of collecting assorted information on the operation of the simulation. An interrupt in the simulation is initiated for one of three reasons:

(a) To indicate that some future event occurred; e.g., a reservoir expansion.

(b) To indicate that some rare event occurred; e.g., a spillage.

(c) To indicate that some disastrous event occurred; e.g., an invalid demand modification request.

Each interrupt that is encountered in the simulation is stored for print-out at the conclusion of the simulation. All of the accumulated interrupts are printed following the last page of statistical tables produced by the model.

The printed output of interrupts consist of one line for each break in the simulation. On each line, the following items appear:

(a) The cumulative time in months at which the interrupt occurred.

(b) The calendar date at which the interrupt occurred.

(c) A message describing the cause of the interrupt.

(d) The values for up to three pre-selected variables.

In the table below, a complete listing of interrupt codes, messages, and variables whose values are returned are presented. Under each numbered heading appears the item or variable name whose value will be returned with the message. If no variable name appears under a numbered heading, then the value printed at that positon will be zero. As an example, consider the following line from an

interrupt print out.

95 1979/11 IMPLEMENTATION OF NEW STREAM 105.00 95.00 0.00

This message tells one that a new stream was added to the water system in the 95th consecutive month from the beginning of the simulation or alternatively, in November of 1979. By consulting the table below, we find that the first number following the message (105.00) is the plan number the user assigned to this stream addition when he prepared data card type VI. The second number following the message (95.00) is time in cumulative months at which this stream was to be initiated (this number was specified by the user on data card type VI). Finally, our table indicates that the third number following this message (0.00) does not represent a physical quanity and therefore should be zero.

INTERRUPT CODES AND MESSAGES

CODE	INTERRUPT MESSAGE	-1-	-2-	-3-
1	SPILLAGE	RLEVEL	SPILLAGE	
	LEVEL BELOW CONSERVATION POOL	RLEVEL	RCPL	
3	RESERVOIR EMPTY	RLEVEL		
4	PLAN FILE 5 EXHAUSTED			
5	IMPLEMENTATION OF NEW STREAM COMPLETED	PLAN NO	BEG. TIME	
6	IMPLEMENTATION OF NEW RESERVOIR COMPLETED	PLAN NO	BEG. TIME	RLEVEL
7	IMPLEMENTATION OF NEW WELL COMPLETED	MO	NEW FLOW	
8	IMPLEMENTATION OF NEW PROJECT COMPLETED	MO	NEW FLOW	
9	RECYCLING IMPLEMENTED	OPTN1	RRON	RROFF
10	PERCENTAGE RATIONNING EXCEEDS LIMIT	RATION	PRL	
11	LEVELS 1 THRU 4 SUM TO ZERO	SUM 1-4		
12	ITTERATION LIMIT EXCEEDED	QR1	QR2	QR3
13	DISTRIBUTION MODIFICATION REQUEST INVALID	USER NO	AWT L NO	%
14	CD-STANDBY DEMAND MODIFICATION REQUEST INVALID-A	USER NO	AWT L NO	ADD-D
15	CD-STANDBY DEMAND MODIFICATION REQUEST INVALID-B	NOCD		
16	INDUSTRIAL EQUATION CONSTANT INCREASED	PLAN NO	CONSTANT	
17	CD-STANDBY DEMAND MODIFIED AS SHOWN	PLAN NO	INC DMND	
18	CD-STANDBY DEMAND ADDED AS SHOWN	PLAN NO	NEW DMND	

APPENDIX F

VARIABLE NAME LIST

VARIABLE NAME	DESCRIPTION	UNITS	PRESET VALUES
AITP	ADDITIONAL INCREMENT TO PROJECTS	A.F.	
AITR	ADDITIONAL INCREMENT TO RESERVOIRS	A.F.	
AITW	ADDITIONAL INCREMENT TO WELLS	A.F.	
AUSE	ANNUAL WATER USE	A.F.	
AWTO	ADVANCED WASTE TREATMENT OPERATION ARRAY		
CD	CONTINUOUS DEMANDS	MG/D	
CMAX	CUT, MAXIMUM FLOW LEVEL	CFS	
CMIN	CUT, MINIMUM FLOW LEVEL	CFS	
CN1-4	CUMULATIVE NET FLOW AT LEVELS 1-4	MG/D	
CNR	CUMULATIVE NET FLOW AT LEVEL 4 DESTINED FOR THE RESERVOIR	MG/D	
CODE	TYPE OF CONSTRUCTION UNDER WAY		
CONS	CONSUMPTION LOSSES AT LEVELS 1-3	MG/D	
DATES	DATE A NEW STREAM WAS IMPLEMENTED		
DEFCC	DEFLATOR, CONSTRUCTION COSTS		1.0
DEFOMC	DEFLATOR, OPERATION AND MAINTENANCE COSTS		1.0
DIST	PERCENTAGE DISTRIBUTIONS		
DL	DEMAND FOR WATER, LEVEL	MG/D	
DPRIDC	DIFFERENTIAL PRICE RATE INCREASE, SUMMER MONTHS , DOMESTIC AND COMMERCIAL		1.0
DPRII	DIFFERENTIAL PRICE RATE INCREASE, SUMMER MONTHS , INDUSTRIAL		1.0
DT	DEMAND FOR WATER, TYPE	MG/D	
EG	EMPLOYMENT, RATE OF GROWTH OF	MOS	0.0045
EMPLOY	EMPLOYMENT	MEN	7240.0
EVAP	EVAPORATION PERCENTAGES, MONTHLY		
EXCESS	EXCESS FLOW AT THE LAST LEVEL OF RECYCLING IF NOT LEVEL 4	MG/D	
H	HISTORICAL DATA ON ANNUAL STREAM FLOWS	CFS	
HTC	HISTORICAL CUMULATIVE TIME	MOS	264
ICD	CONTINUOUS DEMANDS, SUBSCRIPT OF DEMAND TYPE		
IDIST	DISTRIBUTION, SUBSCRIPT OF DEMAND TYPE		
IFRQ	INDEX FOR TABULATING THE FREQUENCY OF THE IDSNQ PRINTOUT		
INVC	INVESTMENT COSTS ARRAY		
IP	NUMBER OF CONSECUTIVE MONTHS OF INCREASED PROJECT FLOWS	MO	
IR	INDICATOR FOR THE RETURN OF A PLAN FROM EXPAND		
IS	STREAM INCREMENT, FOR DATE OF COMPLETION		
IT	TEMPORARY INTEGER		
IW	NUMBER OF CONSECUTIVE MONTHS OF INCREASED WELL FLOW	MO	
IX	TEMPORARY INTEGER		
IYR	NUMBER OF YEARS OF HISTORICAL DATA ON STREAM FLOWS	YRS	10

JANQ	FLOW, TO THE AWT ON JAN. 1	MG/D	
KO	CONSTANT FOR WATER QUALITY TEST		250
LAB	LABELS FOR AWTO TABLE		
LCD	CONTINUOUS DEMANDS, SUBSCRIPT OF DEMAND LEVEL		
LDIST	DISTRIBUTION, SUBSCRIPT OF DEMAND LEVEL		
LDR1-4	LOSS, IN THE DEMAND ROUTES AT LEVEL 1-4		
LEAK	RESIVOR LEAKAGE CONSTANT	CFS	10.0
LL	LOSS, IN THE AWT PROCESS AT EACH LEVEL		
LYR	YEARS, FOR PRINTOUT		
MEAN	MEAN OF THE RANDOM ERROR TERM ADDED TO THE DEMAND EQUATIONS	MG/D	
MESS	ARRAY OF MESSAGES FOR THE INTERRUPT CODES		
MINQ	MINIMUM REQUIRED OUTFLOWS PER STREAM (DATA READ IN IN C.F.S.)	A.F.	
MINRQ	AGGREGATE MINIMUM REQUIRED RESIVOR FLOWS, (MONTHLY)	A.F.	
MO	TIME, YEARLY IN MONTHS	MOS	
N1	NUMBER OF STREAMS INITIALLY IN USE + 1		NSTA+1
NAS	NUMBER OF ADDITIONAL STREAMS PLUS ONE		1
NATP	NUMBER OF ADDITIONS TO PROJECTS		
NATR	NUMBER OF ADDITIONS TO RESERVOIRS		
NATW	NUMBER OF ADDITIONS TO WELLS		
NC	LOGICAL UNIT NUMBER FOR CARD PUNCH		7
NDEC	NUMBER OF DECADES IN THE SIMULATION		
NN	TEMPORARY INTEGER		
NO	NUMBER OF CONSECUTIVE MONTHS RECYCLING HAS BEEN OPERATIONAL		0
NOCD	NUMBER OF CONTINUOUS DEMANDS		0
NOCUTS	NUMBER OF CUTS ALLOWED UNDER WATER LAW		
NODS	NUMBER OF DEMAND SUBDIVISIONS		0
NODYS	NUMBER OF DAYS IN EACH MONTH	DAYS	
NOFILE	NUMBER OF PLANNING FILES, TOTAL		
NPS	NUMBER OF PASSES THRU EACH LEVEL OF THE AWT		
NOSTA	NUMBER OF STREAMS OR STATIONS, TOTAL		30
NP	LOGICAL UNIT NUMBER FOR LINE PRINTER		6
NR	LOGICAL UNIT NUMBER FOR CARD READER		5
NSTA	NUMBER OF STREAMS CURRENTLY IN USE AT TIME T		28
NT	TEMPORARY INTEGER		
NYRPRJ	NUMBER OF YEARS OF PROJECTION OR SIMULATION	YRS	50
OC	OPERATING COSTS	M$	
OFF	VARIABLE FOR THE CODE FOR OFF		9
ON	VARIABLE FOR THE CODE FOR ON		1
OPTN1	IS THE RECYCLING FEATURE DESIRED (=0, NO = 1, YES)		YES
OPTN2	MUST STREAM EFFLUENT BE TREATED AT LEVEL 1 (= 0, NO =1, YES)		NO
OTHRC	FIXED AND VARIABLE COSTS FOR STREAMS, RESERVOIRS, WELLS, AND PROJECTS		
PC	PIPELINE CONSTRAINT ON FLOW	CFS	
PEQ1-5	PARAMETERS FOR DEMAND EQUATIONS 1-5		
PC	POPULATION, RATE OF GROWTH OF	MOS	0.0045
PLEVEL	PREVIOUS RESIVOR LEVEL	A.F.	65704.0

PLSTQ	PERCENTAGE OF LOCAL TO SECOND. TREAT. FLOW		
PLTQ	PERCENTAGE OF LAWNS TO TOTAL FLOW		
POP	POPULATION	MEN	150000.0
PRICE1	PRICE, TEMPORARY VALUE FOR DOMESTIC AND COMMERCIAL	$/TG	
PRICE2	PRICE, TEMPORARY VALUE FOR INDUSTRIAL	$/TG	
PRICEC	PRICE, MUNICIPAL	$/TG	0.000
PRICED	PRICE, OF DOMESTIC AND COMMERCIAL WATER	$/TG	0.717
PRICEI	PRICE, OF INDUSTRIAL WATER	$/TG	0.400
PRICEM	PRICE, MILITARY	$/TG	0.000
PRICEN	PRICE, NON-POTABLE WATER	$/TG	0.270
PRL	PERCENTAGE RATIONNING LIMIT		0.30
PROBL	PROBATILITY LIMIT WHEN USING RECYCLING TO TRIGGER STREAM OR RESIVOR EXPANSION		0.70
PROC	PROCESS LABELS FOR OPERATION COSTS TABLE		
PROJCT	PROJECT FLOWS	A.F.	
PT1-2	PROCESS TYPE, LEVELS 1+2 AWT		
PW	PRESENT WORTH OF INVESTMENT COSTS ARRAY	M$	
Q	FLOW, AVERAGE INTO EACH LEVEL OF THE AWT	MG/D	
QA	FLOW, AGRICULTURE	MG/D	
QG	FLOW, GENERATED AT EACH LEVEL OF AWT	MG/D	
QI	FLOW, IMPORTED WATER (AND LATER THE FLOW RETURNED TO STREAMS)	MG/D	
QIR	FLOW, IMPORTED ENTERING RECYCLE PROCESS	MG/D	
QL	FLOW, LOCAL WATER	MG/D	
QM1-4	FLOW, MAXIMUM AT LEVELS 1-4	MG/D	
QMA	FLOW, NET PER CYCLE AT LEVELS, DESTINED FOR THE RESERVOIR	MG/D MG/D	
QOL	FLOW, OF LAWN USE	MG/D	
QOUT	FLOW, NET DRAIN OUT OF THE RESERVOIR	A.F.	
QRR	FLOW, RECYCLED TO RESERVOIR	MG/D	
QR1-4	FLOW, RECYCLED FROM LEVELS 1-4, EXCLUDING THE RESERVOIR	MG/D	
QS	FLOW, SOLD TO OTHER CITIES	MG/D	
QU1-4	FLOW, CUMULATIVE USE AT LEVELS 1-4	MG/D	
QUR	FLOW, CUMULATIVE USE AT LEVEL 4 DESTINED FOR THE RESERVOIR	MG/D	
R	INTEREST RATES		
RAIN	RAINFALL FOR THE CURRENT MONTH	INCH	
RAINAV	RAINFALL, AVERAGE FOR THE MONTH	INCH	
RATION	PERCENTAGE RATIONNING		
RCPL	RESERVOIR, CONSERVATION POOL LEVEL	A.F.	3325.0
RECYCL	RECYCLE SWITCH, ON OR OFF		ON
REVAP	RESERVOIR EVAPORATION, MONTHLY	A.F.	
RIMPRT	RESERVOIR, LEVEL OF IMPORT WATER	A.F.	
RINDEX	RAIN INDEX FOR DOMESTIC DEMAND EQUATION		
RITL	RECYCLE ITTERATION LIMIT		30
RLEAK	RESERVOIR LEAKAGE	A.F.	
RLEVEL	RESERVOIR, CURRENT LEVEL AT TIME T	A.F.	66743.0
RLMAX	RESERVOIR, MAXIMUM LEVEL	A.F.	125614.0
RLOCAL	RESERVOIR, LEVEL OF LOCAL WATER	A.F.	33371.5
RQIN	RESERVOIR, FLOW IN	A.F.	
RQOUT	RESERVOIR, FLOW OUT	A.F.	

RROFF	RESERVOIR RECYCLE, OFF LEVEL	A.F.	42667.0
RRON	RESERVOIR RECYCLE, ON LEVEL	A.F.	30000.0
SAWT	SUMMARY OF ADVANCED WASTE TREATMENT ARRAY		
SEAS1	SEASONAL CUT, BEGINNING MONTH	MOS	
SEAS2	SEASONAL CUT, ENDING MONTH	MOS	
SD	STANDARD DEVIATION OF THE RANDOM ERROR TERM ADDED TO THE DEMAND EQUATIONS		
SKIP	THE NUMBER OF YEARS OF GENERATED FLOWS THAT ARE TO BE SKIPPED BEFORE STARTING THE SIMULATION		0
SNAME	STREAM, NAME OF		
SNQ	STREAM, NET FLOW	CFS	
SQ	STREAM, VIRGIN FLOW	CFS	
SQA	STREAM, TOTAL ANNUAL FLOW	CFS	0.0
SQ12	STREAM, 12 MONTH FLOW	CFS	0.0
SSS	SUMMARY OF SUPPLY IN STORAGE ARRAY		
STA	STREAM, INDEX FOR		
STNO	STREAM, STATION NUMBER		
STQ	SECONDARY TREATED FLOW	MG/D	
SW1	SWITCH, INDICATOR FOR LEVEL 4 WATER DEMAND		
SW2	SWITCH, INDICATOR FOR FIRST PASS THRU LEVEL 4 FOR RECYCLING TO THE RESERVOIR		
SW3	SWITCH, INDICATOR FOR FULLFILLMENT OF DEMAND AT THE CURRENT AWT LEVEL ON THE CURRENT PASS		
SWD	SUMMARY OF WATER DEMANDS ARRAY		
T	TIME, CUMULATIVE IN MONTHS	MOS	
TAPE1	LOGICAL UNIT NUMBER FOR STREAM FLOW DATA		15
TAPE2	LOGICAL UNIT NUMBER FOR IDSNQ DATA DEVICE		16
TAPE3	LOGICAL UNIT NUMBER FOR INTERRUPT MESSAGES		17
TITLE	TITLE, TO APPEAR ON EACH PAGE		
TEMP1	TEMPORARY REAL NUMBER		
TEMP2	TEMPORARY REAL NUMBER		
TEST	TEST VALUE OF WQR BEFORE LEVEL 4 TREATMENT		
TQIR	TOTAL FLOW RECYCLED FROM THE USERS DURING THE CURRENT MONTH	MG/D	
TYPE	TYPE OF WATER IN STREAM (LOCAL OR IMPORT)		
VC	VARIABLE COSTS FOR EACH INCREMENT TO STREAMS RESERVOIRS, WELLS OR PROJECTS	$	
VOLR	VOLUME OF THE RESERVOIR	A.F.	
WQR	WATER QUALITY OF THE RESERVOIR		70.0
X5-7	TEMPORARY VARIABLES		
X	TEMPORARY REAL ARRAY		
XPLN	THE CURRENT PLAN RETURNED FROM THE PLANNING FILE		
YR	YEARLY INCREMENT	YRS	
YRST	STARTING YEAR OF THE SIMULATION	DATE	1972
Z	TEMPORARY ARRAY		

****** EDITING FEATURES ******

VARIABLE NAME	DESCRIPTION	NO	YES	DEFAULT
IDSNQ	INTERMEDIATE DATA, STREAM NET FLOWS	=0	=1	NO
FREQ	FREQUENCY OF IDSNQ PRINTOUT			=5
DCII	DATA CARD TYPE II PRINTOUT	=0	=1	YES
DCIII	DATA CARD TYPE III PRINTOUT	=0	=1	YES
DCIV	DATA CARD TYPE IV PRINTOUT	=0	=1	YES
DCV	DATA CARD TYPE V PRINTOUT	=0	=1	YES
DCVI	DATA CARD TYPE VI PRINTOUT	=0	=1	YES
DCVII	DATA CARD TYPE VII PRINTOUT	=0	=1	YES
DCVIII	DATA CARD TYPE VIII PRINTOUT	=0	=1	YES
DCIX	DATA CARD TYPE IX PRINTOUT	=0	=1	YES
DCX	DATA CARD TYPE X PRINTOUT	=0	=1	YES
DCXI	DATA CARD TYPE XI PRINTOUT	=0	=1	YES
DCXII	DATA CARD TYPE XII PRINTOUT	=0	=1	YES
GRAPH	PUNCH DATA FOR GRAPH PROGRAM	=0	=1	NO