WATER SUPPLY HANDBOOK

A Handbook on
Water Supply Planning
and
Resource Management

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U.S. Army Institute for Water Resources
Policy and Special Studies Programs

The Institute for Water Resources (IWR) is part of the Corps of Engineers Water Resources Support Center in Alexandria Virginia. It was created in 1969 to analyze and anticipate changing water resources management conditions, and to develop planning methods and analytical tools to address economic, social, institutional, and environmental needs in water resources planning and policy. Since its inception, IWR has been a leader in the development of tools and strategies to plan and execute Corps water resources planning.

IWR's program emphasizes planning concepts for use by Corps field offices. Initially, this work relied heavily on the experience of highly respected planners and theorists, gained in the many river basin and multiple purpose studies undertaken in the 1960s. As these concepts matured and became a routine part of Corps planning, the emphasis shifted to developing improved methods for conducting economic, social, environmental, and institutional analyses. These methods were essential to implementation of the Water Resources Council's (WRC) Principles and Standards (P&S), which required a multi-objective analysis of and tradeoffs among national and regional development, environmental quality, and social effects.

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PREFACE

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The field of water resources covers a wide range of topics and subject matter. This handbook focuses on one of those, the issue of water supply planning and resource management. Subject matter centers on U.S. Army Corps of Engineers projects and authorities, but is equally valid for use by others interested in this topic. The document is intended to serve as a comprehensive desk top reference on water supply topics that are spread throughout a voluminous body of Corps regulations, manuals, technical letters and memoranda, and also literature from the private sector. Information in this handbook is intended for easy access and reference purposes only, and is not intended as a substitute for Headquarters U.S. Army Corps of Engineers policy or implementation guidance. It is envisioned that the handbook will be kept current through the Internet. Changes will be made as laws of the land and policies of the Administration change. The various E-mail addresses and models contained throughout the report can also be kept current through this process.

This handbook contains nine chapters and eight supporting appendices. After an introductory chapter, topics include policies, procedures, and legislation pertaining to storage of water supplies in new and existing Corps reservoir projects; several water supply databases; a separate chapter on reallocation; a water supply partnership kit suitable for reproduction and submittal to those who may be interested in obtaining water supplies from Corps reservoirs; and then four chapters that focus on how supplies of water are managed through modeling, conservation, forecasting and water control systems.

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CHAPTER 1: INTRODUCTION

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A. PURPOSE

The purpose of this study by the U.S. Army Corps of Engineers Institute for Water Resources is to develop a "stand alone" water supply handbook. This handbook is to be a comprehensive desk reference for use by the U.S. Army Corps of Engineers (Corps), academia and non-Federal entities interested in water supply planning and management. The focus is two fold: first; on providing water supplies (municipal, industrial, agricultural and emergency/drought contingency) from new and existing Corps reservoir projects, and second; on how those supplies are managed through modeling, water conservation, forecasting and water control systems. It is envisioned that this handbook will be kept current thought the Internet. Changes will be made as laws of the land and policies of the Administration change. The various E-mail addresses and models contained throughout the report can also be kept current through this process. The information in this handbook is for reference purposes, and is not intended as a substitute for HQUSACE policy or implementation guidance.

B. HISTORY

1. Introduction. The national policy of the United States regarding water supply, as defined by Congress, has been developed over a number of years and is still being clarified and extended by legislation. This policy recognizes a significant but declining Federal interest in the long range management of water supplies and assigns the financial burden of supply to users.

2. Development of Federal Water Supply Policy.

a. Pre-1958. The first act to authorize domestic water supply at Corps reservoirs was the War Department Civil Appropriations Act of 1938. Under this act, the non-Federal beneficiaries were to pay the costs of the increased storage capacity, but cost allocation was difficult to determine. The law also asked the beneficiaries to advance the funds prior to construction. The Flood Control Act of 1944 Public Law 78-534) really put Federal water supply policy on a forward track, when it authorized the Secretary of the Army to contract with cities, states, and private companies for sale of surplus water (for domestic, industrial, and agricultural use) from U.S. Army Corps of Engineer projects. However, what comprised “surplus water,” remained unclear.

b. 1958 to 1986.

(1). The era of major involvement of Federal water supply began with the Water Supply Act of 1958 (Title III of Public Law 85-500). In the early 1950's, the growing water supply problems of the United States led the Chief of Engineers (Lt. General Samuel Sturgis, Jr.), to advocate that all Corps reservoirs constructed for river control include water supply storage. The ensuing legislation made the point that water supply would remain primarily a non-Federal responsibility, but that the Federal government should cooperate and support local efforts by modifying existing projects and addressing water supply problems through Federal water studies. The Water Supply Act of 1958 authorized the Corps to include Municipal and Industrial (M&I) water supply for present and future demand at Corps reservoir projects. This act is the primary vehicle for Corps of Engineer involvement in water supply storage.

(2). The 1958 Act called for: the M&I water supply cost plus interest to be paid by non-Federal interests within the life of the project (50 years), 30 percent of project costs (and storage) could be allocated for future water supply, and a 10-year interest free period for future supplies was authorized. The Act was applicable to all reservoir projects to be planned, under planning at the time, under construction, or operational. However, any project modification which would seriously affect the purposes for which the project was authorized, surveyed, planned, or constructed, or which would involve major structural or operational changes, could be made only upon the approval of Congress.

(3). During the 28-year period between 1958 and 1986, only two acts modified the 1958 Water Supply Act. The first of these was the 1961 Federal Water Pollution Control Act Amendments (Public Law 87-88). This act modified the 1958 Act with respect to construction cost payments for future water supply demands. The second of these modifications was the Water Reservoir Act of 1963 (Public Law 88-140). This act allowed for a permanent right to use the storage for the life of the project once construction costs were repaid. One other piece of legislation (the Water Resources Development Act of 1974 (Public Law 93-251)) was inacted during this period. While not modifying the 1958 Act, it did impact on the Corps authority in the field of water supply. This act established authority for the Chief of Engineers to provide emergency safe drinking water for “drought distressed” communities, providing the Governor of the State requests assistance.

c. 1986. The Water Resources Development Act of 1986 (Public Law 99-662), sharply modified the Federal role that had been largely defined in the Water Supply Act of 1958. This act included the following: elimination of the 10-year interest free period, reduction of the payback period from 50 to 30 years, annual reimbursement of the operation and maintenance cost (although it had been established policy that these costs be repaid on an annual basis), non-Federal share of municipal and industrial water supply was assigned 100 percent of the costs and the non-Federal share of agricultural water supply was assigned 35 percent of the costs, the interest rate formula was modified, a rate of 0.125 percent was added for transaction costs, and the interest rate is to be recomputed every five years. These amendments are applicable only to Corps projects and not the Bureau of Reclamation projects. The water supply portions of the 1986 WRDA have not, as yet, been modified. However, Section 322 of the Water Resources Development Act of 1990 (Public Law 101-640), reduced the price of water supply for low income communities.

d. Post 1986.

(1). In today’s climate, when water supply storage is included as a purpose in a new project being considered for construction, current policy is for the project sponsor to repay construction costs allocated to M&I water supply either prior to or during construction. This policy also applies to reallocation of storage for water supply. In addition, single purpose water supply projects will not be supported or recommended for construction. This new approach to water supply has shifted the emphasis from construction to better water management of existing supplies through operation, reallocation, and water conservation.

(2). U.S. Army Corps of Engineers and other Federal reservoirs represent a combination of large economic investments and commitments of valuable natural resources. These reservoirs can make important contributions to the nation's economy. Over time, as population shifts and growth and need changes, the purposes of some Federal reservoirs may no longer satisfy the original project priories. To meet these changing needs, the Corps is continually turning to reallocation. Reallocation of storage to municipal and industrial water supply has been considered in a number of different ways. However, any new reallocation agreement must provide the states or others with financial incentives not available elsewhere and the use of existing storage in Corps facilities must be cheaper for the potential user than the construction of new or additional facilities. Corps policy for reallocated storage is to charge the user the cost of the storage as if it were constructed today. Types of opportunities for reallocations include: the use of water supply storage not under contract, temporary use of storage allocated for future conservation purposes and sediment, storage made available by change in conservation demand or purpose, seasonal use of flood control space, reallocation of flood control space during the dry season, modifying reservoir water control plans and method of regulation, raising the existing dam, and system regulation of Corps and non-Corps reservoirs. Opportunities for reallocation can also be created through new partnerships with states and other water agencies.

3. Water Supply Storage. Out of approximately 330 million acre feet of storage in Corps reservoir projects, about 219 million acre-feet is active storage. Of this active storage, less than 5 percent, or about 9.5 million acre feet (which represents an initial investment cost of a little over $1.3 billion) is allocated to M&I water supply. Of this 9.5 million acre feet of storage, 6.3 million is under a present use repayment agreement, 2.4 million is under a future use agreement, and 0.8 million is allocated to future use and not under a repayment agreement. Of the 9.5 million acre feet of storage space, approximately 72 percent is located in the Corps' Southwestern Division. The storage space for M&I water supply is represented by 235 separate agreements in 117 different reservoir projects. Again, the vast majority of these repayment agreements (73 percent) and projects (55 percent) are located in the Southwestern Division.

C. ORGANIZATION OF REPORT

1. Chapter 1: Introduction. This chapter provides the purpose of the report, a brief history of the Corps of Engineers involvement in municipal and industrial water supply, and explains how the report is organized. The report is organized into the various aspects of water supply planning and management. There are two general sections, the first focuses on water supply storage in new and

existing reservoir projects and the marketing and contracting for those supplies (Chapters 2-5, accompanied by Appendices A-D) and the second section focuses on the management of those supplies through modeling, conservation, forecasting and water control systems (Chapters 6-9, accompanied by Appendices E and F). Also provided, as Appendix G, is a list of definitions and conversion factors and, as Appendix H, an index of key words. The first section of this report was originally published as Institute for Water Resources Report 96-PS-4 dated December 1996.

2. Chapter 2: Authorities, Policies and Procedures. This chapter presents the legislative landmarks upon which the Corps mission in water supply is founded as well as the major policies and procedures that have evolved from this legislation. Sections are included on Legislation, Municipal and Industrial (M&I) Water Supply, Agricultural Water Supply, Emergency and Drought Contingency Water Supply, and Seasonal Operations for Water Supply. Appendix A and Appendix B accompany this chapter. Appendix A "Legislation" has a compendium of legislation pertinent to water marketing as well as several of the major legislative landmarks in their entirety. Appendix B "Model Formats for Agreements and Permits," contains the three standard water supply agreement formats.

3. Chapter 3: Water Supply Databases. This chapter presents an overview of databases relative to Corps reservoir projects. Sections are included on the Hydrologic Engineering Center's Database Network, Reservoir Database, M&I Water Supply Database and Agricultural Water Supply Database. These latter two databases were developed in the 1980's but were updated by the divisions and districts in March 1996 in response to a request by the Institute for Water Resources (CEWRC-IWR-P) for review of the first draft of chapters 1-5. Appendix C, "Databases," accompanies this chapter. This appendix contains the details of the databases by the following four methods.

- M&I Water Supply Reservoir Database
- M&I Water Supply Agreement Database, Division and District Summaries
- M&I Water Supply Agreement Database by Projects and Agreements
- Agricultural Water Supply Database

4. Chapter 4: Storage Reallocation. The purpose of this chapter and its accompanying appendix, Appendix D, is to provide in more detail the procedures to be followed in the development of a reallocation report. The chapter discusses: the authority and opportunities for reallocations, the policies and procedures to be followed in reallocations, and suggested contents for a reallocation report with examples. Also included is a summary of reallocations that have been performed at Corps reservoir projects.

5. Chapter 5: Water Supply Partnership Kit. This chapter is, in essence, a self-contained pamphlet that can be copied and provided to local sponsors who may desire to enter into water supply agreements. It defines the Corps' mission, authorities, policies and procedures in the area of water

supply planning and contracting. It also provides some general background information on the organization and responsibilities of the various levels of the Corps. The pamphlet includes an example of a letter of introduction from the district to the non-Federal sponsor. It is suggested that appropriate model formats be copied and supplied to the prospective sponsor.

6. Chapter 6: Modeling and Water Supply Planning. The purpose of this chapter and its accompanying appendix, Appendix E, is to inform the water supply planners and managers of the types of computer models that can be obtained in the field of water supply planning. The modeling community is discussed and descriptive data is given for a variety of models and where these models can be obtained. Models are subdivided into the following areas: demand forecasting, groundwater, watershed runoff, water distribution system, stream hydraulics, river and reservoir water quality, reservoir/river system operation, and water conservation.

7. Chapter 7: Water Conservation and Planning for Drought. This chapter provides some insight for areas normally outside the Corps traditional role in water supply, namely water distribution and water conservation, as well as the normal role in responding to drought through effective use of Corps reservoirs. Sections are included on water conservation methods, reservoir drought contingency plans, the “National Study of Water Management During Drought,” and on the evaluation of existing water distribution systems.

8. Chapter 8: Water Supply Needs Analysis. This chapter provides a summary of the methods used in forecasting available water supplies and the methods used in forecasting the demand for those supplies. A brief review of the main computer models used in demand forecasting (IWR-MAIN and WEAP), previously described in more detail in Chapter 6, is also presented.

9. Chapter 9: Management of Water Control Systems. This chapter presents a general overview of what is required in the management of water control systems. There are sections on Objectives and Principles of Water Control Management, Development of Water Control Plans, Water Control Data Systems, Management of Water Control Projects, and Preparation of Water Control Documents. An accompanying appendix, Appendix F, provides outlines for four water control documents, Standing Instructions to Project Operators for Water Control, Water Control Plans, Water Control Manuals, and Master Water Control Manuals.

CHAPTER 2: DECEMBER 1998
AUTHORITIES, POLICIES AND PROCEDURES

A. LEGISLATION

1. The Federal Interest. National policy concerning the U.S. Army Corps of Engineers (Corps) role in water supply has developed over many years and is still being clarified and extended by legislation. This policy is based on a recognition that states and local sponsors have the primary responsibility in the development and management of their water supplies. The policy also recognizes a significant but declining Federal interest in the long range management of water supplies and assigns the financial burden of supply to users. The Corps may, however, participate and cooperate with states and local sponsors in developing water supplies in connection with water resource improvements when certain conditions of non-Federal participation are met. These supplies may be included in Federal navigation, flood control, or multipurpose projects when they are being considered for construction, operation, maintenance, and/or modification. A compendium of the legislation pertinent to the Corps water supply program is contained in **Appendix A**. These laws are of major significance to the Corps mission in water supply planning in that they provide authority for the Corps to use their reservoirs for municipal, industrial, surplus and agricultural water supply. These laws also give the Corps authority to provide emergency water and assist states and local interests in their water supply planning process. Eight of these laws have been reproduced in their entirety in **Appendix A.** Four of the more significant legislative landmarks are discussed in the following paragraphs.

2. Section 6, Public Law 78-534. Under Section 6 of Public Law 78-534 (the 1944 Flood Control Act), the Secretary of the Army is authorized to enter into agreements for surplus water with states, municipalities, private concerns, or individuals at any reservoir under the control of the Department of the Army. The price and terms of the agreements may be as the Secretary deems reasonable. These agreements may be for domestic, municipal, and industrial uses, but not for crop irrigation. See paragraph B5 of this chapter for implementing guidance on surplus water.

3. Section 8, Public Law 78-534.

a. Original Authorization. Under Section 8 of Public Law 78-534 (the 1944 Flood Control Act) Corps lakes in the 17 contiguous Western States in which Reclamation Law applies may include irrigation as a project purpose upon the recommendation of the Secretary of the Interior. Section 8 also provides that the Secretary of the Interior may provide needed irrigation works to make use of irrigation storage. It is the Department of Interior's responsibility to construct, operate, and maintain the additional works needed to utilize irrigation storage and enter into agreements for the storage space. When the project costs allocated to irrigation exceeds the estimated amount that can be repaid to the United States by the water users, the amount of the excess will be stated and appropriate reference made to the fact that special authorization by Congress is required.

b. 1986 Amendment. Section 931 of Public Law 99-662 (the Water Resources Development Act of 1986 (WRDA '86)) amended Section 8 of the 1944 Flood Control Act. This amendment authorized the Secretary of the Army to allocate water provided in projects operated by the Corps for M&I water supply, which is not under a repayment agreement, for the interim use for irrigation purposes. See paragraph C of this chapter for implementing guidance on this authority.

4. Title III, Public Law 85-500.

a. Original Authorization. Title III of Public Law 85-500 (the 1958 River and Harbor Act) is entitled the "Water Supply Act of 1958." Section 301(a), established a policy of cooperation in development of water supplies for domestic, municipal, industrial, and other purposes. Section 301(b) is the authority for the Corps to include municipal and industrial (M&I) water storage in reservoir projects and to reallocate storage in existing projects to M&I water supply. However, as specified in Section 301(d), modifications to a planned or existing reservoir project to add water supply, which would seriously affect the project, its other purposes, or its operation, requires congressional authorization. This act was amended by Section 10 of Public Law 87-88 and by Section 932 of Public Law 99-662. See paragraph B of this chapter for implementation guidance on M&I water supply.

b. Section 10, Public Law 87-88. Section 10 of Public Law 87-88 (the Federal Water Pollution Control Act Amendments of 1961) modified the 1958 Water Supply Act. This modification permitted the acceptance of assurances for future water supply to accommodate the construction cost payments for future water supply.

c. Section 932, Public Law 99-662. Section 932 of Public Law 99-662 (WRDA '86), amended the Water Supply Act of 1958, as amended. This amendment applies to Corps projects but not to Bureau of Reclamation projects. The amendment eliminated the 10-year interest free period for future water supply, modified the interest rate formula, limited repayment to 30 years, and required annual operation, maintenance and replacement costs to be reimbursed annually. This latter requirement had always been a part of Corps policy and repayment procedures.

5. Public Law 88-140. Public Law 88-140, approved 16 October 1963, extended to the non-Federal sponsor of water supply storage the right to use the storage for the physical life of the project subject to repayment of costs. This removed an uncertainty as to the continued availability of the storage space after the 50-year maximum period previously allowed in contracts. See paragraph B1 of this chapter for additional information on permanent rights to storage.

B. MUNICIPAL AND INDUSTRIAL WATER SUPPLY

1. Storage.

a. Definitions. The term “storage” conveys the right to store a resource (water) in a Corps reservoir project without guaranteeing that the resource will be available. The right to withdraw water from the storage space usually requires a separate agreement (see following paragraph h on water rights). "Municipal and industrial," while not defined in legislative history, have been defined by the Corps to mean supply for uses customarily found in the operation of municipal water systems and for uses in industrial processes. Industrial processes can include thermal power generation and mining operations. Agricultural irrigation is not ordinarily found among customers of a municipal system and, therefore, is not eligible to be included in a project under the M&I authority unless so specifically authorized by Congress. Water supply storage will be provided under the authority of the 1958 Water Supply Act, as amended. Services to be provided will normally consist of space in a reservoir for use in regulating the flow of water so that it is useful for water supply purposes. Where necessary, facilities in the project structure to provide for the release or withdrawal of the stored water may also be provided. Repayment agreements for storage space will base the amount of storage to be provided on the yield required by the non-Federal sponsor.

b. Cost of Storage. The cost of authorized M&I water supply storage in new and existing projects will be the total construction cost allocated to the water supply storage space. This cost will include (as appropriate)interest during construction and interest after the ten-year interest free period. This cost will also include (as appropriate), the costs of water supply conduits and the cost of past expenditures for items such as repair, replacement, rehabilitation and reconstruction. The share of the users cost of storage represented in the repayment agreement will be the same ratio as the share of the users storage space is to the total water supply storage space. An agreement covering all costs allocated to water supply must be approved by both the non-Federal sponsor and the Federal Government. This agreement must be approved before construction of a new project, modification of an existing project, or, if no modification is required, the initiation of the use of the storage space in an existing project.

c. New Construction Starts. Cost sharing and financing will be based on construction new start guidance provided in the most current new construction start Engineering Circular. This applies to water supply included in projects considered for a new construction start, projects funded for construction but are unstarted, resumptions, and separable elements of ongoing projects. Single purpose M&I projects, even it authorized, will not be proposed for construction.

d. Immediate and Future Use Storage. In the normal context, “immediate use storage” is that storage that the local sponsor must begin payment on immediately upon final approval of the water supply agreement whether or not it is needed, and “future use storage” is all other. Based on provisions in the Water Supply Act of 1958, as amended, not more than 30 percent of total construction costs can be allotted to water supply for future use. It is, however, Department of Army policy, when practical, to obtain full payment from the non-Federal sponsor for the allocated capital costs of water supply prior to or during construction. For these reasons, storage for future water supply should be formulated only on an exception basis. Requests for such exception should be forwarded to HQUSACE (CECW-A) for approval prior to preparation of draft feasibility reports for new reservoir projects.

e. Single Purpose Water Supply.

(1). Limits. A single purpose water supply project is defined as follows:

(a). Case 1. The project has justified, separable storage for flood control, navigation, and/or agricultural water supply. In this case, the sum of benefits for these purposes must be at least 10 percent of total National Economic Development (NED) benefits. If M&I water supply benefits exceed 90 percent of total benefits the project is considered single purpose water supply and is not eligible for Federal participation.

(b). Case 2. The project does not have separable storage for flood control, navigation, and/or agricultural water supply. In this case the sum of the benefits for these purposes must be at least 20 percent of total NED benefits. If M&I water supply benefits exceed 80 percent of total benefits the project is considered single purpose water supply and is not eligible for Federal participation.

(2). Funding of Single-Purpose Water Supply Studies. The Corps will not conduct single purpose water supply studies except for analysis of existing data under Section 22 of the 1974 Water Resources Development Act (Public Law 93-251). The Corps may, however, conduct single purpose water supply studies for non-Federal interests as a support activity under the provisions of the Intergovernmental Cooperation Act of 1968 (Public Law 90-577). The prohibition against involvement in single-purpose water supply projects does not include reallocations of existing storage or additions of storage to an existing project for water supply purposes.

f. Permanent Rights to Storage. Public Law 88-140 grants to the local interest a permanent right to the storage space after they have repaid the costs of the storage. This provision is only applicable to agreements under the 1958 Water Supply Act. Their right to use the storage continues as long as the storage is physically available, taking into account equitable reallocations as necessitated by sedimentation. They must also agree to continue to pay their annual share of operation and maintenance costs, together with their share of any periodic costs allocated to repair, reconstruction, rehabilitation, or replacement of any features that may be required to operate the project. This right to storage space does not connote a right to water. The right to water must be obtained by separate means (see following paragraph h). Surplus water agreements executed under the authority of Section 6 of the 1944 Flood Control Act, drought contingency water, and seasonal water do not receive permanent rights to storage.

g. Withdrawal and Conveyance Systems. Releases through a dam into the stream are frequently used to convey water from an impoundment to downstream users. It is the user's responsibility to protect the releases made for it from intervening diversion or consumption. The feasibility report must present the evaluation of alternative water supply measures. These measures must consider the costs of all facilities needed to withdraw and convey water from the various sources to the user's system, the impact on project justification of both including or not including these facilities, and the ability and willingness of potential water users to pay for the delivery system. Withdrawal and conveyance facilities may be incorporated as components of Federal projects when they are essential for the effective development and use of water resources for flood control, M&I water supply, agricultural water supply (irrigation), navigation, hydroelectric power production or other purposes in which Federal interest resides. This provision does not extend to inclusion of local water distribution systems. If, before initiation of construction, one or more users can be found to reach an agreement for repayment of the conduit costs, the conduit may be included as a part of the dam structure. These costs will be identified as a specific water supply cost with 100 percent of investment and annual costs being repaid by the user. For existing projects with conduits, any remaining unpaid conduit cost will be prorated just as storage costs are prorated unless one or more entities agree to repay the entire cost.

h. Water Rights. Potential encroachment on the water rights of lawful downstream water users by the operation of water supply storage must be carefully considered and coordinated with responsible state and local interests. Water rights necessary for use of stored water will not be acquired by the Corps. This acquisition of water rights is a responsibility of the water users. The Corps will not become involved in resolving conflicts among water users concerning rights to use stored water, but will look to responsible state agencies to resolve such conflicts. Where there is more than one water user, it is desirable but not required, to arrange for payment for the entire water supply storage from a single agency. For additional information on water rights see Chapter 7 of this report and EP 1165-2-1.

i. Water Quantity and Quality. Water supply agreements under the authority of the 1958 Water Supply Act are for storage space only. The Federal Government makes no representation with respect to the quantity or quality of water and assumes no responsibility for the treatment, or availability of the water.

2. Reallocations. A change in the use of storage in an existing reservoir project from its present use to M&I water supply (reallocation) is authorized by the Water Supply Act of 1958. Reallocations or addition of storage that would seriously affect the purposes for which the project was authorized, surveyed, planned, or constructed, or which would involve major structural or operational changes, will be made only upon the approval of Congress. Providing the above criteria are not violated, 15 percent of total storage capacity allocated to all authorized project purposes or 50,000 acre feet, whichever is less, may be allocated from storage authorized for other purposes or may be added to the project to serve as storage for M&I water supply at the discretion of the Commander, USACE. For reallocations up to 499 acre-feet the Commander, USACE has delegated approval authority to the division commander. Reallocations that exceed the Commander's authority may be approved at the discretion of the Secretary of the Army if such reallocations do not require Congressional approval as described above. In the present climate where it is becoming difficult to formulate and construct multipurpose reservoirs, reallocation of reservoir storage to M&I water

supply is becoming an increasingly viable option to district planners. Because of this increased viability, a separate chapter in this handbook (Chapter 4 and accompanying Appendix D) is devoted to reallocations.

3. Addition of Storage. When water supply storage is added to an existing project and existing storage space is not reallocated, a willingness to pay concept will be used to assign costs to the new water supply purpose. Under this concept the non-Federal sponsor will be responsible for paying 100 percent of all new construction costs assigned to the added water supply feature. These costs are to be paid during the construction period. In addition, payments equal to 50 percent of the sponsor's savings are required. The sponsor's savings are defined as the cost of the most likely alternative to be constructed by the non-Federal sponsor in lieu of the proposed modification, less the cost of the modification attributed to water supply. Total local capital contributions (original project plus modification) should not exceed the sum of the local share of the new construction costs, plus the Federal construction costs of the original project. The non-Federal sponsor shall also be responsible for an appropriate share of the specific and joint use operation, maintenance, replacement and major rehabilitation costs.

4. Reduced Price for Certain Storage.

a. Applicability. Section 322 of WRDA '90 authorized a reduced price of water for low income communities. The provisions are applicable only to those cases when the updating methodology is used to determine the price of water. This provision is discretionary in that the ASA(CW) may, but is not required to offer the lower price. Section 322 should be used only for public water supply needs consistent with the purposes of the Water Supply Act of 1958. Questions concerning the applicability of the provisions to specific entities and/or purposes should be directed to HQUSACE (CECW-A) before lengthy negotiations.

b. Definition of Community. Low income communities are identified by the law as communities with a population of less than 20,000 that are located in counties with a per capita income of less than the per capita income of two-thirds of the counties in the United States. A community may be any sector of the public located in one or more qualifying counties served by a single M&I water supply system. Often, the entity that provides the water service may not be an actual city, town or other governmental jurisdiction, but a rural water system or cooperative. Only water systems that are publicly licensed and/or controlled and regulated by state water laws are eligible for repayment agreements under this section. Ownership of such systems may, however, be publicly or investor owned. The right to enter into an agreement is limited to the actual water supply system and not to a larger water supplier or state water agency that provides water to smaller systems. Population is to be based on the latest decennial census figures unless annual census estimates have been made and published. Not all water suppliers will serve communities with census data. In those cases, estimates of population based on numbers of residential hookups and county average persons per household should be used. A community, for the purposes of this provision may extend across county boundaries, however, all counties served must qualify as low income counties to obtain the reduced price allowed under this Section.

c. Data Source for Per Capita Income. The data source for the per capita income will be the same as that used for the ability to pay for flood control. These data will be published annually by HQUSACE (CECW-P) in an engineer circular. The factors are based on county per capita personal income for each of the last three calendar years for which information is available. For example, for Fiscal Year 1998, such information is based on the years of 1993-95. This source of data is published yearly in the Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business.*

d. Price. The price to be charged is the greater of (1) benefits foregone or, (2) the updated cost of storage but not to exceed $100 per acre foot of storage space. Individual contract prices, once approved, are not subject to further indexing. The $100 per acre-foot of storage set forth in the authorization is applicable only to contracts signed in fiscal year 1991. This price will be adjusted on 1 October every year based on the Consumer Price Index for the September immediately preceding the fiscal year. This price index is published monthly in the Department of Commerce, Bureau of Economic Analysis, Survey of Current Business. The September index is published in the October issue and is normally available in December.

5. Surplus Water.

a. Authority. An agreement for "surplus water" conveys the right to a specific resource (water) out of a Corps project that the sponsor has acquired the rights to by another means. The authority to sell surplus water was granted to the Secretary of the Army by Section 6 of the 1944 Flood Control Act, as amended. Under this authority, the Secretary of the Army is authorized to make contracts for surplus water with states, municipalities, private concerns and individuals at such prices and on such terms as he may deem reasonable. These agreements may be for domestic, municipal and industrial uses, but not for crop irrigation. An Army General Counsel opinion of March 13, 1986, states that Section 6 of the 1944 Flood Control Act empowers the Secretary of the Army to make reasonable reallocations between different project purposes, thus, water stored for purposes no longer necessary can be considered surplus. In addition, the Secretary may use his broad discretionary authority to reduce project outputs, envisioned at the time of authorization and construction, if it is believed that the municipal and industrial use of the water is a higher and more beneficial use. Surplus water declarations citing use for higher beneficial purposes should be made with caution and only on a fixed period agreement for temporary use. When long term use is desired by the user, a permanent storage reallocation should be performed under the authority of the 1958 Water Supply Act, as amended.

b. Classification. Surplus water will be classified as one of the following cases.

(1). Water stored in a Department of Army reservoir that is not required because the authorized need for the water never developed or the need was reduced by changes that have occurred since authorization or construction.

(2). Water that would be more beneficially used as municipal and industrial water than for the authorized purpose that, when withdrawn, would not significantly affect authorized purposes over some specified period.

c. Requirements and Restrictions. Surplus water declarations will only be made when related withdrawals would not significantly affect authorized purposes. Agreements covering surplus water will normally be for small amounts of water and for temporary use as opposed to storage reallocations and a permanent right to that storage. Terms of the agreements are normally for five (5) years, with an option for a five (5) year extension, subject to the space being needed for the authorized purposes, or the authorized purpose is deauthorized. All such agreement extensions will be subject to recalculation of reimbursement. Use of the Section 6 authority is allowed only where non-Federal sponsors do not want to purchase storage because: use of the water is needed for a short term only; or use would be temporary pending development of the authorized use and reallocation of storage is not appropriate.

d. Reporting Requirements. Surplus water agreements will be accompanied by a brief letter report covering topics similar to those of storage reallocation reports (see Chapter 4) and shall include how and why the storage is determined to be surplus. The scope of the letter report should be commensurate with the amount of storage under review, the period of use, and economic and environmental considerations. The views of the affected state(s) will be obtained, as appropriate, before consummating any agreement using the Section 6 authority. These views will be included in the letter report. Declaration of surplus irrigation water in the 17 Western states (see Paragraph C1 of this chapter) will require appropriate coordination/consultation with the Department of the Interior (Bureau of Reclamation).

e. Cost. The annual cost deemed reasonable for surplus water supply is to be determined by the same procedure used to determine the annual payment for an equivalent amount of reallocated storage (see Chapter 4). To this annual cost will be added an estimated annual cost for operation, maintenance, repair, replacement, rehabilitation and reconstruction. The total annual cost is to be limited to the annual cost of the least costly alternative, but never less than the benefits foregone or, with hydropower, revenues foregone. For small withdrawals (including a group of separate users at a specific project), under Section 6 authority, a standard minimum charge or standard unit charge should be established and applied for all of the withdrawals. All proposals for establishment of such standard charges must be submitted to HQUSACE (CECW-A) for approval.

6. Repayment Provisions.

a. Interest Rate.

(1). General. The Federal discount, repayment, reimbursement, hydropower, and water supply interest rates are published yearly by HQUSACE (CECW-PD) in an economics guidance memorandum. The most recent of these memorandums was issued in November 1997 and is for use in Fiscal Year 1998. The discount rates applicable to water supply are provided in the following paragraphs.

(2). Water Supply Act of 1958. Shown in **Table 2-1** are the interest rates determined by the Department of the Treasury according to provisions of the Water Supply Act of 1958, Section 301(b). These rates are applicable to projects under construction with authorized water supply storage and reallocations approved before the effective date of WRDA '86 (17 November 1986).

Table 2-1
1958 Water Supply Act Interest Rates

Fiscal Year	Interest Rate (%)	Fiscal Year	Interest Rate (%)	Fiscal Year	Interest Rate (%)	Fiscal Year	Interest Rate (%)
1959	2.670						
1960	2.699	1970	3.342	1980	7.250	1990	10.075
1961	2.632	1971	3.463	1981	8.605	1991	9.920
1962	2.742	1972	3.502	1982	9.352	1992	9.737
1963	2.936	1973	3.649	1983	10.051	1993	9.503
1964	3.046	1974	4.012	1984	10.403	1994	9.319
1965	3.137	1975	4.371	1985	10.898	1995	9.226
1966	3.222	1976	5.116	1986	11.070	1996	9.134
1967	3.225	1977	5.683	1987	10.693	1997	9.012
1968	3.253	1978	6.063	1988	10.371	1998	8.878
1969	3.256	1979	6.595	1989	10.250	1999	

(3). The Water Resources Development Act of 1986. The interest rates shown in **Table 2-2** have been determined by the Department of the Treasury according to provisions of Section 932 of WRDA '86. These rates will be used for projects not under construction as of 17 November 1986 (where repayment is made over time), storage reallocations (including reallocations under the authority of Section 322 of WRDA '90), addition of storage, surplus water, drought contingency, and seasonal use water agreements. The interest rates will be readjusted every five years. The authorized one-eighth of one percentage point for transaction costs (see Section 106 of WRDA '86) have already been added to the values shown.

Table 2-2
1986 Water Resources Development Act Interest Rates

Fiscal Year	Interest Rate (%)	Fiscal Year	Interest Rate (%)	Fiscal Year	Interest Rate (%)
1987	7.625	1992	8,125	1997	7.125
1988	10.000	1993	7.500	1998	6.750
1989	9.250	1994	6.125	1999	
1990	8.250	1995	7.750	2000	
1991	9.125	1996	6.750	2001	

b. Repayment Period.

(1). General. For new projects, current policy is to repay all costs during construction. For existing projects and for reallocated storage (including reallocations under the authority of Section 322 of WRDA '90), the maximum repayment period used to calculate annual payments will be 30 years from the date in which storage is available. For addition of storage, the costs are to be repaid within 25 years from completion of project modification, or if water supply is already a project purpose, within 30 years from the time the project was first used for water supply.

(2). Date of Availability.

(a). Existing Storage. For existing storage, the date the storage is available will be the plant-in-service date or the date the first storage repayment agreement is signed, whichever is later.

(b). Reallocated Storage. For reallocated storage, the date the storage is available will generally be the date the repayment agreement is signed by the ASA(CW) or his duly authorized representative.

c. Interest Free Period. A ten-year interest free period for future use water supply will be available only for authorized M&I storage in projects completed or under construction as of November 17, 1986. The ten-year interest free period is not applicable for agreements in existing projects where the plant-in-service date was set more than 20-years ago or for reallocated storage.

d. Annual Operation and Maintenance Expense. Non-Federal sponsors (including those determined to be a low-income community under the authority of Section 322 of WRDA '90) are responsible for all operation and maintenance expenses allocated to water supply. These costs must be paid yearly and should be paid in advance based on an estimated expenditure. Appropriate adjustment will be made at the end of the year. These annual billings are to be between the district and sponsor and approval and/or review by higher authority is not required.

e. Repair, Replacement, Rehabilitation, and Reconstruction Costs. Costs allocated to water supply associated with repair, replacement, rehabilitation and reconstruction are to be paid by all non-Federal sponsors either during construction of such items or in lump sum, with interest, upon completion of construction. The non-Federal sponsor should be encouraged to establish a sinking fund to cover these costs should they occur. Costs expended in existing projects for these programs before entering into a repayment agreement will be added to the initial project investment cost for repayment purposes except for reallocated storage (see Chapter 4).

f. Dam Safety Program Costs.

(1). Costs. Costs of project modification for dam safety will follow the provisions of Section 1203(a)(1) of WRDA '86. Under these provisions, fifteen (15) percent of the costs of the modification are allocated among purposes and shared with appropriate project sponsors in the same percent as the joint-use expenditures are allocated in the original cost allocation. Where water supply storage is reallocated, the terms of the reallocation agreement will form the basis for the assignment of dam safety costs. The portion of the fifteen (15) percent of the dam safety modification cost assigned to the water supply purpose would be allocated in the same manner as was used as the basis for the assignment of costs. For example, if a dam safety modification cost $20,000,000, and the unit of water supply storage assigned to the sponsor was 2.5% of the joint-use costs, then the water supply sponsor would be required to pay ($20,000,000 x 0.15 x 0.025) or $75,000 of the dam safety modification cost.

(2). Repayment Period. Recovery of the non-Federal share of the dam safety modification cost will be determined by the current arrangement for project cost recovery. If the current agreement does not contain a provision for recovery of this cost, it will need to be modified, or a new agreement signed to cover the dam safety cost sharing. If no current agreement covers this cost, the sponsor may elect to repay the cost, with interest, over a period up to 30 years in accordance with provisions of Section 1203(a)(2) of WRDA '86. The interest rate to use for repayment will be as prescribed in Section 1203 (which is the same as the water supply rate prescribed in Section 932 of WRDA '86) and will remain constant for the repayment period.

7. Processing Repayment Agreements.

a. Disposition of Revenues. All revenues received from water supply repayment agreements will be deposited in the Treasury of the United States as miscellaneous receipts.

b. Model Agreement Format for Water Supply Storage. Provided in **Appendix B**, is the standard format to be used when entering into water supply storage agreements under the authority of the 1958 Water Supply Act, as amended. Payment provisions in this format are for new projects, unused storage space in existing projects, added storage and for all reallocated storage (including storage reallocated under the low-income community provisions of Section 322 of WRDA '90). Bracketed language may be changed as appropriate in particular circumstances and material peculiar to either present or future use storage may be deleted if such storage is not included in the contract. For projects where construction was initiated after 31 December 1971 (date of enactment of Public

Law 91-611), non-Federal parties to water storage agreements must meet the requirements of Section 221 of the Flood Control Act of 1970 (42 U.S.C. 1962-5b), as amended.

c. Disclosure of Lobbying Activities. Water supply storage agreements will be accompanied by a signed "Certificate Regarding Lobbying" and, if applicable, a completed "Disclosure of Lobbying Activities." These forms are provided as Exhibit E to the Water Storage Agreement (see **Appendix B**). These forms must be thoroughly discussed with the sponsor before the signature by the District Engineer. Completed forms will be attached to the agreement before its signature by the District Engineer, and kept on file by the district for later submission to HQUSACE, if requested.

d. Model Agreement Format for Surplus Water. Provided in **Appendix B**, is the standard format to be used when entering into surplus water agreements. The agreement can also be tailored to the format of a storage agreement. Terms of the agreement are normally for five (5) years, with an option for a five (5) year extension, subject to the space being needed for the authorized purpose, or the authorized purpose is deauthorized. All such agreement extensions will be subject to recalculation of reimbursement.

e. Submittal and Review.

(1). Development of Draft Agreements. It is recognized that the model agreements provided in Appendix B will usually require minor modifications and this is accepted. During negotiations leading to a draft agreement, significant departures from policy, the model formats, or any complex interpretations of policy or legislation, are to be submitted to HQUSACE (CECW-P) before spending the time and resources to negotiate a draft agreement. All draft agreements should be discussed with the local sponsor before submittal of the draft to higher authority. All departures from the draft agreements are to be detailed in a paper that is to accompany the draft.

(2). Storage Agreements.

(a). Approval Authority. The first storage agreement on any project will be approved by the ASA(CW) as will all agreements that deviate from the approved model (other than editorial changes). Approval authority for subsequent agreements and reallocation reports that do not require Congressional approval has been delegated to the Commander, USACE, and to division and district commanders according to the instructions provided on **Table 2-3**. Where the 4000 ac-ft/10% limit expressed in footnote five of the table has been or will soon be exceeded, the request for extending the delegation of authority for the next 4000 ac-ft/10% increment will be submitted for approval. The reallocation report will document both the immediate needs and impacts and also the prospects for utilization of and impacts caused by, placing the entire increment under a repayment agreement. When approval is received, the delegations as laid out in the table will remain in effect for the entire increment.

(b). Submittal. For storage agreements approved under a delegation, two copies of all agreements, draft and final, along with appropriate reallocation reports must be submitted to

HQUSACE (CECW-AR). One will be retained in HQUSACE files and the other will be provided to ASA(CW). Draft agreements and reallocation reports that require ASA(CW) review (or approval), and all final agreements requiring HQUSACE or ASA(CW) approval, must be accompanied by four copies of the agreement and reallocation report.

(3). Surplus Water Agreements. Procedures similar to those described in the preceding paragraph for water storage will be applied to surplus water agreements. Approval authority will be according to the instructions provided in **Table 2-4**. Agreements submitted to HQUSACE (CECW-A) will be accompanied by a brief letter report (see Paragraph B5d of this chapter). Two copies of all agreements, draft and final, approved under delegated authority must be submitted to HQUSACE (CECW-AR). If not delegated, then four copies of all agreements must be forwarded to HQUSACE.

(4). Limits on Policy Changes. The cutoff point for incorporation of policy changes into water supply agreements will be the date of approval of the draft agreement by the ASA(CW). An approved agreement will be exempt from application of policy changes provided a final agreement is signed by the non-Federal sponsor within six months of the date of approval of the draft agreement. An exception may be granted to the six-month limitation; however, a request for an exception should accompany the draft agreement and must contain complete justification.

Table 2-3
Water Supply Storage Agreement Approval Authority [1]

Drafts				
Acre - Feet [2]		**Storage Agreements [3]**		**Reallocation Reports [5]**
From	**To**	**Without Reallocation**	**With [4] Reallocation**	
0	99	District [6]	District [6]	District
100	499	Division [6]	Division [6]	Division
500	999	Division [6]	ASA(CW)	HQUSACE [7]
1000	& up	ASA(CW)	ASA(CW)	HQUSACE [7]
Finals [8]				
Acre - Feet [2]		**Storage Agreements**		
From	**To**	**Without Reallocation**	**With [4] Reallocation**	
0	499	District	District	
500	999	District	HQUSACE	
1000	& up	HQUSACE	HQUSACE	

Notes:
[1] A copy of all approved agreements will be provided to ASA(CW).

[2] In any particular agreement, the acre-feet of storage needed to produce the water under agreement on a dependable basis.

[3] At projects where storage agreements have been previously approved. The first storage agreement on any project will be approved by the ASA(CW).

[4] For reallocations which do <u>not</u> require Congressional approval, i.e., no significant effect on other authorized purposes and/or no major structural or operational changes.

[5] When the cumulative amount of storage reallocated exceeds the lesser of 4000 ac-ft of 10% of available storage, reports will be submitted to ASA(CW) prior to approval.

[6] When using approved model or approved model with editorial changes only. Agreements involving other changes will be submitted to ASA(CW) for approval.

[7] Submitted to ASA(CW) with the draft agreement prior to approval.

[8] When using the approved draft agreement and local signature within six months of draft approval. If beyond six months or if changes are made, the final agreement will be resubmitted for approval to the office with approval authority for the draft. If the proposed agreement involves changes other than editorial changes, the agreement will be submitted to ASA(CW) for approval. The ASA(CW) reserves the right to retain approval authority of any final agreement he approved as a draft. In cases where that right will be exercised in advance, the draft agreement will so note.

Table 2-4
Surplus Water Agreement Approval Authority [1]

Drafts			
Acre - Feet [2]		**Agreement [3]**	**Letter Report [4]**
From	**To**		
0	99	District [5]	District
100	499	Division [5]	Division
500	999	Division [5]	HQUSACE [6]
1000	& up	ASA(CW)	HQUSACE [6]
Finals [7]			
Acre - Feet [2]		**Agreement [3]**	
0	499	District	
500	999	District	
1000	& up	HQUSACE	

Notes:
[1] A copy of all approved agreements will be provided to the ASA(CW).

[2] The storage needed to produce the agreed to water on a dependable basis.

[3] Not affecting authorized purposes (water not being used for an authorized purpose). When surplus water agreements involve water being used for an authorized purpose, they will be treated like a reallocation agreement and report (see Table 2-3).

[4] When the cumulative amount of storage reallocated exceeds the lesser of 4000 acre-feet or 10% of available storage, reports will be submitted to ASA(CW) for approval.

[5] When using approved model or approved model with editorial changes only. Agreements involving other changes will be submitted the ASA(CW) for approval.

[6] Submitted to ASA(CW) with the draft agreement prior to approval.

[7] When using the approved draft agreement and local signature within six months of draft approval. If beyond six months or if changes are made, the final agreement will be resubmitted for approval to the office with approval authority for the draft. If the proposed agreement involves changes other than editorial changes, the agreement will be submitted to ASA(CW) for approval. The ASA(CW) reserves the right to retain approval authority of any final agreement he approved as a draft. In cases where he will exercise that right in advance, the draft agreement will so note.

C. AGRICULTURAL WATER SUPPLY

1. Western States.

a. Bureau of Reclamation. Storage of water for irrigation of agricultural lands, whether to meet the entire needs or to supplement natural supplies, may be considered in plan formulation. The Reclamation Act of 1902, Public Law 57-161, established irrigation in the West as a national policy. For purposes of Reclamation Law, the West is defined as those 17 contiguous states lying west of the 98th meridian. The Reclamation Act authorized the Secretary of the Interior to locate, construct, operate and maintain works for the storage, diversion, and development of waters for the reclamation of arid and semi-arid lands in the Western States (32 Stat. 388, 43 U.S.C. 1457). In these 17 western states, in conformity with Reclamation Law, the repayment arrangements and agreements for irrigation water from Corps reservoirs is administered by the Bureau of Reclamation.

b. Corps of Engineers. Section 8 of the 1944 Flood Control Act provides that Corps reservoirs may include irrigation as a purpose upon the recommendation of the Secretary of the Interior. Section 8, which applies only to the 17 Western States, also provides Interior with the authority to provide the irrigation works needed to make use of the irrigation storage. It is Interior's responsibility to construct, operate and maintain the additional irrigation works and to contract for the storage space. If allocated irrigation costs exceed the amount that can be repaid by water users, then in accordance with Reclamation Law, the excess amount will be stated. It will also be pointed out that special Congressional authorization is required for projects where irrigation costs exceed water users' repayment ability.

2. Areas Outside the Western States. Subsection 103(c)(3) of WRDA '86 establishes the cost sharing rules that apply to agricultural water supply outside the 17 Reclamation states. In non-Reclamation states, non-Federal sponsors must provide 35 percent of the joint and separable construction costs and 100 percent of the joint and separable costs of operation, maintenance, repair, reconstruction, rehabilitation, and replacement, allocated to this purpose. Non-Federal sponsors requesting irrigation capacity as a project purpose should provide a firm expression of intent to use and pay for the storage, obtain water rights or their equivalent and posses legal power to enter into a repayment agreement with the Federal government.

3. Interim Use of M&I Water Supply Storage for Irrigation.

a. Authority. Section 931 of WRDA '86 provides that for any Corps reservoir project the Secretary of the Army may allocate to irrigation purposes, for an interim period, storage included in the project for M&I water supply that is not under a repayment agreement. No agreements for the interim use of such storage shall be entered into which would significantly affect then-existing uses of the storage.

b. Repayment Provisions.

(1). Cost of Storage Space. The cost to the non-Federal sponsor under Section 931 agreements will be 35 percent of the original project investment cost (including any accrued interest after the 10-year interest free period) allocated to M&I water supply (for the block of storage to be used for irrigation as determined by the Use of Facilities cost allocation method). The non-Federal sponsor will also be responsible for 100 percent of the operation and maintenance, repair, replacement, rehabilitation, and reconstruction costs allocated to the storage space being placed under the repayment agreement. The term of the agreement for this interim use will not exceed five (5) years. An option for incremental five year extensions is allowed but only if recalculations for the annual costs are performed at the end of each five-year increment.

(2). Annual Cost Computation. The project water supply interest rate in effect when the project went under construction is to be used for all interest computations including the repayment amortization schedule for the interim use storage agreement. For projects that went under construction after 17 November 1986, the rate will be as established in Section 932 of WRDA '86 and will be adjusted at 5-year intervals (see Table 2-2). The period of analysis for computing the annualized payment will be 30 years. The annual operation and maintenance expense for the required interim use storage/water may be estimated if the expected annual operation and maintenance cost is relatively low and would not justify annual billing procedures. Otherwise, reimbursement of applicable actual project operation and maintenance expenses would be required. An estimated annual repair, replacement, rehabilitation and reconstruction cost is to be determined and included as a part of the annual repayment costs.

c. Credit. Future sponsors for municipal and industrial use of the storage space will not receive any credit from the interim use payments toward repayment of investment cost when such interim use is for agricultural water supply.

d. Reporting Requirements. Repayment agreements under the authority of Section 931 of WRDA '86 will follow the same reporting requirements as those for surplus water agreements (see Paragraph B5c of this chapter). A letter report will accompany the draft agreement. The report will document the exact use of the water to assure that it will not be used for M&I purposes, explain the manner in which the annual costs were developed and show the impacts of the interim use on the currently existing uses. The letter report will also include an analysis that describes and assess any adverse and/or beneficial environmental impacts expected to result from the interim use of storage that was not discussed in the Final Environmental Impact Statement for the project.

4. Processing Repayment Agreements. Processing repayment agreements for agricultural water supply outside the 17 western states and for Section 931 agreements will be the same as for surplus water (see Paragraph B7e(3) and Table 2-4 of this chapter).

D. EMERGENCY AND DROUGHT CONTINGENCY WATER SUPPLY

1. Emergency Water.

a. Clean Drinking Water. Public Law 84-99 as amended by Section 82 of Public Law 93-251, grants the Chief of Engineers discretionary authority to provide emergency supplies of clean water. This supply can be provided to any locality that he finds is confronted with a source of contaminated water causing or likely to cause a substantial threat to the public health and welfare of the inhabitants of the locality. Work under this authority requires a request from the governor of the state where the source of water has become contaminated and is normally limited to 30 days. Loss of water source or supply is not correctable under this authority. Terms for repayment will be determined by the Chief of Engineers.

b. Disaster Relief. Public Law 95-51 further amended Public Law 84-99 to provide the Secretary of the Army authority to construct wells and to transport water to farmers, ranchers, and political subdivisions of those areas determined to be drought distressed. A written request for assistance may be made by any farmer, rancher or political subdivision within a distressed area. Corps assistance will only be considered when non-Federal sponsors have exhausted reasonable means for securing necessary water supplies (within the limits of their financial resources) including assistance from other Federal agencies.

c. Restrictions. Evaluations of requests for assistance are to be tempered by the fact that Corps assistance is supplemental to state and local efforts. Long term solutions to water supply problems are the responsibility of state and local interests. The authorities are not to be used to provide drought emergency water assistance in cases where an owner of livestock has other options. Those options include raising funds from private sources through a loan, selling all or part of the herd, or relocation of the animals to an area where water is available. Federally-owned equipment must be used to the maximum extent possible. Assistance can be made available to transport water for consumption. The cost of transporting water is provided by the Corps; however, cost of purchasing and storing water is the non-Federal sponsor's responsibility. Assistance can also be provided to construct wells. Federal costs associated with well construction must be repaid.

d. Emergency Water Supply Planning.

(1). According to an interagency agreement between Defense and Interior, dated 8 March 1983, the Department of the Army has absorbed emergency water supply functions that formerly were a responsibility of the Department of the Interior. Executive Order (E.O.) 11490, issued 28 October 1969 (and amended by E.O. 11921 issued 11 June 1976) suggested that the Secretary of the Army should develop the following procedures.

(a). Prepare a national emergency plan and develop preparedness programs covering all usable waters, from all sources within the jurisdiction of the United States, which can be managed controlled and allocated to meet emergency requirements.

(b). Consider emergency preparedness factors in the conduct of regular agency functions.

(c). Be prepared to implement, if there is an emergency, the prepared plan for such events.

(2). The transferred responsibilities complement previously held authorities and will permit more comprehensive and efficient management of water as a scarce resource during an emergency. This program is managed by CECW-O.

2. Drought Contingency Water.

a. Authority. Water control managers will continually review and adjust water control in response to changing public needs. Many areas of the country face chronic or serious drought conditions. Preparation of drought contingency plans is, for Corps projects with controlled reservoir storage, a part of the Corps overall water control management activities. Drought and other emergencies affecting domestic, municipal and industrial water supplies will likely generate requests for water stored in Corps reservoirs. When these drought situations occur, Section 6 of the 1944 Flood Control Act provides adequate authority to permit temporary withdrawal of water from Corps projects to supplement normal supplies. In providing surplus water under the Section 6 authority, the preferred approach is for a state or political subdivision to enter into an agreement with the Secretary of the Army and to agree to act as wholesaler for all of the water requirements of individual users. This action places the local governments in a position to help their citizens during difficult times and minimizes the potential for problems that could arise if the Secretary was to determine who was entitled to shares of surplus water based on assessments of local needs. The Drought Contingency Plan appendix of the Water Control Manual (see Chapter 9 and Appendix F) for each Corps reservoir should assess the availability of surplus water (storage) for emergency water supply withdrawals.

b. Cost. The price for drought contingency water supply will be determined in the same manner as for surplus water (see paragraph B5 of this chapter) but never less than $50 per agreement per year. All revenues from drought contingency agreements will be deposited in the Treasury of the United States as miscellaneous receipts.

c. Submittal and Review. For projects with approved Drought Contingency Plans, the District Commander has approval authority for emergency demands that require less than 100 acre-feet of storage and the Division Commander for demands that require from 100 to 499 acre-feet. These agreements should follow the format for surplus water agreements. The term of the agreement will not exceed one year. Requests for larger amounts and agreements not following the standard, should be submitted to HQUSACE (CECW-A).

d. Processing Repayment Agreements. All situations should be the subject of a Section 6 agreement (**Appendix B**).

e. Declaration of a State of Emergency. For those locations where the Governor of the state has declared a state of emergency due to drought, small amounts of surplus water (withdrawals from 50 acre-feet of storage or less) may be made available under the Section 6 authority. This water can be made available for domestic and industrial uses but not for crop irrigation. Project managers are authorized to sign the agreements via the form provided in **Appendix B**. However, if the water user will be installing water lines or other facilities or equipment, then an appropriate real estate instrument must be issued under ER 405-1-12.

E. SEASONAL OPERATIONS FOR WATER SUPPLY

1. Legislative and Policy Guidance. General Congressional authority to include storage in Corps projects for seasonal use of M&I water supply, either as withdrawals or to improve groundwater supplies, has not been provided. This does not, however, preclude project specific authorizations. This prohibition also does not include unscheduled emergency drought conditions as described in paragraph D, above. Where not specifically authorized, seasonal operation of a project for water supply may be conducted consistent with authorized project purposes and law, subject to hydrologic and hydraulic capability of the project. This water supply could be used to enhance groundwater replenishment, to increase downstream flows, or to otherwise enhance the general usage of the project for M&I purposes. Such modifications, however, must be consistent with authorized project purposes and law and must be documented in the project water control plan in accordance with ER 1110-2-240.

2. Repayment Provisions.

a. Project Costs to be Repaid. Pricing policy for changes in project operations for seasonal M&I water supply will require the non-Federal sponsor to pay to the Federal government the following costs.

(1). One hundred (100) percent of the new construction and new operational costs including the cost of revising the water control plan.

(2). A share of joint use operation, maintenance and replacement cost based on Use-of-Facilities cost allocation.

(3). The value of benefits foregone.

(4). Compensation to others for losses incurred in their operations (may be the same as (3) above).

(5). A partial reimbursement of the existing Federal investment in the project. This payment will take the form of an amount equal to one-half of the savings to the non-Federal interest (the cost of the least cost alternative minus the specific costs of the modifications listed in (1) through (4) above).

b. Limit on Cost. The cost to the non-Federal sponsor, excluding annual O&M costs, should not exceed the costs derived for permanent reallocation as described in Chapter 4.

3. Processing Repayment Agreements. Agreements for seasonal water will be processed similar to those for storage space (see Paragraph B7 of this chapter).

F. REFERENCES

The following U.S. Army Corps of Engineers Headquarters publications:

EM 1110-2-1304, 12 October 1982. Civil Works Construction Cost Index System, Chapters 1-2.

EP 1165-2-1, 15 February 1996. Digest of Water Resources Policies and Authorities.

ER 405-1-12, 20 November 1985. Real Estate Handbook, Chapters 23-27.

ER 1105-2-100, 31 October 1997. Guidance for Conducting Civil Works Planning Studies, Chapter 4, Section VII.

ER 1110-2-240, 8 October 1982. Water Control Management.

CECW-PA/CECW-E, 4 April 1994. Policy Guidance Letter No. 43, Cost Sharing for Dam Safety Assurance.

CECW-PD Memorandum. Economic Guidance Memorandum 98-1: Fiscal Year 1998 Interest Rates.

CHAPTER 3: *WATER SUPPLY DATABASES*

A. DATABASE NETWORK

1. Network Concept. A database network concept was developed by the Corps of Engineers (Corps) Hydrologic Engineering Center (HEC), Davis, California. This concept is contained in *HEC Reservoir Database Network* draft report dated March 1994. The network concept is illustrated in **Figure 3-1**. At the center, or hub, of the network is a database, NETID, that contains identifying information for all Corps reservoirs including locks and dams. Each reservoir has over 20 unique identifiers; e.g., river, state, county, hydrologic unit, latitude and longitude, congressional district, zip code, etc. Each identifier provides a key piece of information that may be used to access information in other databases and which can then be used for a variety of planning and management purposes. The concept of accessing other databases is also illustrated in Figure 3-1 with spokes reaching out from the center. Without some common identifier to link the databases with the reservoirs the information in the other databases cannot be accessed. For additional information on this network contact Mr. Bill Johnson at CEWRC-HEC, phone (530) 756-1104.

2. Databases Used. The databases currently in the network and used for the standard reports come from a variety of sources. These databases are as follows:

a. Reservoir Network Identification Information (NETID). This database contains location and identification information to enable Corps reservoirs to be linked with other databases. This database has been developed and is maintained by HEC (CEWRC-HEC) by Bill Johnson, phone (530) 756-1104.

b. Water Control Data (NEWPERT). Originally developed by the Hydraulics and Hydrology Branch, Headquarters (CECW-EH) from a survey of district offices, this database contains hydrologic data about floods, runoff, water control and reservoir storage. For additional information on this database, contact Dick DiBuono (CECW-EH) by phone at (202) 761-8511.

c. Authorized and Operating Purposes of Corps of Engineer Reservoirs (LEGAUTH). This database was developed in response to Section 311 of the Water Resources Development Act of 1990 (see following Paragraph B3). It contains the authorizing public laws, referenced House and Senate documents and excerpts from the authorizing legislation. It was developed and is maintained by HEC by Bill Johnson, phone (530) 756-1104.

d. National Inventory of Dams - Corps of Engineers Dams (COEDAM). This database is a subset, with later additions, of the National Inventory of Dams database (1982) and contains only Corps dams. The data describes the structural, hydrologic and other physical features of the dam and reservoir. This database is maintained in Headquarters (CECW-EP) by Wayne King, phone (202) 761-8689.

e. Hydroelectric Power at Corps of Engineers Projects (CEHYDRO). This database on hydroelectric power was developed and is maintained by the Institute for Water Resources (CEWRC-IWR-R) by Mike Walsh, phone (703) 428-7087.

f. Natural Resources Management System (NRMS). This system contains a number of databases that define recreational facilities and visitation at Corps projects including reservoirs. This system is maintained at Headquarters, in the Operations, Construction and Readiness Division (CECW-ON) by Judy Rice, phone (202) 761-1796.

g. Water Supply Contracts (WSCONT). When this database was originated, the phrase "water supply contract" was used, this has since been changed to "water supply agreement." No one in the Corps currently has the responsibility for this database or to keep it updated. The database that is contained in the HEC network was developed by CECW-P in the late 1980's. This database was updated by CEWRC-IWR-P through a survey of divisions and districts in March 1996 to reflect conditions current at that time. This is the primary database that relates to storage for municipal and industrial water supply. Detailed information on this database is contained in following Paragraph C. For additional information, contact Ted Hillyer (CEWRC-IWR-P), phone (703) 428-6140.

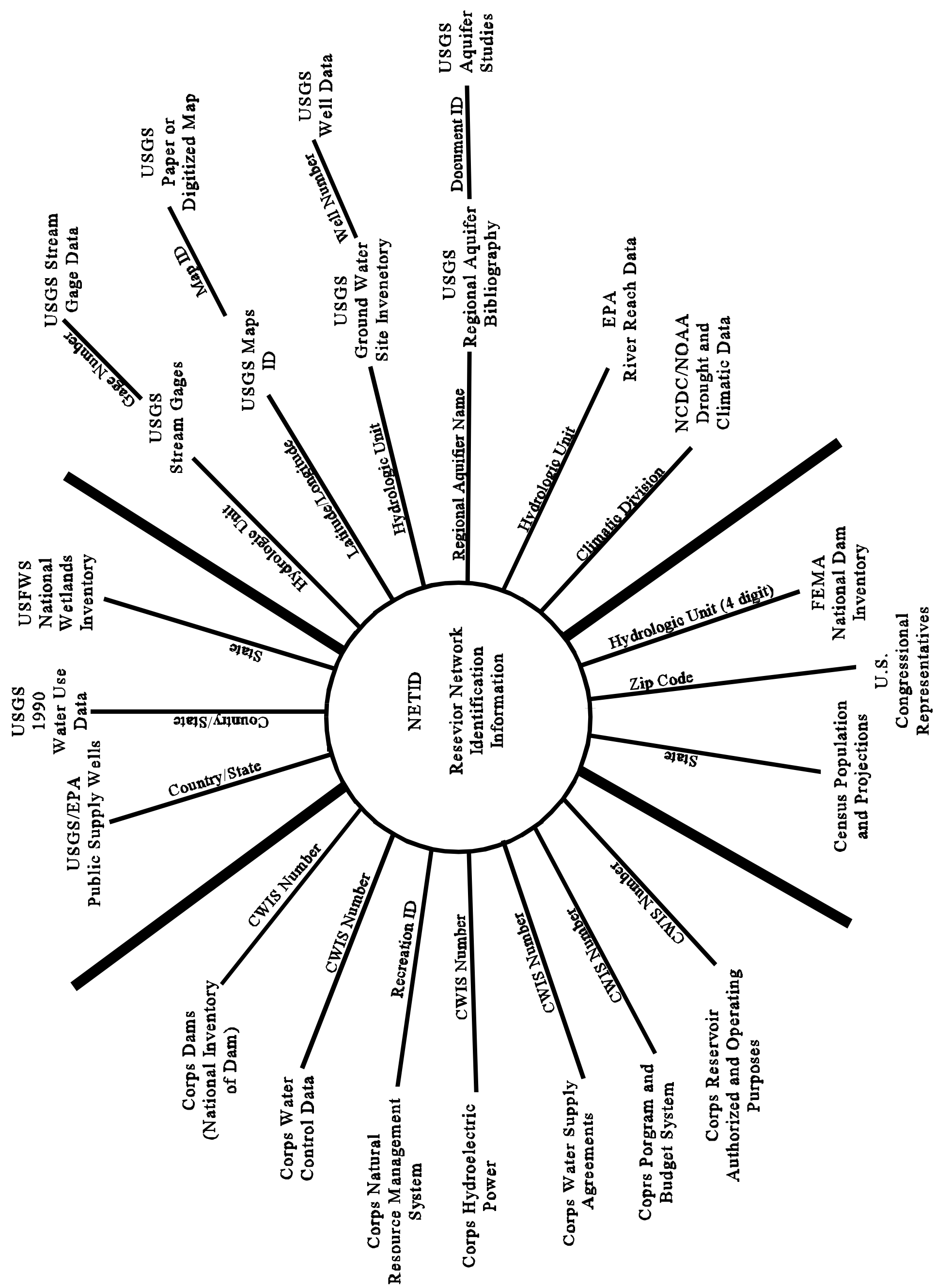

Figure 3-1
HEC Reservoir Database Network

B. RESERVOIR DATABASE

1. Definition of "Reservoir". The word "reservoir" as generally used in Corps terminology, can be either a dam and reservoir project or a lock and dam project for which water control management is routinely required to control either water level and/or water flow. Excluded from this list are other kinds of water control structures such as river diversion structures and pumping stations that do not routinely impound water. Water for municipal and industrial, agricultural, seasonal, low flow, and for contingencies is made available from lock and dam projects as well as dam and reservoir projects. However, "storage" for municipal and industrial water supply purposes is found only in dam and reservoir projects.

2. Authorized Purposes. Most purposes served by Corps reservoirs fall into eight general categories; flood control, navigation, hydroelectric power, irrigation, municipal/industrial water supply, water quality, fish/wildlife, and recreation. The purposes that a reservoir is to serve are given in laws that may be grouped into three categories; (1) laws initially authorizing construction of the project, (2) laws specific to the project passed subsequent to construction, and (3) laws that apply generally to all Corps reservoirs. Specific project authorizations (categories 1 and 2, above) are found in a variety of public laws but most commonly in a series of River and Harbor and Flood Control acts passed by Congress since 1870. Recent project authorizations have been contained in a series of Water Resources Development acts. Laws that apply generally to all projects (above category 3) are very few in number. With respect to water supply, general legislation is contained only in Public Law 78-534, 1944 Flood Control Act, as amended, (for surplus water and agricultural water) and in Public Law 85-500, 1958 River and Harbor Act, as amended, (for storage space). This latter act (Title III of Public Law 85-500) also provides the authority for the Corps to reallocate storage in projects for the purpose of municipal and industrial water supply.

3. Database.

a. Corps Report. A study conducted by the Corps in response to Section 311 of the 1990 Water Resources Development Act (Public Law 101-640), determined that there were a total of 541 Federally-owned reservoirs operated by the Corps. The results of the study are contained in a July 1992 report entitled *Authorized and Operating Purposes of Corps of Engineers Reservoirs*. For each reservoir, information is provided about the purposes for which it is authorized, the laws granting authority, and the purposes for which water is being controlled by the Corps. These data are arranged in table format for ease of reference and are contained in an appendix to the report. Also contained in the report are appendices which list all the public laws cited in the report together with the dates of enactment, statute numbers and popular or common name. Also provided are indexes to the projects alphabetically by state, alphabetically by project name, and by Corps division and district office. This is the "LEGAUTH" database that is contained in the HEC network.

b. Summary. The 1992 report lists a total of 183 projects which contain M&I water supply as either an "operating purpose" and/or an "authorized purpose." This list of 183 projects is provided in **Appendix C, Database I**. The projects are listed by division and district and indicate whether M&I water supply is an operating purpose and/or an authorized purpose, the location by state(s), and whether M&I water supply storage is provided. The cross reference on M&I water supply storage was developed from the data contained in Paragraph C of this chapter. A summary of this information is provided in **Table 3-1**. Almost half (43 percent) of the reservoir projects that have water supply as either an operating purpose and/or an authorized purpose are located in the Southwestern Division, followed by the Great Lakes and Ohio River Division with 16 percent and the Northwestern Division with about 14 percent.

Table 3-1
Reservoirs with M&I Water Supply as a Purpose

Division	Number of Projects	Number with M&I as an Operating Purpose	Number with M&I as an Authorized Purpose	Number of Different States	Number with M&I Storage Agreements
NAD	9	9	9	5	7
SAD	19	17	15	6	10
LRD	29	29	19	7	17
MVD	17	14	17	7	6
NWD	25	19	25	10	12
SWD	78	64	76	5	63
SPD	6	5	6	3	2
TOTAL	183	157	167	36	117

C. MUNICIPAL AND INDUSTRIAL WATER SUPPLY DATABASE

1. National Summaries.

a. Total Storage. The national total of all municipal and industrial (M&I) water supply storage contained in Corps reservoir projects is shown in **Table 3-2**. These numbers represent an updated survey of the data contained in the HEC WSCONT network database. This survey of the

Table 3-2
National Total by Division
M&I Water Supply Storage Database

Division	Storage Space (Acre Feet)			Contract Price ($000)			
Proj./Cont.	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
NAD: 7 / 8	138,450	4,000	142,450	127,133	7,500	0	134,633
SAD: 10 / 19	120,626	96,740	217,366	107,984	9,586	219	117,789
LRD: 17 / 18	577,940	53,469	631,409	54,393	15,996	68	70,457
MVD: 6 / 4	181,900	187,750	369,650	22,757	18,904	0	41,661
NWD: 12 /15	184,360	622,880	807,240	25,032	86,623	2,696	114,351
SWD:63/168	4,873,217	2,012,399	6,885,616	319,667	394,484	35,591	749,742
SPD: 2 / 3	258,900	212,000	470,900	8,290	96,625	0	104,915
Total:117/235	6,335,393	3,189,238	9,524,631	665,256	629,718	38,574	1,333,548

divisions and districts was performed by CEWRC-IWR-P in March 1996. This table represents a total by division and shows there are 235 signed M&I water supply agreements in 117 reservoir projects. These 117 projects have a total of about 9.5 million acre-feet of storage for M&I water supply. In this table "present use" defines the storage that is under a signed agreement for immediate use. Some of this storage has already been repaid and some is being repaid over a 30 to 50 year period. The "future use" includes storage that is under a future repayment agreement as well as storage that is not under a repayment agreement. The total storage, including the cost of specific water supply facilities, is about $1.3 billion. This dollar value is reflective of the investment cost used in the agreement and, accordingly, is not in current dollars. The table also includes storage that has been reallocated. The vast majority (approximately 73 percent) of the storage is contained in reservoir projects located in the Southwestern Division.

b. Storage Under a Repayment Agreement. The amount of storage in Corps reservoir projects that is under either a present and/or future use repayment agreement and the corresponding dollar value of this storage is shown, by division, in **Table 3-3**. As shown, a little over 8.7 million acre feet of storage is under a repayment agreement for either present use (6.3 million acre feet) or future use (2.4 million acre feet). This storage is represented by a corresponding construction cost of about $1.2 billion (including conduit costs). Of the 9.5 million acre-feet of storage space available, approximately 67 percent is under a present use repayment agreement and 25 percent is under a future use repayment agreement.

Table 3-3
National Total by Division
M&I Storage Under a Repayment Agreement

Division	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
NAD	138,450	4,000	142,450	127,133	7,500	0	134,633
SAD	120,626	96,740	217,366	107,984	9,586	219	117,789
LRD	577,940	51,269	629,209	54,393	11,696	68	66,157
MVD	181,900	0	181,900	22,757	0	0	22,757
NWD	184,360	531,380	715,740	25,032	58,317	365	83,714
SWD	4,873,217	1,515,150	6,388,367	319,667	329,085	35,070	683,822
SPD	258,900	212,000	470,900	8,290	96,625	0	104,915
Total	6,335,393	2,410,539	8,745,932	665,256	512,809	35,722	1,213,787

c. Storage Not Under a Repayment Agreement. The amount of storage in Corps reservoir projects that has not been committed to a repayment agreement is shown, by division, in **Table 3-4**. This shows that only 779,185 acre feet (approximately 8 percent) of the 9.5 million acre feet of the storage that has been included in constructed projects has not been placed under a reimbursement agreement. While the Southwestern Division has placed the vast majority of storage under contract, it also has the majority of the storage space that is not under a repayment agreement (approximately 64 percent).

Table 3-4
National Total by Division
M&I Storage Not Under a Repayment Agreement

Division	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
NAD	0	0	0	0	0	0	0
SAD	0	0	0	0	0	0	0
LRD	0	2,200	2,200	0	4,300	0	4,300
MVD	0	187,750	187,750	0	18,904	0	18,904
NWD	0	91,500	91,500	0	28,306	2,331	30,637
SWD	0	497,249	497,249	0	65,399	521	65,920
SPD	0	0	0	0	0	0	0
Total	0	778,699	778,699	0	116,909	2,852	119,761

2. Division and District Summaries. Databases of municipal and industrial water supply agreements by storage space, storage investment cost, conduit investment cost and division and district summaries are presented, respectively, in **Appendix C, Databases II through V**.

3. Projects and Signed Agreements. Detailed information on each M&I water supply agreement is presented in **Appendix C, Database VI**. This list is subdivided by division, district, project, and then by individual agreement.

4. Definitions. In Appendix C, the following definitions are followed:

a. Present Storage and Present Investment. This is the storage space and corresponding cost that are under present or immediate use in the water supply agreement.

b. Conduit Cost. In some reservoir projects, a specific water supply conduit is included as part of the dam and intake structure. This cost is to be repaid through one or more water supply agreements.

c. Type. This refers to the type of water supply agreement; i.e., storage, surplus, withdrawal, temporary use of irrigation storage space, reallocation of flood control (or some other storage space), etc.

D. AGRICULTURAL WATER SUPPLY DATABASE

1. Introduction. Agricultural water supply is included in Corps reservoir projects in the Western states under repayment agreements between the Bureau of Reclamation and the local sponsors. To date, there are no agricultural water supply agreements in Corps reservoir projects in the Eastern states, although “irrigation” can be an authorized project purpose such as in the Central and Southern Florida Flood Control Project.

2. Irrigation Storage in Completed Corps Projects. Irrigation storage and the corresponding total and Federal cost for this storage is summarized by division in **Table 3-5**. This data, originally compiled in a 1982 survey by CECW-P, was updated by CEWRC-IWR-P in a survey of divisions and divisions in March 1996. This information shows there are 50 completed projects that include agricultural water supply in some form. Most of the 50 projects include storage for “joint”and/or "specific" use. Some, however, contain no irrigation storage. **Appendix C, Database VII** should be reviewed to obtain project specific data and clarifying footnotes. The joint storage, listed as approximately 56 million acre-feet, can be used for flood control, navigation, recreation and/or hydroelectric power as well as for irrigation purposes. The total Federal cost allocated to the irrigation purpose, less the reimbursable cost, is listed as about $1.7 billion.

Table 3-5
Irrigation Storage at Completed Projects

Division	Number of Projects	Total Project Cost ($1000)	Total Federal Cost (1) ($1000)	Storage Reserved For Irrigation	
				Joint (Acre-Feet)	Specific (Acre-Feet)
Northwestern	31	3,581,937	1,164,318	50,348,000	Not Available
South Pacific	17	822,670	506,319	5,677,000	597,000
Southwestern	2	85,500	42,100	0	64,000
Total	50	4,490,107	1,712,737	56,025,000	(NA)

Footnote:
(1)Total cost less reimbursables.

3. Irrigation Storage in Corps Projects that are Under Construction. According to the best available information, there are no projects currently under construction with irrigation as a purpose.

E. REFERENCES

U.S. Army Corps of Engineers Draft Report, HEC, March 1994. Hydrologic Engineering Center Reservoir Database Network.

U.S. Army Corps of Engineers Report, HQUSACE, July 1992. Authorized and Operating Purposes of Corps of Engineers Reservoirs.

CHAPTER 4: STORAGE REALLOCATION

A. AUTHORITY

1. Water Supply Act of 1958. Reallocation is the reassignment of the use of existing storage space in a reservoir project to a higher and better use. Authority for the Corps to reallocate existing storage space to municipal and industrial (M&I) water supply is contained in Public Law 85-500, Title III, Water Supply Act of 1958, as amended (72 Stat. 319)(see Appendix A). Section 301(b), of this Act states ". . . it is hereby provided that storage may be included in any reservoir project surveyed, planned, constructed or to be surveyed, planned, and/or constructed . . . to impound water for present or anticipated future demand or need for municipal and industrial water supply." Section 301(d) of the Act states "[M]odifications of a reservoir project heretofore authorized, surveyed, planned, or constructed to include storage as provided in subsection (b), which would seriously affect the purposes for which the project was authorized, surveyed, planned, or constructed, or which would involve major structural or operational changes, will be made only upon the approval of Congress as now provided by law."

2. Guidance. Official Headquarters guidance on reallocations can be found in ER 1105-2-100. In this regulation, the guidance on reallocation of water supply storage is contained in Chapter 4, Section VII (Water Supply), Paragraph 4-32d, dated 31 October 1997. Additional information in the ER is contained in Chapter 6, Section XV (Cost Allocation), Paragraph 6-205, dated December 1990. Periodic Engineering Circulars and Policy Guidance Memorandums can also be issued on this procedure. The intent of this chapter is not only to capture all current policies and procedures, but also to provide additional information that may be helpful to Corps planners attempting to reallocate storage.

B. OPPORTUNITIES

1. Reservoirs.

a. Multipurpose Pools. A typical multipurpose reservoir consists of three pools; a flood control pool, a conservation pool, and an inactive or sediment pool. The flood control pool is normally kept empty to permit storage of runoff during times of high inflow. The conservation pool can consist of dedicated storage for one or more of the following purposes: hydropower, navigation, water supply, water quality, or irrigation. Recreation can also have dedicated storage, but in most all Corps multipurpose reservoir projects, the recreation feature uses the top of the conservation pool. The inactive or sediment pool, while it can be used, is generally not available to meet downstream water needs. This storage is normally set aside for hydropower head and/or to store the sediment expected to accumulate over the life of the project.

b. Types of Reallocations. Opportunities to reallocate storage in Corps reservoirs from an authorized purpose to M&I water supply was the subject of a study performed by the Institute for Water Resources. The study, *Opportunities for Reservoir Storage Reallocation,* IWR Policy Study 88-PS-2, dated July 1988, documents eight opportunities available for reallocation. These opportunities for reallocation are:

(1). Use of water supply storage not under contract;

(2). Temporary use of storage allocated for future conservation purposes and sediment;

(3). Storage made available by change in conservation demand or purpose;

(4). Seasonal use of flood control space during dry seasons;

(5). Reallocation of flood control space;

(6). Modification of reservoir water control plan and method of regulation;

(7). Raising existing dams; and

(8). System regulation of Corps and Non-Corps reservoirs.

c. Limits of this Chapter. This chapter limits the study of reallocations to those that permanently transfer storage from another authorized use (flood control, hydropower, other conservation, or sediment) to M&I water supply.

(1). Change in Conservation Storage Demand or Need. Originally authorized project purposes may no longer be required to meet present needs or may be available for some new equal or higher purpose. The opportunity then exists to modify or update the authorized project purposes through reallocation. For example, changes in a reservoir's upstream conditions may provide an opportunity to consider whether to extend the period that sediment could be collected without encroachment on other storage or to allow part of the storage initially reserved for sediment to be reallocated to water supply. Another case is where water quality storage originally provided to dilute pollutants may no longer be needed if pollutants are now being removed before being discharged into a stream or river. The reallocation of hydropower storage is the most common example of reallocation. This has been accomplished several times when the benefits of the reallocation are positive. In these cases, however, transferring some of the revenues collected from the water supply user to the local power marketing agency may be necessary. If reallocation of hydropower storage is contemplated and an economic question arises, the Power Branch of the U.S. Army Corps of Engineers Northwestern Division (CENWD-ET-WP) should be contacted for assistance. This branch (the Hydropower System Economic Evaluation Center) is the official center of expertise for hydropower evaluation in the Corps.

(2). Reallocation of Flood Control Space. Three conditions that create an opportunity to reallocate flood control storage to water supply storage are:

• Where reallocated flood control storage volumes are small and do not affect flood protection. If the effect is large, Congressional action is required;

• Where the downstream floodplain has changed or supplemental protection has been provided; and

• Where reservoirs have been designed to a maximum site capacity that is larger than required by hydrologic analysis.

2. Partnerships. Opportunities for reallocation can also be created through new partnerships with states and other water agencies. The Memorandum of Understanding (MOU) between the State of Kansas and the Department of the Army is the principal example. This MOU was signed on 11 December 1985 and was an effort to realize the highest level of benefits possible in existing Corps regulated reservoirs in the state. While the MOU has since expired, it was an example of a unique opportunity to:

• Solve the State's water supply problems regarding availability and dependability;

• Increase the recovery of Federal investments occurring in the State's water resources developments;

• Shift a greater portion of operation and maintenance costs from the Federal government to the State; and

• Establish a water resource management plan.

The major benefits to the State of Kansas and to the Nation are summarized in **Table 4-1**. Such partnerships occur where careful planning and analyses precede cooperative discussions that develop partnerships in which all parties benefit. Should similar situations occur in other areas of the nation, districts should prepare a letter report laying out the circumstances and forward to HQUSACE (CECW-A).

Table 4-1
Benefits of the Kansas MOU

Major Benefits to the State of Kansas	Major Benefits to the Nation
1. Create a dependable water supply since the users never controlled the quality or the quantity of the releases that would take place under the old system. 2. Determined the availability of excess water storage that would be made available through the studies performed under the agreement. 3. Gained control over the lake regulation to enhance their water management program. 4. Price of water supply storage based on the same basis that would have occurred if such storage had originally been authorized for water supply storage instead of the more expensive updated cost of storage required by ER 1105-2-100.	1. Reimbursement of Federal investment and operation and maintenance cost for the State acquisition of water supply storage in the reservoirs. 2. Obtained the State of Kansas' protection of the water quality inflows and releases that would make it possible to meet the Federal government's water quality objectives. 3. The State of Kansas would make up-front payments to secure their commitment and responsibility within the agreement.

3. History of Reallocations. Between 1958 and 1979, several reallocations were performed under the discretionary authority of the Commander, USACE. None of these reallocations were greater than 15 percent of total usable storage and/or 50,000 acre-feet. The price paid for this reallocated storage was based on the original cost of storage. In 1979 a new pricing policy was instituted that required the higher of benefits or revenues foregone, replacement cost, or the updated cost of storage, to be charged for the reallocated cost of storage. Shown in **Appendix D** is a list of the reallocations made at Corps projects, and while not complete, this does show considerable interest in this method of obtaining M&I water supply for a variety of uses. A summary of the reallocations is provided in **Table 4-2**.

Table 4-2
Summary of Reallocations 1965-1998

Reallocated Purpose	Number of Reallocations	Storage Reallocated (acre-feet)
Hydropower	17	102,832
Flood Control	13	119,978
Conservation	8	62,863
Other or Unknown	12	129,719
Total	50	415,392

4. Water Supply Studies. Interest continues nationwide in the study of sources of potential municipal and industrial water supply. As shown in the Presidents budget submission to Congress for Fiscal Year 1999, there are five reconnaissance studies, three feasibility studies and one study in preconstruction engineering and design that include the study of water supply to some degree. A summary of these study proposals is contained in **Table 4-3**. The total Fiscal Year 1999 tentative allocation for these nine studies is $2, 969,000.

Table 4-3
Water Supply Studies
Presidents FY 99 Submission to Congress
(Continued on next page)

District	Type Study	Cost ($000)		Description
		Phase Total Federal	FY 99 Budget	
SAS	Recon.	600	300	Savannah River Basin Comprehensive. The study of the basin will focus on review of the operation of the major reservoirs in the basin, the need for additional flood control measures, environmental restoration, surface water supply, and other allied water resources problems.
SAS	Feas.	840	350	New Savannah Bluff Lock & Dam. The Section 216 study will document existing conditions; investigate appropriate purposes such as water supply, fish and wildlife restoration, and recreation; and determine the interest in turning the project over to another entity.
ORP	Recon.	625	148	Youghiogheny Lake Storage Reallocation. Westmoreland and North Fayette Counties, PA have requested the Corps to explore the potential for improving the storage and release schedule and reallocating a portion of the Youghiogheny Lake storage for water supply.
NWO	Recon.	932	158	Chatfield, Cherry Creek, and Bear Creek. The purpose of this study is to examine, under the 1958 Water Supply Act, as amended, the potential for reallocating storage in the Chatfield, and/or the Bear Creek, project.
NWP	Feas.	2,284	440	Willamette River Basin Review. The study will determine if modifying the operation and maintenance of the system of 13 Corps' reservoirs In the interest of flood control, fish & wildlife conservation, municipal & industrial water supply, and development of additional recreational interests would better serve current and anticipated future water resources needs.

Table 4-3 (continued)

District	Type Study	Cost ($000)		Description
		Phase Total Federal	FY 99 Budget	
NWS	PED	1,687	600	Howard Hanson Dam, Additional Water Storage. Changes to the dam and reservoir which are being studied include water supply storage, low-flow augmentation storage, fish passage improvements, and fish and wildlife habitat improvements.
NWW	Recon.	1,116	240	Walla Walla River Watershed (Columbia River Basing). Of primary concern in this special study is water supply and quality for municipal and industrial needs, irrigated agriculture, and perhaps, mst importantly, sustaining and restoring anadromous fisheries.
SPL	Recon.	1,600	400	Santa Margarita River and Tributaries. The study will examine watershed management, including flood control, environmental restoration, storm water retention, water conservation and supply, and recreation related purposes.
SPL	Feas.	968	333	Prado Basin Water Supply. The study will investigate water conservation potential year round including dam raising and other less costly potential sources of water .

C. PROCEDURES

1. Policies. A reallocation report is separate from a reallocation action. A report may include future needs, but a reallocation action can only be in the context of satisfying immediate needs. An immediate need can be defined as the amount of storage the sponsor will make payment for immediately. A reallocation action is not complete until a water supply agreement for those immediate needs is approved. When the need for reallocation or addition of storage at a project first arises, districts are encouraged to survey not only the immediate water needs but should include the water needs for the next 15-20 year planning horizon although such need may be met through several reallocation actions over a period of several years. This entire need is to be put into one reallocation report. Agreements submitted after approval of the original reallocation report will be accompanied by the original approved report with information showing the changes in impacts (if any) since the time of the report. The new information will also determine the price of storage in the new agreement.

2. Reallocation Report.

a. Purpose. Whenever a reallocation is contemplated, a reallocation report must be prepared. This report can vary in length depending upon the size of the change and the issues encountered.

The purposes of the report and the topics to be discussed are as follows:

(1). Identify and quantify the new use and user;

(2). Evaluate the impacts on other project purposes and users;

(3). Determine environmental effects;

(4). Determine the price to be charged the new user; and

(5). Determine appropriate compensation, if any, to existing users/beneficiaries.

b. Outline. A suggested outline for a reallocation report is given in **Box 4-1**. The text of the

Box 4-1, Suggested Contents for a Reallocation Report

- Purpose
  - Request for M&I water supply
  - Authority for seeking reallocation
- Project Background
  - Project authorization, construction and operation history
  - Project purpose and outputs
  - Project map and pertinent data table
  - Information on previous water supply agreements
- Economic Analysis (Reallocation Feasibility)
  - Water supply demand analysis
  - Analysis of water supply alternatives (benefits)
  - Impacts on other project purposes (benefits foregone)
  - Information on approved cost allocation
- Derivation of User Cost
  - Water supply storage/yield analysis
  - Cost of storage analysis
  - Revenues foregone and cost account adjustments
  - Summary, users cost
- Other Considerations
  - Test of financial feasibility
  - Cost account adjustments
  - Environmental considerations
- Conclusions and Recommendations
  - Summarization of findings
  - Reference applicable appendices
  - Recommendation of the District Engineer
- Appendices
  - NEPA documentation (EA w/FONSI or EIS)
  - Documentation of opportunity for public review of action
  - Letters and views of other Federal, state, and/or local interests affected by the action

report will contain the major subject matter elements (not necessarily to be used as headings) as presented in the table. The level of detail should be commensurate with the amount of storage reallocated and/or the problems encountered because of the reallocation. A reallocation report may even serve as a reauthoriztion report. This would be expected in those reports recommending major changes. A detailed outline of a reallocation report, including examples, is provided in **Appendix D**.

3. Funding for Reallocation Studies. The determination of the feasibility of reallocating storage in an existing reservoir will usually be conducted under the framework established by the March 10, 1983, Water Resources Council's *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*, better known as the "Principles and Guidelines" (P&G). The study will have two phases, reconnaissance and feasibility. The reconnaissance study will be sufficiently detailed to determine if a feasibility study is warranted and if Congressional authorization is required for reallocation or addition of M&I water supply storage. The reconnaissance phase will normally be accomplished using Operation and Maintenance (O&M), General funds. The use of the authority of Section 216 of the 1970 Flood Control Act (Public Law 91-611) (see Appendix A) and the regular survey authority, however, are also options. If O&M funds are used and Congressional authorization is required, cost sharing of the additional studies with the non-Federal sponsor is required by the provisions in Section 105 of WRDA '86. The Federal share of the additional studies, or the feasibility phase cost for a Section 216 or regular survey authority, will be derived from the General Investigations appropriation. At the start of the study, if the proposed reallocation is likely to require Congressional authorization, contact HQUSACE (CECW-P) for additional guidance on requesting funds for the feasibility phase. If the reallocation is determined to be warranted, but does not require additional studies or Congressional authorization, the O&M, General fund may be used to complete the reallocation at Federal expense.

4. Cost of Reallocated Storage.

a. General. The cost allocated to the non-Federal sponsor for the capital investment for reallocated storage space will normally be established as the highest of the benefits or revenues foregone, the replacement cost, or the updated cost of storage in the Federal project. The non-Federal sponsor is also responsible for any specific construction and/or operational costs associated with the reallocation action including costs associated with the revision of the water control plan and environmental mitigation costs. The cost shall not, however, include the cost of past expenditures for replacement, rehabilitation and reconstruction. These later costs are excluded, as the price charged to the user will be at least the price of the storage space in a new project, which assumes the project is in a new state of repair.

b. Benefits Foregone. Benefits foregone are generally estimated using standard Corps' national economic development (NED) evaluation criteria in compliance with the P&G. The benefits foregone should be estimated for the remaining economic life of the project or 50 years which ever is greater. For reallocations from hydropower storage that are within the discretionary authority of the Commander, USACE, benefits foregone may be obtained from in-house power value estimating procedures or otherwise in accordance with the P&G. For large reallocations, estimates should be calculated by P&G procedures for evaluation of hydropower benefits.

c. Revenues Foregone. Revenues foregone to hydropower are the reduction in revenues accruing to the U.S. Treasury as a result of the reduction in hydropower outputs based on the existing rates charged by the power marketing agency. Revenues foregone from other project purposes are the reduction in revenues accruing to the U.S. Treasury based on any existing repayment agreements.

d. Replacement Costs.

(1). From Flood Control. If the reallocated storage is being taken from the flood control pool and adverse impacts warrant replacement measures, it is appropriate to use the replacement cost of equivalent protection. Examples of when replacement of flood control storage would be appropriate are when there is a real estate taking or when the value of the lost flood control storage is greater than the value of the added M&I storage. This would not be appropriate for reallocations within the discretionary authority of Commander, USACE, which by definition, do not have severe impacts.

(2). From Hydropower. For reallocations from hydropower pools, the replacement cost of power should normally be considered equal to the benefits foregone and calculated by P&G procedures for evaluation of hydropower benefits. In cases where the power marketing agency has existing contracts with their customers, the replacement cost of power may be estimated as the agency's cost of obtaining power from the lowest cost alternative source for the duration of the contracts. Once the contracts expire and for the remainder of the period of analysis, the replacement cost of power should be equal to the benefits foregone. Documentation of such contracts and estimates of replacement costs of power to fulfill them should be included in the reallocation report.

e. Updated Cost of Storage. Under the updated cost of storage procedure, the cost of the reallocated storage is determined through a three-step process. These three steps are displayed in **Table 4-4**.

(1). Cost at Time of Construction. Compute the cost of the reallocated storage at the time of construction by using the "Use of Facilities" cost allocation procedure.

(2). Midpoint of Construction. Determine the midpoint of the physical construction period.

(3). Update Cost. Using the appropriate index(s) update the cost from the midpoint of the construction period to the beginning of the fiscal year in which the contract for the reallocated storage is approved.

Table 4-4
Updated Cost of Storage Procedure

Step	Formula	Definitions (Storage in acre-feet)
1	$C_{rs} \quad (C_t \quad C_s) \; x \; \frac{S_r}{S_t \quad (S_s \quad S_h)}$	Crs = Cost of reallocated storage Ct = Total cost Cs = Cost of specific facilities Sr = Reallocated storage St = Total storage Ss = Sediment storage Sh = Hydropower head storage

Step	Construction Phase	Definition
2	Construction Initiated	Either of the following: 1) Start of the month when lands were first acquired; or 2) Date when the first construction agreement was awarded.
	Construction Completed	End of the fiscal year in which final deliberate impoundment of the reservoir was initiated.
	The midpoint of Construction	The month that is half way between initiation and completion of construction.

Step	Time	Cost Item	Index[1]
3	Prior to 1967	All items	ENR
	1967 to Present	Relocations	ENR
		Building, grounds and utilities	ENR
		Permanent operating equipment	ENR
		All other items except lands [2]	CWCCIS

Footnotes:
1.Index.
ENR = *Engineering News Record* Construction Cost Index (see following paragraph 5).
CWCCIS = Corps'"Civil Works Construction Cost Index System." This is maintained in EM 1110-2-1304.

2.Lands. The value of lands will be updated by the weighted average update of all other project features.

5. Engineering News Record Index. The *Engineering News Record* Construction Cost Index is comprised in the following manner: 200 hours of common labor at the 20-city average of common labor rates, plus 25 cwt of standard structural steel shapes at the mill price, plus 22.56 cwt (1.128 tons) of portland cement at the 20-city price, plus 1,088 board-feet of 2 x 4 lumber at the 20-city price. The following cities comprise the 20-cities: Atlanta, Baltimore, Birmingham, Boston, Chicago, Cincinnati, Cleveland, Dallas, Denver, Detroit, Kansas City, Los Angeles, Minneapolis,

New Orleans, New York, Philadelphia, Pittsburgh, St. Louis, San Francisco, and Seattle. In this index, 1913 = 100. The annual average index history from 1906 to the present is provided in **Table 4-5** and the monthly index from January 1970 to the present is provided in **Table 4-6**.

Table 4-5
ENR Construction Cost Annual Average Index
(1913 = 100)

		1920	251	**1940**	242	**1960**	824	**1980**	3237
		1921	202	**1941**	258	**1961**	847	**1981**	3535
		1922	174	**1942**	276	**1962**	872	**1982**	3825
		1923	214	**1943**	290	**1963**	901	**1983**	4066
		1924	215	**1944**	299	**1964**	936	**1984**	4146
		1925	207	**1945**	308	**1965**	971	**1985**	4195
1906	95	**1926**	208	**1946**	346	**1966**	1019	**1986**	4295
1907	101	**1927**	206	**1947**	413	**1967**	1074	**1987**	4406
1908	97	**1928**	207	**1948**	461	**1968**	1155	**1988**	4519
1909	91	**1929**	207	**1949**	477	**1969**	1269	**1989**	4615
1910	96	**1930**	203	**1950**	510	**1970**	1381	**1990**	4732
1911	93	**1931**	181	**1951**	543	**1971**	1581	**1991**	4835
1912	91	**1932**	157	**1952**	569	**1972**	1753	**1992**	4985
1913	100	**1933**	170	**1953**	600	**1973**	1895	**1993**	5210
1914	89	**1934**	198	**1954**	628	**1974**	2020	**1994**	5408
1915	93	**1935**	196	**1955**	660	**1975**	2212	**1995**	5471
1916	130	**1936**	206	**1956**	692	**1976**	2401	**1996**	5620
1917	181	**1937**	235	**1957**	724	**1977**	2576	**1997**	5825
1918	189	**1938**	236	**1958**	759	**1978**	2776	**1998**	5920
1919	198	**1939**	236	**1959**	797	**1979**	3003	**1999**	

Table 4-6
ENR Construction Cost Monthly Index (1913 = 100)

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
1970	1309	1311	1314	1329	1351	1375	1414	1418	1421	1434	1445	1445
1971	1465	1467	1469	1513	1551	1589	1618	1629	1654	1657	1665	1672
1972	1686	1691	1697	1707	1735	1761	1772	1777	1786	1794	1808	1816
1973	1838	1850	1859	1874	1880	1896	1901	1902	1929	1933	1935	1939
1974	1940	1940	1940	1961	1961	1993	2040	2076	2089	2100	2094	2101
1975	2103	2128	2128	2135	2164	2205	2248	2274	2275	2293	2292	2297
1976	2305	2314	2322	2327	2357	2410	2414	2445	2465	2478	2486	2490
1977	2494	2505	2513	2514	2515	2541	2579	2611	2644	2675	2659	2660
1978	2672	2681	2693	2698	2733	2753	2821	2829	2851	2851	2861	2869
1979	2872	2877	2886	2886	2889	2984	3052	3071	3120	3122	3131	3140
1980	3132	3134	3159	3143	3139	3198	3260	3304	3319	3327	3355	3376
1981	3372	3373	3384	3450	3471	3496	3548	3616	3657	3660	3697	3695
1982	3704	3728	3721	3731	3734	3815	3899	3899	3902	3901	3917	3950
1983	3960	4001	4006	4001	4003	4073	4108	4132	4142	4127	4133	4110
1984	4109	4113	4118	4132	4142	4161	4166	4169	4176	4161	4158	4144
1985	4145	4153	4151	4150	4171	4201	4220	4230	4229	4228	4231	4228
1986	4218	4230	4231	4242	4275	4303	4332	4334	4335	4344	4342	4351
1987	4354	4352	4359	4363	4369	4387	4404	4443	4456	4459	4453	4478
1988	4470	4473	4484	4489	4493	4525	4532	4542	4535	4555	4567	4568
1989	4580	4573	4574	4577	4578	4599	4608	4618	4658	4658	4668	4685
1990	4680	4685	4691	4693	4707	4732	4734	4752	4774	4771	4787	4777
1991	4777	4773	4772	4766	4801	4818	4854	4892	4891	4892	4896	4889
1992	4888	4884	4927	4946	4965	4973	4992	5032	5042	5052	5058	5059
1993	5071	5070	5106	5167	5262	5260	5252	5230	5255	5264	5278	5310
1994	5336	5371	5381	5405	5405	5408	5409	5424	5437	5437	5439	5439
1995	5443	5444	5435	5432	5433	5432	5484	5506	5491	5511	5519	5524
1996	5523	5532	5537	5550	5572	5597	5617	5652	5683	5719	5740	5744
1997	5765	5769	5759	5799	5837	5860	5863	5854	5851	5848	5838	5858
1998	5852	5874	5875	5883	5881	5895	5921	5929	5963	5986	5995	5991
1999												

6. Cost Accounts. All income and expenses (investment, operation, maintenance, replacement, etc.) associated with the water supply function will be separately identified in the official cost account record. When there is a loss of revenue from existing purposes, or additional operation and/or maintenance expense to existing purposes are incurred because of the new water supply addition, such charges will be shown as a direct charge against the water supply function. All revenues lost to the project and downstream areas must be considered. This loss will affect the appropriate cost reductions in the existing project purposes and all revenues from the new addition will be credited to the new purpose. If hydropower revenues are being reduced because of the reallocation, the power marketing agency will be credited for the amount of revenues foregone to the U.S. Treasury because of the reallocation assuming uniform annual repayment. In instances where existing repayment agreements between the power marketing agency and their customer would result in a cost to the Federal Government to acquire replacement power to fulfill the obligations of the agreements, an additional credit to the power marketing agency can be made for such costs incurred during the remaining period of the agreements. Such credits should not actually be made for replacement costs until the costs are incurred and documented by the power marketing agency.

7. Financial Feasibility. As a test of financial feasibility, the governing annual cost of storage derived as determined in above paragraph 4, should be compared to the annual cost of the most likely, least costly alternative that would provide an equivalent quality and quantity of water that the non-Federal interest would undertake in the absence of using the Federal projects. This analysis is to be included in the reallocation report.

8. Approval. Providing the criteria of the 1958 Water supply Act are not violated, 15 percent of total storage capacity allocated to all authorized project purposes or 50,000 acre feet, whichever is less, may be allocated from storage authorized for other project purposes or may be added to the project to serve as storage for M&I water supply at the discretion of the Commander, USACE. For reallocations up to 499 acre-feet the Commander, USACE has delegated approval authority to the division commander. Reallocations that exceed the Commander USACE's authority may be approved at the discretion of the Secretary of the Army if such reallocations do not require Congressional approval as described above. The approval of the reallocation report, however, does not signify an approval to reallocate storage. Such approval is governed by the final signature of the water supply agreement. See Chapter 2, Table 2-3 for additional detail.

D. REFERENCES

The McGraw Hill Company. Engineering News-Record, a monthly magazine by a division of McGraw Hill, publishers.

U.S. Army Corps of Engineers, HQUSACE, ER 1105-2-100, 28 December 1990. Guidance for Conducting Civil Works Planning Studies, Chapter 6, Section XV.

U.S. Army Corps of Engineers, HQUSACE, ER 1105-2-100, 31 October 1997. Guidance for Conducting Civil Works Planning Studies, Chapter 4, Section VII.

U.S. Army Corps of Engineers, IWR, Policy Study 88-PS-2, July 1988. Opportunities for Reservoir Storage Reallocation.

Water Resource Council, 10 March 1983. Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation.

CHAPTER 5:
WATER SUPPLY PARTNERSHIP KIT

DECEMBER 1998

A. INTRODUCTION

This chapter is meant to be a self-contained pamphlet that can be copied and provided to local sponsors who may desire to enter into municipal and industrial water supply agreements. The pamphlet includes an example of a letter of introduction from the District Commander to the non-Federal sponsor, defines the Corps' mission in the area of water supply and provides some general background on the organization and responsibilities of the Corps. Draft water supply agreements from Appendix B should be attached to the pamphlet as required by the sponsor.

B. ATTACHMENT

Provided as an attachment is "WATER SUPPLY PARTNERSHIP KIT."

______________ District

U.S. Army
Corps of Engineers

WATER SUPPLY

PARTNERSHIP KIT

DISTRICT LETTERHEAD

*** E X A M P L E ***

Dear Sponsor:

I am pleased to welcome you as a partner with the U.S. Army Corps of Engineers in the development and management of the Nation's water supply and to send you a copy of this Water Supply Partnership Kit.

The Corps of Engineers has been developing municipal and industrial water supply agreements with non-Federal sponsors for storage space in our reservoir projects since 1948. As of August 1996, we had 240 contracts in 117 different projects for about 9.5 million acre-feet of storage space. This space represents a Federal investment of about $1.3 billion in actual dollars. This district has ___ contracts in ___ reservoirs for a total of _____ acre-feet of storage space.

This Partnership Kit contains a collection of tools designed to help you to understand the Corps' water supply mission better. It includes the water supply authorities under which we operate and the various options we have to help satisfy your water supply needs, including model formats for different types of water supply agreements. It also includes some basic information on the Corps organization, addresses of all the offices and responsibilities of the various levels within the organization. We believe that if we improve our understanding of each other our partnerships will be more efficient, productive and successful in providing quality projects and service.

In this district [the water supply function is handled in the _______(branch)______. The chief of this branch is _______.] (or) [the initial contact is with the project manager at _________ Lake. The project manager at this lake is _____________ .] Mr./Ms. can be reached by phone at _________________. If you have any ideas about how this kit can be improved, or suggestion about other ways in which we can help, please do not hesitate to contact me at the above address.

Sincerely,

____
(Name)

____
(Title)

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INTRODUCTION

We welcome you as a partner with the U. S. Army Corps of Engineers in the development and management of the Nation's water resources. This Partnership Kit contains a collection of tools designed to help you better understand the Corps mission in the area of municipal and industrial water supply and how you can utilize this mission to help you meet your water supply needs. This kit also includes some general information about the Corps, as well as more specific information about the District office in your area.

The Army Corps of Engineers (Corps) is the Federal government's largest water resources development and management agency. Our water resources (Civil Works) program began in 1824, when Congress first appropriated funds for improving navigation. Since then, we have been involved in improving navigation in rivers and harbors, reducing flood damages, and protecting our shorelines. Many projects designed for these missions also generate hydroelectric power; supply water for cities, industries and agriculture; and provide outdoor recreation. Entwined within these missions is environmental management and restoration.

WATER SUPPLY MISSION

National policy concerning the Corps role in water supply has been developed over a number of years and is still being clarified and extended through budgetary guidance and by legislation enacted through water resources development acts. This policy is based on a recognition that states and local interests have the primary responsibility in the development and management of their water supplies. The Corps role in water supply can be defined by three legislative acts. These are; Section 6 of the 1944 Flood Control Act (surplus water), Section 8 of the 1944 Flood Control Act (agricultural water supply), and the 1958 Water Supply Act (storage). In limited circumstances, we may also provide emergency supplies of clean water to a locality confronted by a source of contaminated water likely to cause a substantial threat to public health. These specifically defined roles are discussed in more detail in the following sections in the order of significance from a Corps mission standpoint.

WATER SUPPLY STORAGE

AUTHORITY.

Most likely, your request for assistance from the Corps to help you solve your water supply needs will fall under the general category of "water supply storage." The authority for the Corps to include storage for municipal and industrial (M&I) water supply in both new and existing reservoir projects is contained in the 1958 River and Harbor Act. Title III of this Act (Public Law 85-500) is entitled the "Water Supply Act of 1958." While this act gives the Corps authority to modify projects for water supply, any modification which would seriously affect the project, its other purposes, or its operation, can only be accomplished with the approval of Congress.

The 1958 Water Supply Act has been amended twice, once by Section 10 of the Federal Water Pollution Control Act Amendments of 1961, and again by Section 932 of the Water Resources Development Act of 1986 (WRDA '86). The 1961 amendment eased restrictions of the 1958 Act by permitting the acceptance of assurances for the use of future water supply as a means of accommodating the construction cost payment for future water supply. The 1986 amendment put more burden on the non-Federal sponsor for water supply in Corps projects, but not for water supply in Bureau of Reclamation projects. This amendment eliminated the 10-year interest free period; modified the interest rate formula; reduced the repayment period from 50 to 30 years; and required the annual operation, maintenance and replacement costs to be reimbursed on an annual basis. This latter requirement was already a part of Corps repayment policy. For your information, a copy of the 1958 Water Supply Act, as amended, is provided as **Attachment A**.

One other act has had a major impact on the Corps mission in providing storage in projects. This act was Public Law 88-140, enacted on 16 October 1963. Under this act, the non-Federal sponsor of water supply storage has the right to the use of the storage for the physical life of the project after the costs of storage have been repaid, and subject to the continued repayment of annual operating costs. This provision removed the uncertainty as to the continued availability of the storage space after the 50-year maximum period previously allowed in contracts.

DEFINITION.

What exactly does the Corps mean by "M&I water supply storage?" While the term has not been defined in law, the Corps has taken it to mean supply for uses ordinarily found among customers of a municipal systems and for uses in industrial processes. Services to be provided will normally consist of space in a reservoir for use in regulating the flow of water so that it is useful for water supply purposes, and the provision, where necessary, of facilities in the project structure to provide for the release or withdrawal of stored water for water supply purposes.

Water rights necessary for the use of the stored water will not be acquired by the Corps but will be obtained as necessary by the water users. Where it is a requirement of State law, the non-Federal sponsor shall provide proof of a water right for the water to be stored or released from the Corps project.

Water supply agreements under the authority of the 1958 Water Supply Act are for storage space only. The Federal government makes no representation with respect to the quality or quantity of water and assumes no responsibility for the treatment, or availability of the water.

COST.

Your most primary concern is probably with the cost; how much will the Corps charge me for the water I want and what will be the repayment requirements? That is not a easy question to answer because it depends upon a number of factors. These factors include:

1) is this to be a new project, or is it already constructed?

2) if the project is existing was it constructed before or after 1986?

3) if the project is existing, is the space you want to utilize already authorized, or will it require a reallocation?

4) are you a low income community and, therefore, available for a reduced price for water under certain circumstances? and

5) regardless of the above factors, what other costs may you be responsible for?

The following sections will attempt to clarify the cost and repayment responsibilities for each of the above situations.

1) New Projects: A "new" project is classified as one for which construction started on or after 17 November 1986, the date of enactment WRDA '86. Since the Corps' ability to construct new multipurpose reservoirs projects is severely limited, the possibility of storage in new projects is unlikely. However, should the storage be in one of these "new" projects, the ***cost*** of storage will be the actual construction cost allocated to the amount of storage assigned to your use. While the law permits the ***repayment*** of these costs over a 30-year period, Administration policy requires the repayment of these costs either before or during the period of construction of the reservoir project. For this reason, all water supply storage in "new" projects is committed to non-Federal sponsors prior to construction and there is no available storage in new projects for new sponsors. Policy also prohibits the construction of single purpose water supply projects; i.e., water supply can only be considered when at least 20 percent of the new project benefits are attributed to flood control, navigation, environmental restoration, and/or

agricultural water supply.

2) <u>Existing Projects With Uncommitted Storage Space</u>: There are 20 Corps reservoir projects located in six states with almost 780,000 acre-feet of municipal and industrial water supply storage space that is not currently under a repayment agreement and is available for your use. These projects, the storage, the state and the Corps district office responsible for the project is provided in **Table 1**. If you are located in the proximity of one of these projects, you should enter into an agreement for this storage as it is less expensive than new storage or reallocated storage. In these projects the ***cost*** to be repaid is the actual cost assigned to the storage space at the time of construction. There are two options for ***repayment*** of these costs over time.

Table 1
Existing Corps of Engineers Projects With Authorized But Uncommitted Storage Space

Corps District	Project	State	Acre -Feet
Pittsburgh	Stonewall Jackson	West Virginia	2,200
St. Louis	Clarence Cannon	Missouri	20,000
Vicksburg	DeGray	Arkansas	167,750
Kansas City	Long Branch	Missouri	6,200
	Smithville	Missouri	75,700
Little Rock	DeQueen	Arkansas	17,275
Tulsa	Birch	Oklahoma	7,630
	Broken Bow	Oklahoma	144,145
	Copan	Oklahoma	2,500
	Eufaula	Oklahoma	42,967
	Hugo	Oklahoma	2,198
	Kaw	Oklahoma	80,211
	Keystone	Oklahoma	1,999
	Oologah	Oklahoma	15,595
	Optima	Oklahoma	*
	Pine Creek	Oklahoma	20,600
	Skiatook	Oklahoma	47,652
	Tenkiller Ferry	Oklahoma	5,016
	Waurika	Oklahoma	109,600
	Wister	Oklahoma	347
Portland	Lost Creek	Oregon	9,600

* Optima Lake in the Tulsa District was designed for 76,200 acre-feet of water supply storage. However, due to changed conditions, Optima has never filled. Optima has no storage or yield.

The first repayment option is to repay the costs over a period of 30 years from the date of availability of the storage space. The date of availability is defined as the plant-in-service date of the project or the date the first water supply agreement in the project was signed, whichever is later. The interest rate to use in this case will be the rate as established by the 1958 Water Supply Act for the date of initiation of project construction. These interest rates are shown in **Table 2**. If this repayment option is utilized, in many cases the period left to repay the cost will be less than 30 years. If this is the case, then another option is available to the local sponsor.

Table 2
1958 Water Supply Act Interest Rates

Fiscal Year	Interest Rate (%)	Fiscal Year	Interest Rate (%)	Fiscal Year	Interest Rate (%)
1959	2.670				
1960	2.699	1970	3.342	1980	7.250
1961	2.632	1971	3.463	1981	8.605
1962	2.742	1972	3.502	1982	9.352
1963	2.936	1973	3.649	1983	10.051
1964	3.046	1974	4.012	1984	10.043
1965	3.137	1975	4.371	1985	10.898
1966	3.222	1976	5.116	1986	11.070
1967	3.225	1977	5.683		
1968	3.253	1978	6.063		
1969	3.256	1979	6.595		

The second repayment option is to permit the repayment of costs over a 30-year period at the repayment rate as prescribed in Section 932 of WRDA ‘86. In this case, the rate will be the rate that is current as of the time of signing of the water supply agreement. This rate will be adjusted at 5-year intervals over the repayment period. The rate will be increased by one-eight of one percentage point for transactions costs. These rates are shown in **Table 3**. In this table, the rates have been increased to include the transaction factor. While these rates are not applicable to what rates may be in the future, they do give an indication of what the past rates have been and the fact that they can vary significantly from one year to the next. The interest rate formula is defined in the 1958 Water Supply Act, as amended, that is provided in **Appendix A**.

Table 3
1986 Water Resource Development Act Water Supply Interest Rates

Fiscal Year	Interest Rate (%)	Fiscal Year	Interest Rate (%)	Fiscal Year	Interest Rate (%)
		1991	9.125	1996	6.750
1987	7.625	1992	8.125	1997	7.125
1988	10.000	1993	7.500	1998	6.750
1989	9.250	1994	6.125	1999	
1990	8.250	1995	7.750	2000	

3) Reallocations: Since the Corps is currently not constructing many reservoir projects, the most viable means to obtain storage in Corps reservoirs is through reallocation. Reallocation is considered to be a reassignment of the usage of existing storage space in a reservoir project to a higher and better use. In this process, economic, political and public welfare issues are taken into consideration. The reallocation process is normally conducted through a "Reconnaissance" study phase that is fully funded at the Federal level. If this study proves feasible, then a more detailed "Feasibility" study is undertaken. This study is funded equally between us, and you may provide up to one-half of your share (that is, up to one-quarter of the total study cost) by in kind services instead of cash. The details of this study process can be provided by your local Corps office.

Since 1979, nine of the Corps districts have performed a total of 35 reallocations. These reallocations transferred storage from flood control, hydroelectric power, water quality, and sediment reserve, to M&I water supply. These procedures reallocated a total of about 272,000 acre-feet of storage space. In addition, the Presidents Fiscal Year 1999 budget has a total of $2.97 million for an nine water supply studies. These studies are being performed by the Pittsburgh, Omaha, Portland, Seattle, Walla Walla, Savannah (2) and Los Angeles (2) Districts.

The ***cost*** of reallocated storage assigned to you will be the highest of the benefits or revenues foregone as a result of the allocation, the replacement cost of an equivalent amount of storage in another or a new project, or the updated cost of storage in the Federal project. The cost which usually governs is the updated cost of storage. This procedure is an attempt to duplicate the cost of the project, as originally constructed, at today's prices. This process updates original construction cost through use of the *Engineering News Record* Construction Cost Index and the Corps' "Civil Works Construction Cost Index System." Your portion of the cost is then prorated based on the storage reallocated to your use.

Repayment of costs assigned to the reallocation will be over a period of 30 years from the date of availability of the storage space. This date of availability is normally considered to be the date the repayment agreement is signed by the Assistance Secretary of the Army (Civil Works) (ASA(CW)) or his duly authorized representative. The interest rate to use for repayment will be the rate as established in WRDA '86 (see **Table 3**). The rates are adjusted at 5-year intervals over the repayment period. The 10-year interest free period is not available for reallocated storage. In addition, any cost associated with the reallocation; e.g., the relocation of camping and picnic facilities as a result of a raise in the lake level, must be paid prior to or during the relocation period.

4) Low Income Community: Section 322 of the 1990 Water Resources Development Act authorized, at the discretion of the ASA(CW), a reduced price of water for low income communities. Low income communities are identified by the law as communities with a population of less than 20,000 which are located in counties with a per capita income of less than the per capita income of two-thirds of the counties in the United States. For the purposes of this provision, a community may extend across county boundaries, however, all counties served must qualify as low income counties to obtain the reduced price allowed under this Section. The amount of storage which can be made available to any one community under this provision is the amount required in any reservoir to yield two million gallons of water per day. This provision for a reduced price is only applicable to reallocations.

The ***price*** under this provision of law is the greater of (1) benefits foregone, or (2) the updated cost of storage but not to exceed (for fiscal year 1991) $100 per acre foot of storage space. Individual contract prices, once approved, are not subject to further indexing. The $100 charge was applicable only to contracts signed in Fiscal Year 1991. This price shall be adjusted on 1 October every year based on the Consumer Price Index for the September immediately preceding the fiscal year. This price index is published monthly in the Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business.*

Repayment is permitted over 30 years from the date the water supply storage agreement is signed by the ASA(CW). The applicable interest rate for repayment is that authorized by WRDA '86 (see **Table 3**). This rate will be adjusted at 5-year intervals over the repayment period. If you think you may be eligible for this pricing policy, please contact your local Corps district office.

5) Additional Costs. Regardless of the method used to assign to you the cost of storage in the Corps project, you will also be responsible for your pro-rata share of additional costs required to operate and maintain the project. These costs consist of:

Annual operation and Maintenance Expense. All non-Federal sponsors (including those determined as being a low-income community) are responsible for all operation and maintenance expenses allocated to their portion of the water supply storage space. These costs are to be paid yearly and should be paid in advance based on an estimated expenditure.

Repair, Replacement, Rehabilitation, and Reconstruction Costs. Costs allocated to water supply which are associated with these four items are to be paid by the non-Federal sponsor either during construction of such item or in lump sum, with interest at the rate prescribed in WRDA '86, upon completion of construction. You are encouraged to establish a sinking fund in order to cover these costs should they occur. Costs expended in existing projects for these programs prior to entering into a repayment agreement shall be added to the initial project investment cost for repayment purposes. An exception to this rule is for reallocated storage which, through the updating procedure, assumes a new project.

Dam Safety Assurance Costs. Modifications to a dam project and related facilities deemed necessary for dam safety assurances shall be considered to fall under the provisions of rehabilitation except for cost sharing. Costs of project modification for dam safety shall be in accordance with the provisions of Section 1203 of WRDA '86. Under this provision, 15 percent of the cost of the dam safety assurance modification is allocated among purposes and shared with appropriate project sponsors.

SURPLUS WATER

AUTHORITY.

A lesser used authority for the Corps to contract for water supply was authorized by

Section 6 of the 1944 Flood Control Act. Under this Section, the ASA(CW) is authorized to enter into agreements for surplus water with states, municipalities, private concerns, or individuals at such prices and on such terms as he may deem reasonable. These agreements may be for domestic and M&I uses but not for crop irrigation, from surplus water that may be available at any reservoir under the control of the Department of the Army.

DEFINITION.

Surplus water is classified as either; (1) water stored in a Corps reservoir which is not required because the authorized need for the water never developed or the need is reduced by changes which have occurred since authorization or construction, or (2) water which would be more beneficially used as M&I water than for the authorized purpose and which, when withdraw, would not adversely affect existing lawful uses of such water over some specified time period.

Agreements covering surplus water will normally be for small amounts of water and for temporary use as opposed to storage reallocations and a permanent right to that storage. Surplus water agreements will be limited to a 5-year period. Use of the Section 6 authority is allowed only where non-Federal sponsors do not want to purchase storage because use of the water is desired for a short term only, or, use would be temporary pending development of the authorized use.

COST.

The ***cost*** for surplus water is determined by the same procedure as used to determine an equivalent amount of reallocated storage. ***Repayment*** of this storage is to be based on an annualized amount based on repaying the cost of the storage over a 30-year period. The interest rate to use for this annualized computation is that as authorized in WRDA '86 (see **Table 3**). To this annual cost will be added an estimated annual cost for operation, maintenance, repair, replacement, rehabilitation and reconstruction. The **total annual price** is to be limited to the annual costs of the least costly alternative, but never less than the benefits foregone, or, in the case of hydropower, revenues foregone.

Should you require a 5-year extension to your water supply agreement, such addition may be granted on a case by case basis. The cost however, will be redetermined based on current prices and interest rates.

AGRICULTURAL WATER SUPPLY

AUTHORITY.

The Reclamation Act of 1902, Public Law 57-161, established irrigation in the 17 contiguous western states as a national policy to be administered by the Secretary of the Interior. Section 8 of the 1944 Flood Control Act provides that Corps reservoirs may store water for irrigation of agricultural lands upon the recommendation of the Secretary of the Interior.

COST.

The ***cost*** and ***repayment*** for irrigation storage depends upon your location.

1) Western States. If you are in one of the 19 western states (including Alaska and Hawaii), in conformity with Reclamation Law, the ***cost*** and ***repayment*** arrangements and agreements for irrigation water from Corps projects will be determined, and is administered by, the Bureau of Reclamation.

2) Eastern States. Subsection 103(c)(3) of WRDA '86 establishes the ***cost*** that is applied to agricultural water supply stored in Corps projects east of the Reclamation states. In these non-Reclamation states, non-Federal sponsors must provide 35 percent of the construction costs assigned to the storage space, and 100 percent of the operation, maintenance, repair, reconstruction, rehabilitation and replacement costs. ***Repayment*** of construction costs shall be made during the period of construction of the project.

3) Interim Use of M&I Water Supply Storage for Irrigation. Section 931 of WRDA '86 provides that for any reservoir project constructed and operated by the Corps, the ASA(CW) is authorized to allocate storage which was allocated in the project for M&I water supply, and which is not under contract, for the interim use for irrigation purposes. These projects and the amount of storage available is shown in **Table 1**. The ***cost*** to you for this storage will be 35 percent of the construction cost and 100 percent of the operation and maintenance expense, repair, replacement, rehabilitation, and reconstruction costs allocated to the storage space being placed under contract. ***Repayment*** shall be annualized on a 30-year basis based on the original project construction cost. The interest rate will be the project rate that was in effect at the time of initiation of the project (see **Tables 2** and **3**). The term of the agreement for this interim use shall not exceed five (5) years. An option for incremental five year extensions is allowed with the basic agreement only if recalculations for annual operation and maintenance, replacements, rehabilitation and reconstruction costs are performed at the end of each five year increment.

EMERGENCY WATER SUPPLY

CLEAN DRINKING WATER.

Public Law 84-99, as amended by Section 82 of the Water Resource Development Act of 1974, provides the Corps an opportunity to provide emergency supplies of clean water to any locality which the Chief of Engineers finds is confronted with a source of contaminated water causing or likely to cause a substantial threat to the public health and welfare of the inhabitants of the locality. ***Cost*** and ***repaymen***t shall be as the Chief of Engineers determines to be advisable. Work under this authority requires a request from the governor of the state where the source of water has become contaminated and is normally limited to 30 days. Loss of water source or supply is not correctable under this authority.

DISASTER RELIEF.

Public Law 88-99 was further amended by the Disaster Relief Act of 1974 Appropriations (Public Law 95-51), to provide the ASA(CW) authority under certain statutory conditions to construct wells and to transport water to farmers, ranchers, and political subdivisions within areas he determines to be drought distressed. A written request for assistance may be made by any farmer, rancher or political subdivision with a distressed area. Corps assistance will only be considered when non-Federal sponsors have exhausted reasonable means for securing necessary water supplies (within the limits of their financial resources) including assistance from other Federal agencies.

RESTRICTIONS.

Evaluation of requests for assistance are to be tempered by the fact that Corps assistance is supplemental to state and local efforts. Long term solutions to water supply problems are the responsibility of state and local interests. These authorities are not to be used to provide drought emergency water assistance in cases where a livestock owner has other options. Assistance can be provided to transport water for consumption by Federally owned equipment with the cost of transportation to be paid by the Corps. Cost of storage of the water, however, is a non-Federal responsibility. Federal assistance can also be provided to construct wells. The Federal cost, however, must be repaid.

DROUGHT CONTINGENCY WATER

AUTHORITY.

Section 6 of the 1944 Flood Control Act (surplus water) provides adequate authority to permit temporary withdrawal of water from Corps projects to supplement normal supplies in time of drought. Should you have such a need, the preferred approach is for a state or political subdivision to enter into an agreement with the

ASA(CW) and to agree to act as the wholesaler for all the water requirements of individual users. This places the local governments in a position to help their citizens during difficult times and minimizes the potential for problems that could arise if the ASA(CW) was to determine who was entitled to shares of surplus water based on assessments of local needs.

<u>COST</u>.

The ***cost*** for drought contingency water supply will be determined in the same manner as for surplus water but never less than $50 per agreement year.

SEASONAL OPERATIONS FOR WATER SUPPLY

<u>AUTHORITY</u>.

General Congressional authority for seasonal operations for water supply as an alternative to reservoir storage space has not been established to date. Where not specifically authorized, seasonal operation of a project for water supply may be conducted consistent with authorized project purposes and law, subject to hydrologic and hydraulic capability of the project, in order to provide an intermediate seasonal source of water supply. This water supply could be used to enhance groundwater replenishment, to increase downstream flow, or to otherwise enhance the general usage of the project for M&I purposes.

<u>COST</u>.

The ***cost*** to be repaid is:

(1) 100% of the new construction costs and new operational costs including the cost of revising the water control plan;

(2) A share of the joint use operation, maintenance, rehabilitation, and replacement cost based on the use-of-facilities cost allocation;

(3) The value of benefits foregone;

(4) the value of damages or losses incurred by others as a result of the changed operations (may be the same as (3) above); and

5) A partial reimbursement of the existing Federal investment in the project in the form of a payment in an amount equal to one-half of the savings to the benefited non-Federal interest (the cost of the least cost alternative minus the specific costs of the modifications listed in (1) thought (4) above).

There is to be limit on the cost (excluding annual operation and maintenance payments) which is not to exceed the costs derived for permanent reallocation as described earlier.

The ***repayment*** shall be consistent with the charges as developed in the above paragraph on costs as previously developed for storage and surplus water.

REPAYMENT AGREEMENTS

DISPOSITION OF REVENUES.

For your information, none of the payments you make to the Corps District associated with your interest in water supply, is maintained in the District Office or even a "Corps Account" for general use by the Corps. All revenues received from water supply repayment agreements is deposited in the Treasury of the United States as miscellaneous receipts.

MODEL AGREEMENTS

The Corps has prepared model water supply agreements for each class of water supply as discussed above. A copy of each of these agreements is provided as **Attachment B**. Payment provisions in this format are for new projects, unused storage space in existing projects, added storage and for all reallocated storage (including storage reallocated under the low-income community provisions of Section 322 of the 1990 Water Resource Development Act).

Bracketed language may be changed as appropriate in particular circumstances and material peculiar to either present or future use storage may be deleted if such storage is not included in the agreement.

CORPS ORGANIZATION AND RESPONSIBILITIES

INTRODUCTION

Our Civil Works work force consists of about 28,000 individuals, including some 200 military personnel, who represent over one hundred different professional engineering, scientific, environmental and managerial specialty areas. Our Civil Works chain of command has four basic levels of authority, ranging from the Assistant Secretary of the Army for Civil Works in Washington, D.C., to the thirty-eight District offices across the Nation. Each Corps office is generally organized according to project development functions. Approximately 90 percent of the work force is at the District level.

CIVIL WORKS ORGANIZATION

<u>THE ASSISTANT SECRETARY OF THE ARMY (CIVIL WORKS)</u>.

The Assistant Secretary of the Army (Civil Works) (ASA(CW)) is appointed by the President. The Assistant Secretary leads, directs and supervises the Corps Civil Works Program. The Assistant Secretary is also responsible for all Corps foreign activities not exclusively in support of U.S. military forces overseas. These responsibilities are exercised in accord with the program of the President. The Assistant Secretary manages the Civil Works program through:

1) The annual legislative program, which usually includes recommended authorizations to conduct studies and construct projects;

2) The annual Civil Works budget, which includes requests for funding for selected studies and projects;

3) Providing policy to the Corps, and interpreting policy guidance on specific studies, projects and programs.

The currently Assistant Secretary of the Army for Civil Works and his address are:

Joseph W. Westphal
Department of the Army
Office of the Assistant Secretary (Civil Works)
108 Army Pentagon
Washington, D.C. 20310-0108.

<u>HEADQUARTERS</u>.

The Headquarters, U.S. Army Corps of Engineers (HQUSACE) is commanded by the Chief of Engineers. For Civil Works, the Chief reports to the ASA(CW), and has delegated most responsibility for managing the Civil Works Program to the Director of Civil Works.

The current Chief of Engineers and his address are:

LTG Joseph N. Ballard
Chief of Engineers (CECG)
20 Massachusetts Ave. N.W.
Washington, D.C. 20314-1000

The current Director of Civil Works and his address are:

MG Russell L. Fuhrman
Director of Civil Works (CECW-ZA)
20 Massachusetts Ave. N.W.
Washington, D.C. 20314-1000

The Headquarters is responsible for

organizational leadership and efficient management of the program and resources of the Corps. It ensures that policy established by the ASA(CW), including interpretive policy guidance on specific projects and programs, is applied to all phases of project development. The Headquarters also monitors and provides guidance to the Division; provides progress reports to the ASA(CW); supports and helps the Assistant Secretary in working with other agencies and organization; and, together with the ASA(CW), testifies to Congress in support of the Civil Works Program.

DIVISIONS.

Reporting to HQUSACE are eight Divisions commanded by Division Engineers for Civil Works purposes. The Divisions are the regional Corps offices responsible for the supervision and management of their subordinate Districts, including monitoring, providing Quality Assurance and Quality Control, and approving (where delegated) District work.

Divisions are also responsible for efficient use of personnel and funds, ensuring that the Districts' activities are compatible with policy, and monitoring and reporting to HQUSACE on progress. They serve as the regional Corps interface with other regional agencies and organizations within their boundaries. Division Engineers testify to the Congress regarding the status of their work.

DISTRICTS.

The thirty-eight Districts are led by District Engineers. The Districts are the local Corps offices responsible for conducting and completing their assigned Civil Works studies, projects and programs. They are accountable, and must report periodically, to Divisions on the progress and problems encountered in their work.

The Districts are the foundation of the Corps Civil Works Program. District professionals manage water resources developments over a project's entire life cycle; they conduct planning studies, perform project design, oversee the building of projects by construction contractors, and manage completed Corps facilities. They write reports, prepare drawings, estimate costs and schedules, negotiate agreements, and perform all of the day-to-day tasks necessary to get the job done. They are the Corps' face to the Nation, working closely with sponsors and other project partners, other government agencies, businesses, interest groups, homeowners, and all other members of the public. Sponsor contacts and work with the Corps are almost exclusively at the District level.

Districts are also responsible for issuing Section 10 and Section 404 permits for dredging or other construction in the nation's waters, providing responses to natural disasters and national security emergencies, and maintaining a variety of real estate activities related to both Civil Works and Army programs.

A map that displays Division and District boundaries, and a list of Division and District addresses, is provided as **Attachment C**.

RESEARCH AND DEVELOPMENT CENTERS AND LABORATORIES

We also maintain a major research program at six research and development centers and laboratories. These are:

Cold Regions Research and Engineering Laboratory (CECRL)
72 Lyme Road
Hanover, NH 03755-1290
Phone: 603/646-4200

Construction Engineering Research Laboratory (CECER)
P.O. Box 9005
Champaign, IL 61826-9005
Phone: 217/373-7201

Hydrologic Engineering Center (CEWRC-HEC)
609 Second Street
Davis, CA 95616-4687
Phove: 530-756-1104

Topographic Engineering Center (CETEC)
7701 Telegraph Road
Alexandria, VA 22315-3864
Phone: 703/428-6600

Waterways Experiment Station (CEWES)
3909 Halls Ferry Road
Vicksburg, MS 39180-6199
Phone: 601/634-2664

Water Resources Support Center (CEWRC)
7701 Telegraph Rd.
Casey Building
Alexandria, VA 22315-3868
Phone: 703/428-8250

Each of these laboratories and centers is available to conduct applied research and provide technical assistance in direct support of Corps Districts in project development.

ATTACHMENT A

Public Law 85-500

the 1958 River and Harbor Act

Title III, Water Supply Act of 1958, as amended

(72 Stat. 319)

PUBLIC LAW 85-500, 1958 RIVER AND HARBOR ACT
TITLE III; WATER SUPPLY ACT OF 1958, as amended
(72 Stat. 319)

Sec. 301. (a) It is hereby declared to be the policy of the Congress to recognize the primary responsibilities of the States and local interests in developing water supplies for domestic, municipal, industrial, and other purposes and that the Federal Government should participate and cooperate with States and local interests in developing such water supplies in connection with the construction, maintenance, and operation of Federal navigation, flood control, irrigation, or multiple purpose projects.

(b) In carrying out the policy set forth in this section, it is hereby provided that storage may be included in any reservoir project surveyed, planned, constructed or to be planned, surveyed and/or constructed by the Corps of Engineers or the Bureau of Reclamation to impound water for present or anticipated future demand or need for municipal or industrial water, and the reasonable value thereof may be taken into account in estimating the economic value of the entire project: *Provided,* That the cost of any construction or modification authorized under the provisions of this section shall be determined on the basis that all authorized purposes served by the project shall share equitably in the benefits of multiple purpose construction, as determined by the Secretary of the Army or the Secretary of the Interior, as the case may be; *Provided further,* That before construction or modification of any project including water supply provisions for present demand is initiated, State or local interests shall agree to pay for the cost of such provisions in accordance with the provisions of this section; *And provided further,* That (1) for Corps of Engineers projects, not to exceed 30 percent of the total estimated cost of any project may be allocated to anticipated future demands, and (2) for Bureau of Reclamation projects, not to exceed 30 percentum of the total estimated cost of any project may be allocated to anticipated future demands where State or local interests give reasonable assurances, and there is reasonable evidence, that such demands for the use of such storage will be made within a period of time which will permit paying out the costs allocated to water supply within the life of the project; *And provided further,* That for Corps of Engineers projects, the Secretary of the Army may permit the full non-Federal contribution to be made, without interest, during construction of the project, or, with interest over a period of not more than thirty years from the date of completion, with repayment contracts providing for recalculation of the interest rate at, five-year intervals, and for Bureau of Reclamation projects the entire amount of the construction costs, including interest during construction, allocated to water supply shall be repaid within the life of the project but in no event to exceed fifty years after the project is first used for the storage of water for water supply purposes, except that (1) no payment need be made with respect to storage for future water supply until such supply is first used, and (2) no interest shall be charged on such cost until such supply is first used, but in no case shall the interest-free period exceed ten years. For Corps of Engineers projects, all annual operation, maintenance, and replacement costs for municipal and industrial water supply storage under the provisions of this section shall be reimbursed from State or local interests on an annual basis. For Corps of Engineers projects, any repayment by a State or local interest shall be made with interest at a rate to be determined by the Secretary of the Treasury, taking into consideration the average market yields on outstanding marketable obligations of the United States with remaining periods to maturity comparable to the reimbursement period, during the month preceding the fiscal year in which costs for the construction of the project are first incurred (or, when a recalculation is made), plus a premium of one-eight of one percentage point for transaction costs. For Bureau of Reclamation projects, the interest rate used for purposes of computing interest during construction and interest on the unpaid balance shall be determined by the Secretary of the Treasury, as of the beginning of the fiscal year in which construction is initiated, on the basis of the computed average interest rate payable by the Treasury upon its outstanding marketable public obligations, which are neither due nor callable for redemption for fifteen years from date of issue. The provisions of this subsection insofar as they relate to the Bureau of Reclamation and the Secretary of Interior shall be alternative to and not a substitute for the provisions of the Reclamation Projects Act of 1939 (58 Stat.1187) relating to the same project.

(c) The provisions of this section shall not be construed to modify the provision of section 1 and section 8 of the Flood Control Act of 1944 (58 Stat. 887), as amended and extended, or the provisions of section 8 of the Reclamation Act of 1902 (32 Stat. 390).

(d) Modifications of a reservoir project heretofore authorized, surveyed, planned, or constructed to include storage as provided in subsection (b), which would seriously affect the purposes for which the project was authorized, surveyed, planned, or constructed, or which would involve major structural or operational changes, shall be made only upon the approval of Congress as now provided by law.

Sec. 302. Title III of this Act may be cited as the "Water Supply Act of 1958".

Approved July 3, 1958;

As amended by Section 10, Public Law 87-88 (79 Stat. 210); and

As amended by Section 932 of Public Law 99-662 (100 Stat. 4196).

ATTACHMENT B

Model Formats

for

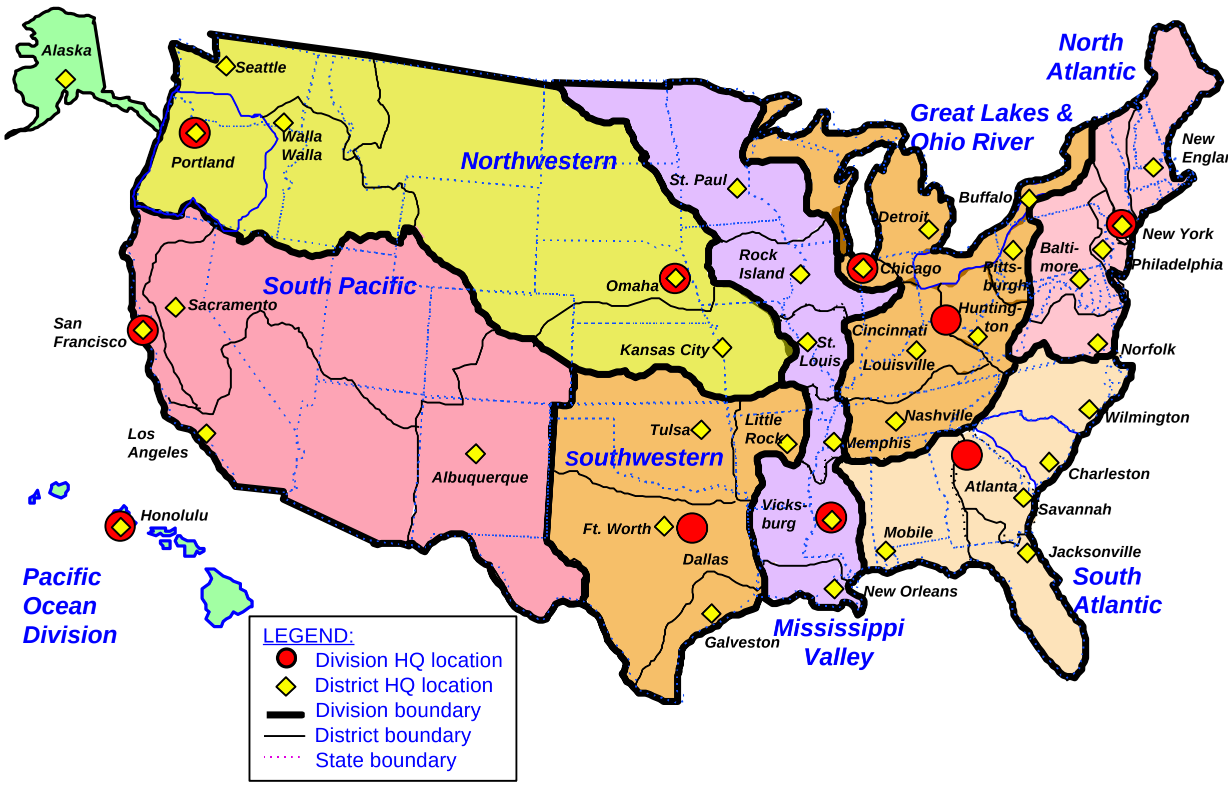
Water Supply Agreements

(Note: Districts should copy appropriate model formats and include behind this page. Model formats are maintained as Appendix B of this IWR Report 96-PS-4 and as Appendix K of ER 1105-2-100.)

ATTACHMENT C

Civil Works

Division and District
Boundaries and Addresses



CIVIL WORKS DIVISION AND DISTRICT BOUNDARIES

Civil Works
Division and District Addresses

Headquarters
U.S. Army Corps of Engineers
Directorate of Civil Works, CECW
20 Massachusetts Avenue, N.W.
Washington, DC 20314-1000
202/761-0105

U.S. Army Engineer Division,
Great Lakes and Ohio River, CELRD
P.O. Box 1159
Cincinnati, OH 45201-1159
513/684-3002

Great Lakes Regional Headquarters, CELRD-GL
111 North Canal Street Suite 1200
Chicago, IL 60606-7205
312/353-6310

U.S. Army Engineer District,
Buffalo, CELRB
1776 Niagara Street
Buffalo, NY 14207-3199
716/879-4200

U.S. Army Engineer District,
Chicago, CELRC
111 North Canal Street, Suite 600
Chicago, IL 60606-7206
312/353-6401

U.S. Army Engineer District,
Detroit, CELRE
P.O. Box 1027
Detroit, MI 48231-1027
313/226-6413

U.S. Army Engineer District,
Huntington, CELRH
502 8th Street
Huntington, WV 25701-2070
304/529-5211

U.S. Army Engineer District,
Louisville, CELRL
P.O. Box 59
Louisville, KY 40201-0059
502/582-5629

U.S. Army Engineer District,
Nashville, CELRN
P.O. Box 1070
Nashville, TN 37202-1070
615/736-5626

U.S. Army Engineer District,
Pittsburgh, CELRP
Room 1828
William S. Moorehead Federal Building
1000 Liberty Avenue
Pittsburgh, PA 15222-4186
412/644-6800

U.S. Army Engineer Division,
Mississippi Valley, CEMVD
P.O. Box 80
Vicksburg, MS 39181-0080
601/634-5000

U.S. Army Engineer District,
Memphis, CEMVM
167 North Main Street
Memphis, TN 38103-1894
901/544-3005

U.S. Army Engineer District,
New Orleans, CEMVN
P.O. Box 60267
New Orleans, LA 70160-0267
504/862-1121

U.S. Army Engineer District,
Rock Island, CEMVR
Clock Tower Building, P.O. Box 2004
Rock Island, IL 61204-2004
309/794-4200

U.S. Army Engineer District,
St. Louis, CEMVS
1222 Spruce Street
St. Louis, MO 63103-2833
314/331-8000

U S. Army Engineer District,
St. Paul, CEMVP
Army Corps of Engineers Centre
190 5th Street East
St. Paul, MN 55101-1637
612/290-5200

U.S. Army Engineer District,
Vicksburg, CEMVK
4155 Clay Street
Vicksburg, MS 39180-3435
601/631-5000

U.S. Army Engineer Division,
North Atlantic, CENAD
90 Church Street
New York, NY 10007-2979
212/264-7104

U.S. Army Engineer District,
Baltimore, CENAB
P.O. Box 1715
Baltimore, MD 21203-1715
410/962-9232

U.S. Army Engineer District,
New England, CENAE
Frederick C. Murphy Federal Bldg.
424 Trapelo Road
Waltham, MA 02254-9149
617/647-8220

U.S. Army Engineer District,
New York, CENAN
Jacob K. Javits Federal Building
26 Federal Plaza
New York, NY 10278-0090
212/264-0102

U.S. Army Engineer District,
Norfolk, CENAO
Waterfield Building
803 Front Street
Norfolk, VA 23510-1096
804/441-7500

U.S, Army Engineer District,
Philadelphia, CENAP
Wanamaker Building
100 Penn Square East
Philadelphia, PA 19107-3390
215/656-6515

U.S. Army Engineer Division,
Northwestern, CENWD
P.O. Box 2870
Portland, OR 97208-2870
503/326-6021

Missouri Regional Office, CENWD-MR
12565 West Center Road
Omaha, NE 68144-3869
402/697-7214

U.S. Army District,
Kansas City, CENWK
700 Federal Building
Kansas City, MO 64106-2896
816/983-3896

U.S. Army Engineer District,
Omaha, CENWO
215 North 17th Street
Omaha, NE 68102-4978
402/221-3020

U.S. Army Engineer District,
Portland, CENWP
P.O. Box 2946
Portland, OR 97208-2946
503/326-6021

U.S. Army Engineer District,
Seattle, CENWS
P.O. Box 3755
Seattle, WA 98124-3755
206/764-3742

U.S. Army Engineer District,
Walla Walla, CENWW
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Jacksonville, FL 32232-0019
904/232-2234

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Mobile, AL 36628-0001
334/690-2528

U.S. Army Engineer District,
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P.O. Box 889
Savannah, GA 31402-0889
912/652-5822

U.S. Army Engineer District,
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South Pacific, CESPD
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San Francisco CA 94105-2195
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Dallas, TX 75242-0216
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ATTACHMENT D

Key Word Index

Key Word Index

CHAPTER 6:
MODELING AND WATER SUPPLY PLANNING

A. INTRODUCTION

1. Scope.

a. Purpose. The purpose of this chapter is to assist water supply planners and managers in determining the data required for informed decision making. This information requirement can range from conversion factors (acre-feet of storage to million gallons per day of flow), a rudimentary spreadsheet, or a complex, specialized data set, run most efficiently from a computer. This chapter will be used to explain what to expect from a variety of processes or programs, how to determine the input requirements and how to use the resulting output. The goal is to assist in selecting which, if any, models best fit the study time, cost and desired level of detail.

b. General Questions. Prior to discussing water resources modeling or model selection, some general questions must be asked of the planner, these are highlighted in **Box 6-1**.

Box 6-1: General Questions

Question	Response to be Examined
What is expected?	What outcome are you expecting from this model? Does this output already exist? How will the model be used? (Don't model for modeling's sake!) What level of detail will be used throughout your investigation? How detailed is your existing data? (This can range from rudimentary to preliminary to the nth decimal.)
What models are available?	What hardware/software is available to you? Will this be a restriction on your modeling? As programs improve and become more "user friendly", the hardware requirements, such as memory and hard drive availability increase. What is your operating system; Disk Operating System (DOS), Windows or Mac?
What is your confidence level?	What confidence level is desired/sought in your output? Do you understand the limitations and assumptions inherent to your effort? If you do not understand how a program works it is of minimum value to your study.

2. Computer Hardware and Software.

a. Definition. Computer software consists of the programs that instruct the hardware (computer and peripheral devices such as printers) to perform desired tasks.

b. General. Computer hardware covers a wide range of equipment which in turn meets a wide range of needs. Computers range from personal or microcomputers to mainframes and supercomputers. While both Macintosh and IBM-compatible personal computers are utilized in water resources planning, this chapter will focus on IBM-compatible models rather than Macintosh. Generally the software discussed in this chapter was designed to run on an IBM-compatible microcomputer with a minimum 80386 processing chip unless otherwise specified. Most computers purchased in the past five years have a 80486 chip or the more recently developed Pentium processors. The data processing time is the single, largest benefit associated with the improvements in computer processors. Hard drive and memory requirements are also key factors in customer satisfaction and the computer's capability to efficiently run or execute selected software. Minimum memory and space available on the hard drive to load a particular program are usually specified in the software documentation. Today, a gigabyte, or 1,000 megabyte (each megabyte is a million bytes) hard drive is not uncommon along with 16 to 64 megabytes of Random Access Memory (RAM) with a Pentium processor. Disk Operating System, or DOS, and Windows were standard purchases with most personal computers purchased for office or home use in recent years. CD-ROMs and internal modems or facsimile tools are often included in users specifications for new personal computers. Check with your information management or automated data processing center to help determine if any hardware limitations exist on your computer equipment.

B. MODELING APPLICATIONS

1. Introduction. Planning is made far easier with the use of models, which essentially are representations of real world phenomena. The models used frequently by water resource (as well as all) planners fall into general categories based on mathematical and applicational distinctions. These are shown in **Table 6-1**, Dzurik (1990). The art of modeling is in selecting variables for analysis and determining their significance in explaining the phenomenon under study, Beecher, et al., (1991). Water resources modeling applications generally focus on either water quality or water quantity, addressing areas such as: groundwater, water distribution, demand forecasting, balancing supply and demand, watershed runoff, stream hydraulics, river and reservoir quality, multipurpose management and operation, and environmental protection.

2. Modeling Development Community.

a. Federal. Many water management models are public domain software packages developed under the auspices of Federal agencies. Some were developed in-house by agency

Table 6-1
Types of Models

Type of Model	Description	Model Use
Predictive and Estimating Models	Designed to explain real-world phenomena and the patterns that may be expected over time.	Often used in planning as standard curves fitted to the appropriate data.
Linear Models - Simple or Complex	Assume that the future is an extension of the past.	Used in planning analysis.
Nonlinear Models	Used when linearity does not adequately explain the relationships between variables.	Solving polynomial models and logistic models.
Optimizing Models	Given a set of constraints estimate the best solution utilizing a group of methods.	Classical calculus, linear programming, nonlinear programming, and dynamic programming.
Stochastic or Probablistic Models	Optimizing methods used when the terms of the problem are probablistic.	Deal with expressions which include terms of uncertainty.

personnel, others were developed by university researchers or consulting firms working under contracts with Federal agencies. Model development is often an evolutionary process with various agency, university, and consulting firm personnel making contributions at various times. Public domain software packages developed and maintained by Federal agencies are widely used by other Federal agencies, state and local governmental entities, private consulting firms, various industries, and universities. Several key Federal and Federally-supported organizations which maintain and distribute generalized water management software are listed in **Table 6-2** with addresses and telephone numbers. Numerous water management models, including a majority of the models cited in this chapter, can be obtained by contacting these organizations.

b. State, Local and Universities. State and local agencies also develop public domain generalized water resources related software packages, but not nearly to the extent as the Federal water agencies. Numerous university researchers are active in developing and applying water management models. Universities are oriented toward development of innovative modeling concepts and technology. Universities tend to be particularly strong in developing new models. Federal agencies typically have stronger institutional capabilities for long-term maintenance and support of models. A majority of water-related university research projects are either completely funded or cost-shared by Federal grants and contracts.

c. Private. Private firms are also active in water resources modeling, including engineering consulting firms and companies specializing in software development and/or marketing. Consulting firms routinely apply models in studies conducted for their clients. Many firms also distribute computer programs developed by the Federal water agencies as well as other non-Federally developed software. Most of the firms that distribute software also provide various forms of technical support for model users. Private firms have added various enhancements to federal computer programs such as graphical user interfaces.

Table 6-2
Selected Federal and Federally-Supported
Model Development and Distribution Organizations

Hydrologic Engineering Center (HEC) U.S. Army Corps of Engineers 609 Second Street Davis, California 95616 (530)756-1104	Institute for Water Resources (IWR) U.S. Army Corps of Engineers 7701 Telegraph Road, Casey Building Alexandria, Virginia 22315-3868 (703)428-9042
Waterways Experiment Station (WES) U.S. Army Corps of Engineers 3909 Halls Ferry Road Vicksburg, Mississippi 39180-6199 (800)522-6937, (601)634-2581	Water Resources Division U.S. Geological Survey (USGS) 409 National Center Reston, Virginia 22092 (703)648-5215
Office of Hydrology National Weather Service NWS/NOAA 1325 East-West Highway Silver Springs, Maryland 20910 (301)713-0006	National Resources Conservation Service U.S. Department of Agriculture P.O. Box 2890 Washington, D.C. 20013-2890 (202)720-4525
Bureau of Reclamation U.S. Department of the Interior Denver Federal Center, Bldg. 67 P.O. Box 25007 Denver, Colorado 80225 (303)236-9208	Center for Exposure Assessment Modeling Environmental Research Laboratory U.S. Environmental Protection Agency 960 College Station Road Athens, Georgia 30613-0801 (706)546-3549
Center for Substance Modeling Support Kerr Environmental Research Laboratory U.S. Environmental Protection Agency P.O. Box 1198 Ada, Oklahoma 74820 (405)436-8500	International Groundwater Modeling Center Institute for Groundwater Research and Education Colorado School of Mines Golden, Colorado 80401-1887 (303)273-3103
National Technical Information Service U.S. Department of Commerce 5258 Port Royal Road Springfield, Virginia 22161 (703)487-4600	McTrans Center for Microcomputers in Transportation University of Florida, 512 Weil Hall Gainesville, Florida 32611-2083 (904)392-3224

3. Corps of Engineers Water Model Centers.

a. Institute for Water Resources. The Institute for Water Resources (IWR) (see Table 6-2) is part of the USACE Water Resources Support Center located in Alexandria, Virginia. The IWR mission is to analyze and anticipate changing water resources management conditions and develop planning methodologies to address economic, social, institutional, and environmental needs in water resources planning and policy. At IWR we look outside for solutions, reaching out to states, cities, environmental groups, consultants, and university researchers for answers. IWR develops tools and strategies needed to plan and execute USACE water resources programs. IWR activities and products also serve the overall water management community, the IWR-MAIN water use forecasting model discussed later, is an IWR product.

b. <u>Hydrologic Engineering Center</u>.

(1). The Hydrologic Engineering Center (HEC) (see Table 6-2) has a mission to support the Corps and the Nation in its water resources management responsibilities. This is accomplished through research, training, and technical assistance programs in hydrologic engineering and planning analysis. HEC has been developing computer programs for hydrologic engineering and planning analysis procedures since its inception in 1964. Software has evolved from computerized procedures to complex modeling systems. The software runs on mainframe, PC-DOS or IBM-compatible computers, UNIX workstations and Windows PC's. The HEC was established in 1964 to develop generalized computer programs and related technical support services for the field offices involved in the USACE water resources development program. HEC activities in hydrologic engineering and planning analysis include applied research, development of analysis methods, conducting short courses and other training, and assisting field offices with special studies. Over the years, the HEC has developed numerous computer programs. Many are widely used by other agencies, consulting firms, and universities, as well as by USACE offices. Currently available major HEC software packages are listed in **Table 6-3**. Feldman (1981) and Davis and Bonner (1990) provide general overviews of HEC models and model development, distribution, and support activities.

(2). An HEC computer program catalog, list of model distributors (vendors), and publications catalog are available by contacting the HEC. HEC publications, including computer program documentation, users manuals, training documents, reports and papers on specific applications of the models, can also be ordered directly from the HEC. The more popular HEC programs are distributed on diskette through private vendors and the National Technical Information Service (NTIS) (see Table 6-2). Federal agencies can obtain any of the programs directly from the HEC.

(3). Most of the HEC programs were originally developed for mainframe and minicomputer systems. The programs are also available in executable format for IBM compatible microcomputers using MS-DOS. The HEC conducts several one- and two-week short courses each year based on the generalized simulation modeling packages. The courses are primarily for USACE personnel with non-USACE personnel being admitted on a space available basis. A number of universities and consulting firms also offer short courses on HEC models, particularly HEC-1 and HEC-2.

Table 6-3
Hydrologic Engineering Center Models

Model	Description
AGDAM	Agricultural Flood Damage Analysis
COED	Corps Editor
DSSMATH	Mathematical Utilities for DSS Data
HEATX	Heat Exchange Program
HEC-1	Flood Hydrograph Package
HEC-1F	Modified HEC-1 for Real-Time Water Control Systems
HEC-1FH	Interior Flood Hydrograph Package
HEC-2	Water Surface Profiles
HEC-4	Monthly Streamflow Simulation
HEC-5	Simulation of Flood Control and Conservation Systems
HEC-5Q	Simulation of Flood Control and Conservation Systems with Water Quality Analysis
HEC-6	Scour and Disposition in Rivers and Reservoirs
HECDSS	Data Storage System
HEC-FDA	Flood Damages Analysis Package
HEC-FFA	Flood Frequency Analysis
HEC-LIB	HEC Subroutine Library
HEC-PRM	Prescriptive Reservoir Model
HGP	Hydraulics Graphics Package
HMR52	Probable Maximum Storm (Eastern United States)
HYCOST	Small-Scale Hydroelectric Power Costs Estimates
HYDPAR	Hydrologic Parameters
HYDUR	Hydropower Analysis Using Streamflow Duration Procedures
MLRP	Multiple Linear Regression Program
NWSDSS	Load NWS Data Tapes in DSS
PAS	Preliminary Analysis System for Water Surface Profile Computations
REGFRQ	Regional Frequency Computation
RESTMP	Reservoir Temperature Stratification
RMA-2	Finite Element Hydrodynamics
STATS	Statistical Analysis of Time Series Data
STORM	Storage, Treatment, Overflow, Runoff Model
THERMS	Thermal Simulation of Lakes
UHCOMP	Interactive Unit Hydrograph and Hydrograph Computation
UNET	One-Dimensional Unsteady Flow Through a Full Network of Open Channels
WQRRS	Water Quality for River-Reservoir Systems
WQSTAT	Water Quality Statistics
WATDSS	Load WATSTORE Data in DSS
	Water Control Programs (group includes a number of programs for real-time water control)

c. Waterways Experiment Station.

(1). As shown in Table 6-2, the Waterways Experiment Station (WES) is located in Vicksburg, Mississippi. This laboratory is the principal research, testing and development facility within the Corps. Its mission is to conceive, plan, study and execute engineering investigations and research development studies in support of the civil and military mission of the Corps and other Federal agencies. WES has experimental facilities and expertise in hydraulic, geotechnical, structural, environmental, and coastal engineering complemented by state-of-the-art computational, simulation and communications capabilities.

(2). WES is a Corps of Engineers research complex consisting of the following five laboratories: Coastal and Hydraulics Laboratory, Environmental Laboratory, Geotechnical Laboratory, Structures Laboratory, and Information Technology Laboratory. Numerous computer models have been developed at WES over the years for studies sponsored by the USACE field offices and other Federal agencies. The WES Computer Program Library Catalog lists several hundred programs developed by the five Laboratories noted above. Modeling applications at WES are typically for specific projects. However, WES has many generalized models which are available to the public. Information regarding requests for models and related documentation can be obtained by contacting the WES Engineering Computer Programs Library (CEWES-IM-DS) at the telephone number and address provided in Table 6-2. Information regarding specific models can also be obtained by contacting technical personnel in the pertinent laboratories.

(3). WES, as the lead Department of Defense Laboratory for research and development in groundwater modeling, has developed the DoD Groundwater Modeling System. This suite of programs addresses groundwater flow and transport of contaminant constituents. Support is provided to the U.S. Army through the U.S. Army Groundwater Modeling Technical Support Center (601/634-4286). The software, developed jointly by government and non-government participants, is available free of charge to the Department of Defense, USACE, U.S. Environmental Protection Agency and the Department of Energy (Internet *http://hlnet.wes.army.mil/software/interfaces/gms*). Others may purchase the software through Brigham Young University (Internet *http://www.ecgl.byu.edu/software/gms/gms.html*).

4. Other. The International Groundwater Modeling Center (Table 6-2) maintains a directory of firms and organizations active in development and distribution of groundwater software. Walton (1993) and Anderson (1993) also provide lists of software distributors for groundwater models. The Hydrologic Engineering Center (HEC) (Table 6-2) maintains a directory of vendors that distribute HEC computer programs. The December 1993 list of HEC model distributors includes nine universities and 63 private firms. Many of these entities also distribute software other than HEC programs and provide various modeling support services. Donley Technology (Box 152, Colonial Beach, VA 22443, 804/224-9427) publishes the Environmental Software Report, a listing of new and upgraded software packages, databases and on-line systems from government and commercial developers. The U.S. Environmental Protection Agency distributes a CD-ROM containing many of the models produced by them, the Corps and other agencies. It is an interactive program and helps a user choose an appropriate model by answering a series of questions concerning their needs. The point of contact is Rich Walentowicz, U.S. EPA, 401 M Street SW, Washington D.C, 20460, telephone (202) 260-8922. The U.S. Army Corps of Engineers Hydropower System Economic Evaluation Center, while not a "modeling center" per se, is the official center of expertise for hydropower evaluation in the Corps of Engineers and should be contacted whenever an economic question on hydropower arises. This center is located in the Northwestern Division Office of the Corps of Engineers, P.O. Box 2870, Portland, Oregon 97208-2870 (attention: CENWD-ET-WP).

C. WATER SUPPLY PLANNING MODELS

1. Types of Models. This section is devoted to describing the software packages that are available in the various areas of Planning. There are many more models than covered in the section, but because of space limitations, only a few are described herein. This is not to imply that there are not other excellent generalized models available. The models highlighted, however, are generally available and cover the range of Planning areas. For additional information on modeling, see "Computer Models for Water Resources Planning and Management," (IWR Report 94-NDS-7), Maidment (1993) and Mays (1996). Planning is separated into nine different areas with a number of models in each. These modeling packages are summarized in **Table 6-4**.

Table 6-4
Water Supply Planning Models, Summary

Area	Models Covered
Demand Forecasting	IWR-MAIN
Groundwater	MODFLOW, PLASM, RANDOM WALK, MOC, and FEMWATER
Watershed Runoff	HEC-1, TR-20, A&M Watershed Model, SSARR, SWMM, HSPF, SWRRB-WQ, and CASC2D
Water Distribution System	KYPIPE2 and WADISO
Stream Hydraulics	HEC-2, WSPRO, FLDWAY, UNET, FESWMS-2DH, HEC-6, and TABS
River and Reservoir Water Quality	QUAL2E, WASP, CE-QUAL-RIV1, CE-QUAL-R1, CE-QUAL-W2, HEC-5Q and WQRRS
Reservoir/River System Operation	HEC-5, IRIS, TAMUWRAP, MODSIM, HEC-PRM, RSS and CALIDAD
Water Conservation	IWR-MAIN 6.1 and WaterPlan 1
Integrated Water Supply and Demand	WEAP

2. Demand Forecasting Model.

a. Description.

(1). Water resources planning and management is highly dependent on projections of future water needs. Urban water use projections are required in planning the future requirements for water supply, distribution and wastewater systems. These projections aid the designers in determining the most economical sizing of infrastructure associated with providing water to a municipal or industrial customer and in satisfying the community's needs for the most likely future scenario at a given location. Water rights or reallocations of storage capacity in reservoirs can also rely on forecasts of future water demand. Water demand forecasts are also used for preparing drought contingency plans, evaluating alternative demand management (water conservation) plans, implementing demand management measures during drought conditions, predicting utility revenues anticipated from water sales, and developing local, regional, and national water resources assessments and formulating water management policies and plans.

(2). These activities are based on estimates of future water requirements. The future may be measured in days, years, or decades. The construction of major water facilities are planned over many years to meet expected water demands extending many decades into the future. On the other hand, implementation of demand management measures during drought conditions may focus on water needs for only the next several days, weeks or months.

b. Detailed Information. For detailed information on IWR-MAIN, see **Appendix E**. Also, see Chapter 8, Paragraph C for additional information.

3. Groundwater Models.

a. Description.

(1). Modeling groundwater systems involves both water quantity (flow) and water quality considerations. Groundwater models incorporate mathematical representations of some or all of the following processes: movement of water and other fluids through saturated or unsaturated porous media or fractured rock; transport of water-soluble constituents; transformation of contaminants by chemical, biological, and physical processes; and heat transport and associated effects of temperature variations on groundwater flow and pollutant transport and fate.

(2). Groundwater modeling applications are typically motivated by water supply and/or water quality concerns. Models have also been used in studies of land subsidence due to groundwater pumping. Groundwater and groundwater models may also play significant roles in managing environmental resources such as ecological systems in rivers, estuaries, and wetlands. Although typically used to address specific water management concerns, models are also research tools used to develop a better generic understanding of groundwater systems and processes. Groundwater flow models are often used in planning, design, and management of well fields. Groundwater models are also applied in broader comprehensive planning studies of alternative water supply and demand management strategies. Models may be used to analyze: water availability or water supply yields under various scenarios, drawdowns to be expected from alternative well construction and pumping plans, and effects of natural and man-induced recharge conditions. The impacts of salt water encroachment or other constraints to water supply may be a motivating concern in modeling applications. Stream-aquifer interactions and conjunctive management of surface water and groundwater may be a key concern in certain studies.

b. Detailed Information. For detailed information on the models covered (MODFLOW, PLASM, RANDOM WALK, MOC and FEMWATER), see **Appendix E.**

4. Watershed Runoff Models.

a. Description.

(1). Watershed models simulate the hydrologic processes by which precipitation is converted to streamflow. The watershed is the system being modeled, with precipitation being provided as input and the runoff characteristics being computed. Water quality is changed during these hydrologic processes. Some models consider only water quantities, while others simulate both water quality and quantity. Simulation results essentially always include streamflow hydrographs and sometimes include the associated pollutographs as well. The watersheds being modeled include streams, reservoirs, drainage improvements, and storm water management facilities as well as the land and land cover upon which the precipitation falls.

(2). Watershed models are used to develop streamflow hydrographs required as input for the stream hydraulics models and the reservoir/river system operation models. Watershed models may provide both volumetric inflows and pollutant loadings required as input for the river and reservoir water quality models.

(3). Streamflow hydrographs and/or associated pollutant concentrations are basic data required in many different types of water management modeling applications. Design hydrographs provide a basis for sizing hydraulic structures such as dams, spillways, flood control improvements, storm sewers, detention basins, culverts, and bridges. Hydrographs are required to delineate flood plains in support of flood plain management programs. Runoff hydrographs are input to models used to support real-time reservoir system operating decisions. Watershed models are used to quantify the impacts of land use changes and management plans on runoff quantity and quality. Pollutant loading estimates are needed for various water quality management activities. Both urban storm water management and control of pollution from agricultural activities involve application of watershed models with quality analysis capabilities.

b. Detailed Information. For detailed information on the models covered (HEC-1, TR-20, A&M Watershed Model, SSARR, SWMM, HSPF, SWRRB-WQ, and CASC2D), see **Appendix E**.

5. Water Distribution System Models.

a. Description.

(1). Analysis of municipal water distribution systems represents a major modeling application. Other types of pipe networks frequently modeled include industrial water conveyance systems, rural water supply systems, sprinkler systems, and surcharged storm sewer systems. Distribution and conveyance systems include pipes, pumps, storage tanks, valves, and various pipe fittings. Although the present discussion focuses on water, the modeling techniques are also applicable to other liquids such as petroleum and chemical products. Models are applied in the investigation of existing facilities, proposed extensions and modifications to existing systems, and, in some cases, proposed new pipe networks.

(2). Models simulate the impacts of various water demand scenarios on pressures and flows throughout a system. For example, the impact of a new residential development on system capabilities for meeting demands and maintaining pressures throughout the water utility service area may be of concern. Simulations are likewise performed to analyze the impacts of alternative system improvements such as new pipes, pumps, or storage tanks. Models are used to size pipes, select pumps, and otherwise design systems. Modeling studies have been performed to develop pump operating strategies which meet water demands while minimizing electrical energy costs associated with pump operation.

b. Detailed Information. For detailed information on the models (KYPIPE2 and WADISO), see **Appendix E.** Also, see Chapter 7, Paragraph E for additional information on water distribution systems.

6. Stream Hydraulics Models.

a. Description.

(1). Model input includes channel geometry and roughness data and either steady-state or time-dependent inflow rates. Steady, varied flow models compute flow depths as a function of location along the channel. Unsteady flow models calculate discharges and flow depths as a function of time and location. Some programs model movable as well as fixed channel beds. Movable boundary models simulate erosion and sediment transport processes as well as flow. Open-channel hydraulics models are typically used in combination with the watershed, river and reservoir water quality, and reservoir/river system operations models. In many cases, hydraulic or hydrodynamic models are an integral component of the models discussed in these other chapters.

(2). Flow rates and velocities computed with hydraulic models provide basic input required by water quality models. Velocities are also required for erosion and scour studies. Water surface profiles are needed for many water management applications. Water supply diversion intake structures may be inoperative if river stages drop below certain levels. Navigation operations and design studies are based on maintaining specified flow depths. Flood plain management programs require flood plain delineations based on water surface profiles for floods of specified exceedence frequency. Flood control structures and channel improvements are sized based on design water surface profiles. Reservoir operations are based on river stages. Erosion and sedimentation may also be a significant consideration in design and operation of river control structures.

b. Detailed Information. For detailed information on the models (HEC-2, WSPRO, FLDWAY, UNET, FESWMS-2DH, HEC-6, and TABS), see **Appendix E.**

7. River and Reservoir Water Quality Models.

a. Description. These models provide a means to predict the impacts of natural processes and activities of man on the physical, chemical, and biological characteristics of water in a river/reservoir system. Models are widely used to evaluate the impacts of waste loads from treatment plants or pollutant loads from various other point and nonpoint sources. Alternative reservoir operating plans can be evaluated from the perspective of the effects of releases on in-pool and downstream water quality. Models can be used in conjunction with water quality monitoring activities to interpolate or extrapolate sampled data to other locations and times. Models are also used as research tools to develop an understanding of the processes and interactions affecting water quality.

b. Detailed Information. For detailed information on the models (QUAL2E, WASP, CE-QUAL-RIV1, CE-QUAL-R1, CE-QUAL-W2, HEC5-Q, and WQRRS), see **Appendix E.**

8. Reservoir/River System Operation Models.

a. Description.

(1). Reservoir/river system analysis models are used for various purposes in a variety of settings. Models are used in planning studies to aid in the formulation and evaluation of alterative plans for responding to water related problems and needs. Feasibility studies may involve proposed construction projects as well as reallocations of storage capacity or other operational modifications at completed projects. Another modeling application involves studies made specifically to reevaluate operating policies for existing reservoir systems. Periodic reevaluations may be made routinely to assure system responsiveness to current conditions and objectives. However, more typically, reevaluation studies are made in response to a particular perceived problem or need. Studies may be motivated by the existence of severe drought conditions. Development of drought contingency plans in preparation for future droughts is an important activity that is receiving increasing attention. Execution of models during actual reservoir operations in support of real-time release decisions represents another major area of application.

(2). Reservoir system management practices and associated modeling and analysis methods involve allocating storage capacity and streamflow between multiple uses/users, minimizing the risks and consequences of water shortages and flooding, optimizing the beneficial use of resources (water, energy, and land), and managing environmental resources.

b. Detailed Information. For detailed information on the models (HEC-5, IRIS, TAMUWRAP, MODSIM, HEC-PRM, RSS and CALIDAD), see **Appendix E.**

9. Water Conservation Models.

a. Description. Demand management or water conservation programs represent a key determinant of water use. Demand management has also provided a major impetus for improving and refining water use forecasting methods in recent years. Before the late 1970s, water supply planning and management was based essentially on increasing dependable supplies to meet projected demands. A major water policy thrust of the late 1970s and 1980s was to shift to a greater reliance on reducing demands by improving use efficiency instead of relying solely on augmenting supplies.

In recent years, methods for forecasting water use and for evaluating water conservation plans are closely interrelated. Water use forecasting methods now typically include capabilities for reflecting alternative demand management strategies in forecasts.

b. Detailed Information. For detailed information on the models (IWR-MAIN 6.1 and WaterPlan 1), see **Appendix E.** Also, see Chapter 7, Paragraph B for additional information on water conservation.

10. Integrated Water Supply and Demand Model.

a. Description.

(1). The preceding categories of planning models in this chapter focus on either a specific method of water supply or of forecasting water demand. Successful water management depends on sufficient supply to meet water demand both now and into the future. The development of new water supplies is an expensive and often prolonged proposition. Environmental issues can extend the planning process for new water supply projects. One tool (Water Evaluation and Planning System) (WEAP) was found which addresses the challenge in balancing water supply projects and demand issues. WEAP presents a holistic picture of the water supplies/demands and water pollution generation/loads for a defined region at a specific time or over a long-term planning horizon. As a policy analysis tool, it simulates and assesses the physical, economic and environmental effects of alternative water development and management programs. Recent versions aim to incorporate awareness of resource conservation, demand management, water use efficiency and social, cultural and environmental impacts of water resources development.

(2). The WEAP model was developed by Stockholm Environment Institute-Boston, Tellus Institute. This unique model integrates both supply and use while providing comprehensive information on the water balance accounting of the evaluated system for a variety of user-specified conditions. Model representation includes *supplies* from rivers, creeks, reservoirs and groundwater, and *demand* needed for water withdrawals, discharges and instream flow requirements. Most water development evaluation tasks, such as sectoral demand analyses, supply source allocations, streamflow and reservoir storage simulations, hydropower generation forecasts, pollution loading estimates, and project benefit-cost analyses can be implemented with the model.

b. Detailed Information. For detailed information on WEAP, see **Appendix E**. Also, see Chapter 8, Paragraph C for additional information.

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CHAPTER 7: WATER CONSERVATION AND PLANNING FOR DROUGHT

DECEMBER 1998

A. OVERVIEW

1. Introduction. Water conservation has two distinct purposes, permanent reduction in demand and temporary reduction to meet an emergency. In some parts of the country new water resources are not anticipated in the near future. For example, in the Boston area during the 1980's, water demand rose, exceeding safe yield. To counter this, permanent conservation reductions were successfully sought reducing actual water use to below safe yield. This permanent conservation reduction will provide water during the years of planning required to examine other new sources. In other situations, temporary conservation reductions are sought in responding to anticipated water shortages caused by chemical spills and other emergency situations, which are not expected to continue indefinitely. These temporary measures are often used in drought situations. Droughts are usually accompanied by warmer and drier than normal weather, which often cause increased water use, especially outdoor water use. This chapter provides some insight for areas normally outside the Corps traditional role in water supply, namely water distribution and water conservation, as well as the normal role in responding to drought through effective use of Corps reservoirs. More efficient municipal and industrial water use or conservation alternatives will be described in the following paragraphs. Agricultural and irrigation water will not be addressed.

2. Need for Water Conservation.

a. Importance of Water Conservation. Water conservation became ideologically important to the Federal Government in the mid-1970's when then-President Carter declared that water conservation was the keystone of his water resources policy. His proclamation concentrated on actions to reduce demand. Prior to that time, most conservation centered on the "conserving" of supplies through the construction of dams. Since that time, water conservation through reduction in demand has moved to the forefront of water planning. While the addition of supplies is still sustained through analysis in many cases, surface water resource development carries high financial and environmental costs. Accordingly, as many urban areas have begun to experience water allocation problems, alternatives that augment supplies are employed less frequently. Groundwater contamination also places additional stress on water resources. Transfers of water across river basins and political boundaries pose a further set of problems and are regulated through legal channels. To combat these water problems, water managers are exploring other alternatives such as more efficient use of existing water sources, preventing further contamination, conjunctive water use, water reclamation, and region wide water management.

b. Used as a Management Tool. Water conservation is a management tool used to decrease water use or reduce losses. Decreased water use occurs when a management practice results in less water used than without the practice. Decreases in end uses of water by residential, commercial, and industrial customers provide conservation savings. Water losses account for quantities of water which were once part of the water supply that are no longer available for use. The municipal and industrial water system savings accrue from reductions to these losses in the storage, transmission, treatment and distribution of water.

B. WATER CONSERVATION METHODS

1. Residential and Commercial Use. The array of conservation alternatives to be analyzed for a given water system is extensive. Shown in **Table 7-1** is the array for residential and commercial conservation options to be considered along with a residential water conservation tips pamphlet. Consideration must be given not only to the quantity of water savings for the conservation practice, but also the targeted sector for the measure, how well the conservation tool/measure will be accepted by the service area customers, the share of customers already using the tool/measure, actual delivery and installation of the conservation tool/measure, water savings overlap with other conservation measures, tool/measure cost and longevity, and secondary benefits, such as reduced energy and sewer savings.

2. Outdoor Use. Outdoor or seasonal water use can be separated from indoor water use for residential and commercial customers. Seasonal use, such as lawn watering or cooling, varies in response to changing weather conditions. Targeting these uses separately will aid in analyzing the effectiveness of conservation programs. These methods are shown in **Table 7-2**.

Table 7-1
Residential and Commercial Conservation Methods

Residential and Commercial Inside Water Use Without Conservation Features	Conservation Alternative(s)
Standard non-conserving toilet	Ultra low-flush toilet Low-flush toilet Toilet tank displacement dam Toilet tank displacement bag
Standard non-conserving showerhead	Ultra low-flow showerhead Low-flow showerhead Shower flow restrictor
Standard non-conserving faucet	Low-flow faucet Faucet aerator Self closing faucet
Leaky toilet	Leak detection tablets
Standard clothes washer	Efficient clothes washer
Standard dishwasher	Efficient dishwasher
Current water fixtures and water use practices	Residential Water Audit Small/large commercial water audit Aggregate commercial water/audit
High water pressure areas	Water pressure reduction
Non-metered water use	Metered residential water use

Table 7-2
Outdoor Water Conservation Methods

Outdoor Targeted Sectors	Outdoor/Landscape Conservation Alternatives
Residential	Watering guides Automatic timer shutoff for manual hose systems Use plants requiring little water (xeriscaping) Landscaping
Commercial/multifamily	Watering guides Watering audits Automatic controllers and valves Soil moisture sensors Use plants requiring little water (xeriscaping) Landscaping Demonstration gardens

3. Industrial Use. Industrial water use is addressed separately from residential or commercial sectors. Industrial water use centers in three areas, process water, cooling water, and general water use. Depending on the industry, process water use varies greatly per unit item produced. These methods are shown in **Table 7-3**.

Table 7-3
Industrial Water Conservation Methods

Industrial Water Use	Conservation Feature
Process water use	Flow regulating valves Reuse and recycling systems Process level water audit
Cooling water use	Flow regulating valves Air cooled condenser Cooling tower/closed loop system
General water use	Leak detection and repair Meter loan program Wastewater disposal codes

4. Education. Various opportunities are available for government agencies, public bodies, public interest groups and the water supplier itself in educating water users regarding water conservation. The results can be effective for long-term programs. An education program is generally voluntary in nature. Some of these programs are summarized in **Table 7-4**.

Table 7-4
Education as a Water Conservation Tool

Item	Description
Direct Mail	Involves the use of mail service to distribute information included with water supplier bills and as a direct mail objective of other entities.
News Media	Involves the use of radio, television, newspapers, billboards, etc., to encourage and facilitate water conservation habits and water use technology.
Personal Contact	Involves the direct contact of individuals with water users to achieve water conservation. Primarily, contact between large water users and government officials may be appropriate or programs where Boy Scouts or other groups may go door-to-door in personalizing the program.
Specific Events	Involves public relations efforts to bring increased attention to the water conservation program.

5. Rate-Making Policies. The characteristics of price as a water management tool is also a very important factor. As summarized in **Table 7-5**, there are a number of rate pricing policies.

Table 7-5
Rate Structure as a Water Conservation Tool

Policy	Description
Metering	The monitoring and charging for water based upon the volume used by the customer. Water metering also provides valuable information on where and when water is used.
Rate Design	Water pricing can impact the consumption of water. Depending on the users' response to price changes (that is influenced by factors such as (1) the new price level, (2) users' income, (3) number of people per household, and (4) rainfall and temperature) and the type of price structure selected, degrees of water conservation can be achieved through new pricing policies. Rate design can be used to achieve long-term or contingent water conservation objectives.
Marginal Cost Pricing	The practice of setting the price of water equal to its marginal cost. The practice is consistent with the efficient use of resources but is seldom employed.
Increasing Block Rates	The practice of setting the unit price for a volume of water and a higher price for the next volume, and so on. The cost of the water to a consumer increases at an increasing rate and, thus, the incentive to conserve water increases.
Peak Load Pricing	The practice of setting the price of water higher during hours of peak use. Since water systems are designed for maximum flow requirements, this pricing structure recovers the costs from the daily peak load users. Rates are established with volume and peak use components.
Seasonal Pricing	The practice of setting the price of water higher during periods of seasonal high use (summer) as opposed to lower winter rates. This is similar to the daily peak load pricing strategy except that seasonal design flow requirements are charged to the seasonal water users.
Summer Surcharge	An additional charge that is added onto a rate structure for the purpose of recovering the delivery costs of summer peak water use.
Excess Use Charge	An additional charge that is added onto a rate structure for the purpose of discouraging water use exceeding some prespecified level.

6. Water Systems. Water systems also have areas to which conservation measures can be applied. Conservation options include distribution system water audits and system leak detection and repair. These areas are covered in Paragraph E of this chapter.

7. Water Conservation Models.

a. Introduction. Two computer models are identified that could provide information beneficial to a conservation effort, IWR-MAIN 6.1 and WaterPlan 1. Appendix E and Chapter 6, Paragraph C provide additional information on these two models.

b. IWR-MAIN, version 6.1. IWR-MAIN was originally developed as a long-term water demand forecasting model for municipal and industrial water systems. Using socioeconomic and demographic data, instead of per capita water use, this model breaks or disaggregates water use into four sectors: residential, commercial, industrial and public/unaccounted. The sectoral water use can then be further broken down, such as residential details for seasonal and indoor/outdoor water use. These detailed projections are utilized as a without conservation measure condition to compare with various conservation scenarios. The conservation module computes water savings by reducing average per household, per employee, or per unit water consumption of specific end uses. For example, a retrofit kit may target replacing standard toilets and showerheads with low-flow fixtures, thereby reducing water use in these specific end-use categories.

c. WaterPlan 1. WaterPlan, version 1, was developed specifically for water use in California. The numbers given for water savings consider California law and regulation, with maximum flow rates established for some water fixtures, such as faucets and showerheads. The Water Conservation Assumptions documentation, accompanying WaterPlan, version 1, provides insight on various water conservation measures that may not be available for other geographic locations.

C. RESERVOIR DROUGHT CONTINGENCY PLANS

1. Corps Guidance.

a. Definition. Drought Contingency Plans (DCP's) are general guides that allow for dynamic management of projects, or systems of projects, to address drought needs. These plans are an important part of the operational guidance for all Corps water control projects with the potential for providing useful service during times of drought. Generally related to water management, this service is usually needed only at projects with controllable storage. These contingency plans are developed on a regional, basin-wide and project bases and coordinated with appropriate state and Federal interests during droughts. A DCP is a part of the project Water Control Manual (see Chapter 9, Paragraphs C and D) and can exist as a physical part of the manual or as an external appendix to the manual. Guidance for developing and updating DCP's is contained in Engineer Technical Letter (ETL) 1110-2-335, dated 1 April 1993.

b. Features. The significant features or objectives of DCP's are: monitoring, identification, implementation mechanisms, coordination, and standard agreements. Monitoring describes the requirements for initiating the DCP action by defining the trigger. Opportunities or actions that can be taken to manage drought situations are identified and a mechanism is established to implement these actions. Coordination with other agencies and organizations, communicants, and methods is undertaken, including identification of the participants. A standard agreement is developed for sale or use of project resources, including information on cost determination.

c. Purpose. Development of a DCP should be a comprehensive evaluation of a project's ability to address any aspect of drought, including issues relative to water supply, water quality, environment, fire protection, industry, recreation, power, navigation and other beneficial uses. Deviations from the water control plan, within the Corps discretionary limits, are a natural part of a DCP. Requests for deviations should be handled through the appropriate division office.

d. Coverage. At the end of Fiscal Year 1992, all projects had an approved DCP in place. Water control plans are continually reviewed and adjusted in response to changing public needs, including droughts, so that the maximum response is made based on current authorities.

2. State and Local Coordination.

a. Coordination. Full coordination with state and local governments is essential when facing a crisis. The DCP in the water control plan must reflect the public's needs during drought situations in order to make the maximum response based on current authorities. Coordination with other Federal and state agencies and local organizations is an essential part of the DCP. Effective coordination facilitates decision making, improves project effectiveness during water-short periods and insures Corps actions are complementary to other ongoing efforts.

b. Legislative Requirement. With the passage of the Water Resources Development Act of 1990 (WRDA '90) public involvement became a requirement in the development of and modification to water control manuals (Section 310(b) of WRDA '90). A DCP approved after WRDA '90, that results in a change of the water control plan, must comply with WRDA '90. It is the policy of the Chief of Engineers that water control plans be continually reviewed, updated, and adjusted as needed to ensure that the best use is made of available water resources.

D. NATIONAL DROUGHT STUDY

1. Authority. The "National Study of Water Management During Drought" (NDS) was undertaken in response to recommendations made by the Corps after the drought of 1988-89. Authority for the study was provided in Sections 707 and 729 of the Water Resources Development Act of 1986. The objective of this study was to find a better way to manage water during drought in the United States. This objective was accomplished by identifying impediments to improved water management and designing a method that addressed the associated concerns. Water resources needs, including hydropower, navigation, recreation, instream flows and municipal, industrial and agricultural consumption, were investigated at the national level in collaboration with state and other Federal water agencies. These findings have been published and are available electronically via the Internet at:
http://www.wrsc.usace.army.mil/iwr/currpt.htm

2. Problem Identification and Definition.

a. Definition. Water managers deal with many issues, such as long term water supply, non-point source pollution and drought. The NDS defined "drought" as a period of time when natural or managed water systems do not provide enough water to meet established human and environmental uses because of natural shortfalls in precipitation or streamflow.

b. Water Supply Planning and Drought. Drought management is a subset of water supply planning. The distinction between a "drought" problem and a "water supply" problem is essentially defined by the nature of the best solution. Urban areas that persistently use more than the safe yield of their water supply systems may have frequent or even standing drought declarations that could only be eliminated through strategic water supply measures. Those measures can be structural, such as the construction of new reservoirs, or non-structural, such as conservation.

c. Concerns Across the Country. Summarized in **Table 7-6** are the drought problems in various areas of the country as identified in the NDS.

Table 7-6
Regional Drought Problems

Region	Summary of Concerns Expressed by States
New England	Increasing susceptibility of public sector water supply and lack of redundancy of water supplies.
Mid-Atlantic	Salt water intrusion and water supply along coast and Delaware River.
South Atlantic	Increasing municipal and industrial use and management of major river systems.
Lower Mississippi Basin	Impacts to agriculture; Mississippi River low flows; drought impacts in Mississippi-Missouri-Ohio River Basin, which drains 41% of contiguous U.S.; impacts to Mississippi River delta.
Ohio River	Ohio River low flows and municipal water supplies of medium to small sized communities.
Lower Colorado River Basin/South Pacific Coast	Increasing municipal water supply needs versus irrigation needs.
Northwest and Pacific Coasts	Municipal water supply needs of smaller communities and competition between power and fish/recreation in northwest.
Plains States	Agricultural impacts; management of the Missouri River Mainstem reservoirs, competition between lake recreation and downstream uses; small community water supplies.
Southwest	Agricultural impacts.
Rocky Mountain West	Agricultural impacts; competition for water between agriculture and instream use; increasing municipal water supply needs.

d. Drought impacts.

(1). General. There are risks involved in setting the threshold at which reduced precipitation and streamflow are officially declared to be droughts. If the drought is declared too early, droughts will be declared more frequently and sometimes unnecessarily. If managers wait longer to declare a drought, water supplies that could reduce the impacts of a prolonged drought will be depleted with normal water use early in the drought.

(2). Measurement. Drought impacts are difficult to measure. Often these long periods of low streamflow and low precipitation are accompanied by higher than normal temperatures. The economic losses of a drought may be difficult to quantify due to limited data and other agitating elements, such as an overlapping recession. A summary of these impacts is provided in **Table 7-7**.

Table 7-7
Drought Impacts

Activity or Use of Water	Potential Impacts of Drought
Municipal and Industrial Water Supply	Fastest growing sector of water use. Fifty percent of all water supply utilities in the U.S. were adversely affected during the 1988 drought. Shortages anticipated in non-drought times due to growing population, water pollution and leaks in distribution.
Agricultural Water Supply	Dryland farming requires irrigation. Conflicts between agricultural and urban use. Reallocate water versus build more supply storage.
Navigation	Transportation delays and losses.
Hydroelectric Power	All other sources of electricity have higher marginal costs than hydropower. Indirect impact to environment with pollution from alternate sources of electricity. Potential for brownouts.
Recreation	Beaches, boat ramps, public and private docks closed. Sport and commercial fishing losses. Economic impact of lost tourism.
Environmental	Potential stress to wetlands, wildlife, forests, groundwater and soils. Saltwater contamination concerns. Groundwater recharge times.
Wastewater Treatment	Inability to dilute effluent from wastewater treatment plants.

(3). California Drought. During the California Drought (1987-1992) the agricultural, industrial, commercial and municipal sectors, energy, recreation and the environment were all adversely impacted. The drought had a pronounced effect on fisheries and aquatic resources, especially salmon and striped bass. Impacts to urban water users included rate increases for the industrial and commercial sectors, and water-conserving life style adjustments for the residential sector. Direct agricultural impacts included significant amounts of land left idle and increased water costs. However, much of the reduction in California agricultural output was offset by increases in other regions of the country. The landscaping and gardening industry of California estimated its losses for 1991 at about 6.5% of its 1990 gross revenues. The California drought also affected water quality, recreation, hydropower production, the public's perception of water use and the institutions that manage water in California.

(4). Strategic Planning. Water supply planning is a strategic endeavor that attempts to balance water supply and use, mindful of economic and environmental costs. Water supply resources or raw water will vary over time depending on the streamflow and precipitation in the basin. Surface and in ground storage facilities are used to reduce these variations to surface water and groundwater resources. The adequacy of a municipal and industrial water supply system is often described as its safe yield, a specified quantity of water which the system can generally support 98% of the time.

3. Current State of Water Management During Drought.

a. Introduction. Much has been done in the United States to reduce vulnerability to drought since the great droughts of the 1930's. The goal of minimal impacts is a moving target since demands can increase and diversify. As with all issues surrounding the human adaptation of the world to specific human purposes, there is a substantial debate about what constitutes success. Most experts agree that better planning, better data, better analytical techniques, and a more coordinated, cooperative and communicative response would improve water management during drought. The reduction of the demand for water is being used more and more often as an alternative to new supply. However, when supply is considered adequate, the cost savings associated with conserving water are often ignored. Many communities that suffered impacts from the droughts of the 1980's said they could have been better prepared. This includes those communities that had prepared contingency plans which specified how the operations of water systems should change during a drought.

b. Existing Drought Response Plans and Measures. Only slightly over half of the states and half of the country's urban water suppliers have drought preparedness plans. Typical plans offer some benefit and require a minimum of public process and staff time, but there are some problems. A major shortfall is that plans are better characterized as documents rather than ways of behaving. Thus, their effectiveness diminishes as staff changes occur and time passes between plan preparation and drought. Newer uses of water may not be recognized and incorporated into the plan. Many plans are designed for the drought of record, without consideration of the rarity of that event. Plans are often triggered by indicators not related in a known way to impacts. Finally, these plans are often not understood or endorsed by those who will suffer the impacts of the drought. There are three time frames for drought response planning: strategic, tactical and emergency measures. These measures are summarized in **Table 7-8**.

c. Legal and Institutional Issues.

(1). Introduction. Law sometimes drives and sometimes constrains water management during drought. There are two basic water law systems governing the right to use water in the United States. Riparian law theory prevails east of the 100th meridian, and the law of prior appropriation predominates in the west. For additional information on water law, see Mays (1996).

Table 7-8
Time Frames for Response Planning

Planning Time Frame	Response Measure
Strategic	Long term physical and institutional responses such as water supply structures, water law and plumbing codes.
Tactical	Water rationing which is developed in advance to respond to expected short term water deficits.
Emergency	Implemented as an ad hoc response to conditions that are too specific or rare to warrant the development of standing plans.

(2). Riparian Water Rights. Riparian or surface water rights are assigned on the basis of land ownership along a stream reach. As water has become more scarce in relation to competing demand and the need to manage water use increased, these rights have been modified by legislation. Over half the eastern states have enacted permit programs to provide more certain water rights by collecting accurate water use data, allocating water by more definite criteria, and asserting a strong state interest in water use and management. In addition, sixteen eastern states have legislation recognizing the need to conserve water supplies.

(3). Appropriation Water Rights. Under appropriation law, the right to divert a specific quantity of water from a stream over time belongs to the party who first beneficially used it, and who is still using it. Thus a prior, or senior right, is a right based on a beneficial use that began earlier than another. This system of law theoretically allocates water during droughts. Junior users lose their rights as the total amount of water available decreases. Basic appropriations doctrine discourages water conservation, because water not put to beneficial use may be lost. Many western states have modified the basic doctrine to accommodate conservation.

(4). Hybrid. A doctrine incorporating both riparian and prior appropriate aspects, know as a hybrid system has been adopted by the Pacific Coast states and the states that straddle the 100th meridian from Texas to North Dakota.

(5). Groundwater. In most states, allocation of groundwater is handled differently from that of surface water. In some states there is no provision at all for state allocation of groundwater.

(6). Significant Issues in Water Law. Water law is changing and evolving across the United States. The National Drought Study identified the areas where the law was changing or needed to be changed to allow better management during drought. These issues are summarized in **Table 7-9**. Many social scientists refer to the sets of rules for making rational decisions as institutions. Institutional analysis is the study of these rule sets and their consequences on the attainment of human goals. The phrase "institutional study" has a narrower common usage in the water resources field. It typically refers to efforts that analyze whether changes in collective choice rules (such as agency jurisdiction and mission, interagency coordination, and law) will allow improvements in water management that could not be obtained by fine tuning the operational rules. Much of the criticism of current American water management focuses on institutional problems.

Table 7-9
Significant Legal and Institutional Water Law Issues

Issue	Current Trend
Site Specific Programs	The trend of water law in both the east and the west is to apply new, improved approaches to specific geographic areas, where problems are sufficiently obvious to warrant political action.
Quantification of Water Allocations	Many senior tribal and Federal water rights are recognized in principle, but no amount has been set. Some western states are taking steps to adjudicate existing water rights to determine how much water is really needed.
Public Trust Doctrine	The public trust doctrine, which holds that the sovereign government retains ultimate control of the water resource to serve public trust purposes, has not always been recognized in water allocation decisions. It has now been explicitly recognized, in some form, in nine states.
Instream Flows	Instream flows are, to some extent, explicitly protected. At least 12 states now protect these by means other than allocation and many eastern states have established minimum stream flows.
Water Conservation	Three appropriation states now allow conserved water to be used for other purposes or conveyed to a third party. Sixteen eastern state recognize the need to conserve water supplies.
Transbasin Diversions	Diversions, a strategic measure to increase water supply reliability, are allowed in a number of states in certain limited situations.
Groundwater Law and Conjunctive Use Management	In most states, allocation of groundwater is handled differently from that of surface water. This complicates the preparation of drought plans which should provide for most effective use of ground and surface water combined.

d. Lessons Learned from the California Drought.

(1). Curtail Use. Domestic water users are willing and able to curtail water use during a drought. During the first two years of the drought, a mixture of voluntary and mandatory conservation in California's cities reduced water use from 10% to 25%. In the last three years of the drought, urban conservation efforts were generally more intense. Similar savings were recorded in Seattle and Tacoma, Washington in their 1992 drought.

(2). Adequate Infrastructure. Investments in infrastructure can increase the options for adaptive behavior. Water banking, storage for instream flow maintenance, conjunctive use of groundwater and surface water, regional interdependence, and economies of scale require a water storage, allocation and distribution system. California's storage and distribution system provided the flexibility and resiliency to withstand severe droughts, even in the face of rapidly growing population and increasing urban and environmental demands on a fixed supply of water.

(3). Water Management Reforms. Droughts act as catalysts for change. Complex sociopolitical systems, which reflect a multitude of competing and conflicting needs, are not particularly well suited for crisis management. Yet despite these well understood and accepted deficiencies in the democratic decision making process, the overall conclusion is that communities not only weathered the drought in a reasonably organized manner, but also introduced a series of useful water management reforms and innovations that will influence future water uses in a positive manner.

(4). Conservation. Conservation may or may not reduce drought vulnerability. To the extent that methods of reducing water use during droughts, such as discouraging outdoor use and physical modifications to toilets and faucets to reduce water use, are used as long term water conservation measures that allow the addition of new customers to a water supply system, drought vulnerability is increased. When normal use becomes more efficient, efficiency gains are harder to realize during a drought. But it is not always that simple. In the Boston Metropolitan area, for example, long term conservation will reduce drought vulnerability because some of the water saved will be stored for use during drought and because some of the most effective long term conservation savings (such as the detection and repair of leaks) cannot be implemented quickly enough to be effective as a drought response.

(5). Summary. The full value of the experiences of those who have survived a severe drought can be realized only if the lessons learned are recorded, critically analyzed, and communicated to others who can use the information. Provided as **Box 7-1** is a summary of the lessons learned from key members of the California water community.

4. Framework for Drought Planning and Management.

a. Introduction. The drought study started with an analysis of problems and a search for implementable measures that would improve the nation's readiness for drought. Three recommendations were made for the remainder of the study. First, test and refine a model approach to drought preparedness in case studies across the country. Second, to produce a National Drought Atlas to provide a national reference for precipitation and streamflow statistics. Finally, to conduct topical studies on issues such as water law, institutions, and negotiations.

Box 7-1
Lessons Learned from the California Drought

- The complex impacts of a sustained drought demand more sophisticated planning.
- Severe drought can change longstanding relationships and balances of power in the competition for water.
- Irrigation can provide complementary environmental benefits.
- Drought can convince communities to accept water management options that are not seriously considered during normal years.
- The success of drought response plans should be measured in terms of the minimization and equitable redistribution of the impacts. There is much to be learned in accomplishing this goal.
- Severe drought can expose inadequacies in state and Federal water institutions, causing significant institutional and legal changes.
- Increases in water rates should precede or accompany rationing plans.
- Mass media can play a positive role in drought response, but water managers should be involved in designing the message.
- Markets are an effective way of reallocating water supplies.

b. <u>The DPS Method</u>.

(1). <u>Derivation</u>. The Drought Preparedness Study (DPS) Method is derived from techniques of multiobjective, multipurpose water resources planning refined through Federal water project planning experience. These well-founded techniques were adapted for use in situations where the Federal government plays a smaller role and the solutions are more likely to be non-structural. The strength of the DPS Method is not that it includes so much that is new, but that it makes practical and whole what is well regarded in theory. This method addresses two common shortcomings in water management: the separation between stakeholders and the problem solving process, and the subdivision of natural resources management by political boundaries and limited agency missions.

(2). <u>Seven Steps</u>. Drought preparedness studies constitute a more general vision of the planning methods and evaluation principles of Federal water resources planning principles. These studies are joint efforts requiring intergovernmental cooperation with those who have a stake in how water is allocated and used. The extensive drought responsibilities of state, regional, and local entities are accommodated in these result oriented studies. The DPS method takes advantage of experience, research, and expertise from across the country in developing these integrated long and short term responses. The resulting plans are dynamic and exercised regularly during virtual droughts. The seven steps of the Drought Preparedness Method are shown in the **Table 7-10**. This method reflects the fact that drought responses are largely behavioral and their success depends on people understanding their role and knowing how their actions fit into a larger response.

Table 7-10
The Seven Steps of the Drought Preparedness Method

Step	Explanation
1	Build a team and identify problems.
2	Develop objectives and metrics for evaluation.
3	Describe the status quo; that is, what will happen in future droughts if the community does nothing more to prepare itself?
4	Formulate alternatives to the status quo.
5	Evaluate alternatives and develop study team recommendations.
6	Institutionalize the plan.
7	Exercise and update the plan and use it during droughts.

c. New Tools for the DPS Method.

(1). Introduction. The DPS Method takes advantage of several innovations developed in parallel during the National Drought Study. The following paragraphs describe these new tools.

(2). Shared Vision Models. The shared vision models are computer simulation models of water systems that have been built, reviewed and tested collaboratively with all the stakeholders. The models represent not only the water infrastructure and operation, but the most important effects of that system on society and the environment. Shared vision models take advantage of new, user-friendly, graphical simulation software to bridge the gap between specialized water models and the human decision making processes. Shared vision models helped DPS team members overcome differences in backgrounds, values and agency traditions.

(3). Circles of Influence. Circles of influence are a way to improve agency collaboration with elected officials and stakeholders. The circles created new ways for people to interrelate and interact, without destroying the old institutions, their responsibilities or advantages. In addition, during the DPS's, political scientists conducted interviews with elected officials and other influential political agents. The interviews were included in reports available to the entire study team, and were used to assure the planning process addressed issues critical to the public and elected officials.

(4). Virtual Drought Exercise. A Virtual Drought Exercise is a realistic simulation of a drought using the shared vision model to simulate that experience without the risk associated with real droughts. Virtual Drought Exercises can be used to exercise, refine and test plans, train new staff, and update plans to reflect new information.

(5). IWR-MAIN. Water conservation management is the prioritization and selection of water conservation measures based on their estimated benefits and costs. A new version of a widely used water use forecasting model, IWR-MAIN 6.1 (see Paragraph B of this chaper, Appendix E and Chapter 6, Paragraph C), provides a powerful new tool for linking water savings with specific combinations of water savings measures.

(6). Trigger Planning. Trigger planning is a collaborative and continuous process for updating water supply needs assessments and responding in time, but just in time, with the necessary economic and environmental investments necessary to address those needs. Trigger planning uses a shared vision model and the DPS method to minimize those investments while reducing the frequency of drought declarations caused by inadequate water supply. Trigger planning was tested and refined in the Boston metropolitan area.

d. National Drought Atlas. The "*National Drought Atlas*" (IWR Report 94-NDS-4) is a compendium of statistical information designed to help water managers and planners answer questions about the expected frequency, duration and severity of droughts. The Atlas provides a national reference for precipitation and streamflow statistics that will help planners and managers assess the risks involved in alternative management strategies.

E. EVALUATION OF EXISTING WATER DISTRIBUTION SYSTEMS

1. Introduction.

a. Authority. General legislative authority does not exist for the Corps to construct, operate or maintain water distribution systems. However, in certain situations, the Corps can receive specific legislation to perform these functions and Corps district offices can be called upon to help local governments under the authority of Section 22 of the Water Resources Development Act of 1974, as amended, to help solve water distribution problems. Also, in feasibility reports or in reallocation studies it may be necessary to develop a planning level design and prepare a cost estimate for a water distribution system. It is, therefore, necessary that Corps offices become familiar with studies of existing water distribution systems.

b. Components. There is no such thing as a "typical" water distribution system. Each one has some unique characteristics due to the water source, service area topography, history of system, etc. In general, there are water sources and water users, and they are connected by a distribution system. Water distribution pipes can be made of ductile or cast iron, steel, concrete with or without embedded cylinders, various types of plastics, asbestos cement, plus some other innovative materials, and may be connected in an almost limitless number of configurations. There can be a single source such as a central water treatment plant and pumping station, or water may be supplied by a large number of wells. While pumps are a common component of systems, where the source is at a sufficiently high elevation, the system may not have any pumping. Most systems contain some storage capacity in the form of tanks which are connected directly to the system. Valves are required to shut off lines, suppress surges, release air, allow air to enter, drain pipes, control pressure, or simply ease the operation of other valves. A hydrant is actually a special type of valve that releases water for fire fighting. Booster pumping may be required to provide adequate pressure in certain portions of a system when there is significant variation in elevation or use rate. On the other hand, pressure reducing valves serving just the opposite purpose may be needed.

c. Guidance. The American Water Works Association (AWWA), headquartered at 6666 West Quincy Avenue, Denver, Colorado 80235-9931, is the primary provider for information in this area. See **Box 7-2** for some of its publications. The AWWA can also be contacted through the Internet at *hppt://www.awwa.org*. Additional quantitative guidance, however, is required for Corps district offices. This specific Corps guidance is contained in ETL 1110-2-297, dated 20 June 1986. This guidance provides the Corps planner with information relative to the collection of data for the evaluation of water systems, the assessment of the economics of water system operation and maintenance, and procedures for using water distribution system models. This information is summarized in the following paragraphs.

Box 7-2
American Water Works Association Publications

Introduction to Water Distribution, AWWA, 1986.

Distribution Requirements for Fire Protection, AWWA Manual M-31, 1989.

Distribution Network Analysis for Water Utilities, AWWA Manual M-32, 1989.

AWWA Standards, AWWA, (continually updated).

AWWA Research Foundation, Water Quality Modeling in Distribution Systems, AWWA, 1991.

2. Testing Water Distribution Systems.

a. Introduction. Collection of accurate data is essential for the evaluation of water distribution systems. Because it is not possible to actually see water flowing or feel the pressure in a closed conduit, it is necessary to conduct tests in order to evaluate the adequacy of system performance. In water conservation and planning for drought it is essential that unaccounted-for water be quantified, identified, and controlled to the extent practical.

b. Unaccounted-For Water. Unaccounted-for water is the difference between water produced at the treatment plant and water sold to the customer. The term "metered ratio" is also used to indicate the amount of water which produces revenue. Causes of unaccounted-for water can be attributed to leakage, inaccurate master meter, inaccurate customer meters, unauthorized use, use for municipal buildings and use through hydrants.

c. Tests. A series of tests which have been developed to quantify the unaccounted-for water are summarized in **Table 7-11.**

Table 7-11
Tests for Water Distribution Systems

Test	Description
Pressure Measurement	Pressure gages are mounted at the suction and discharge ends of pumps, upstream and downstream of pressure reducing valves, the discharge of wells and other important points in distribution systems. Pressure gages do not retain accuracy and, therefore, should be tested regularly. Pressure gages are useful for determining the range of pressures encountered over an extended period of time.
Hydrant Flow Measurement	This test is performed to measure the discharge from an outlet of a fire hydrant. To accomplish this test a gage is inserted into the flow to measure the velocity head in pounds per square inch. Special care must be exercised in conducting a hydrant flow test so that the stream of water does not cause erosion or flooding problems.
Fire Flow Tests	Fire flow tests are conducted to determine the adequacy of distribution systems for fire fighting and can also be used to assist in calibration of water distribution system models. A typical test is begun by attaching a pressure gage to a hydrant and recording the pressure. One or more nearby hydrants are then opened and the total flow is recorded while the pressure at the residual hydrant is again recorded.
Hydraulic Gradient Test	Hydraulic gradient tests are conducted to determine if head losses in distribution systems are within reasonable limits. To conduct a test, measure the pressures at predetermined intervals along a major transmission line during a time in which water use is fairly constant. Next, determine the elevations at which the pressure readings were taken and calculate the elevation of the hydraulic grade line at each location. Then make a plot of hydraulic grade line elevation versus distance from water source. Sections of pipe with significantly greater gradients are sources of high head loss and are likely candidates for cleaning or paralleling.
Coefficient Tests	Head losses in mains are usually calculated by either the Hazen-Williams or Darcy-Weisbach equation. For the Hazen-Williams equation, it is necessary to know the Hazen-Williams C-factor. For the Darcy-Weisbach equation, it is necessary to know the pipe roughness. While values of these factors are available from literature, there is a considerable variation depending on water quality and the condition of the pipe, so it is good practice to conduct head loss tests for pipes in the system. Tests to be run include, average velocity, hydraulic gradient, C-factor, and pipe roughness.

d. Water Loss Surveys. An audit or water loss survey is conducted by isolating "districts" in the system and metering the flow into the districts over the course of a day. The measured flow can be compared with metered water use to determine unaccounted-for water.

e. Leak Detection. Leak detection can be conducted as part of a water loss survey, a continuing program, or a one-time study. Most leak detection devices rely on detection of the sound produced by water leaking from a pipe. Sophisticated equipment has been developed to mechanically or electronically amplify the sound and/or filter out other noises. While tracer gasses, dyes, buried conductors, temperature probes, and sensitive manometers have been used to locate leaks, sonic detection devices are most useful for water distribution system work.

3. Replacement of Water Mains Due to Breakage.

a. Introduction. Breaks occur in water mains for a large number of reasons, such as impact, frost loads, corrosion, excessive surge pressure, improper bedding, and combinations of the above. The rate of breakage tends to increase with the age of pipe. In order to make sound decisions whether to replace a pipe due to breakage, it is important to know the cause of previous breaks. By knowing the causes of these breaks, it can be determined whether the historical break rate will increase, decrease or remain the same in the future. Once a leak or break is located, options available include doing nothing, repair the break or replace the pipe. Doing nothing is attractive when the repair would be difficult, the water is not doing any damage, water is plentiful and inexpensive and/or the pipe is scheduled to be abandoned or replaced in the near future.

b. Cost. In order to determine whether it is economical to replace pipes developing frequent breaks, or employ some other remedial measure as opposed to simply repairing breaks, it is necessary to quantify the costs associated with both the breaks and the remedial measures. The cost of a break can be divided into costs for repair, damages, inconvenience to water users, traffic delays, health and safety effects, and lost water. The cost to replace a pipe is a function of many variables including pipe diameter, depth of cover, type of pipe, and local material and labor prices. Data on replacement costs of pipe should be available from the utility from previous pipe replacement work. While the actual cost to repair and replace pipes is important, the decision to repair or replace pipe actually depends on the relative cost of each. For an identical break rate, it is generally least costly to replace a small pipe and repair a large pipe.

c. Prediction of Break Rates. Knowing the future break rate for water mains is important for making decisions on whether to replace or repair pipes and for projecting costs of repair in future years. The break rate in future years is usually the current break rate with a slight increase over time, since as systems age, the rate of breaks gradually increases. This general statement is accurate only if the years are “typical.” Break rates in a given system can fluctuate by a factor of ten from one year to the next, so an average of the previous several years is the most reliable indication of the current break rate upon which to base estimates of future break rates. Discussing breaks in terms of total breaks in a system can be somewhat misleading, since the number of breaks will depend on the size of the system and time period under consideration. Trends in break rate provide useful information on the causes of breaks and possible remedial actions. For example, if corrosion is the principal cause of breaks, then the rate will increase with time. On the other hand, if breaks are highest after severe winters, then frost penetration may be the factor that triggers breaks. Breaks due to impact or contact with other structures tend to coincide with construction activity in the area. Determining the rate of change of the break rate involves extrapolating trends in the break rate. This can be done graphically by plotting break rate versus time on semi-log graph paper, with the break rate on the logarithmic axis. This corresponds to fitting the data to the equation recommended by Shamir and Howard (1979):

$$J = J_o e^{b(t - t_o)}$$

where: **J** = break rate in year t, breaks/year/mile
J_o = break rate in year t_o, breaks/year/mile
e = 2.718
b = rate constant, 1/year
t = year
t_o = base year.

The value of **b** should be interpreted as indicative of the change in break rate within a group of pipes, whether it is for the entire system or a specific type of pipe laid in a specific time period, rather than the rate of change between different groups of pipes.

4. Rehabilitation of Water Mains.

a. Introduction. Tuberculation, internal corrosion, and deposits on pipe walls gradually reduce the carrying capacity of water distribution systems. In some older systems, the problem has grown to the point that there are pipes in which the carrying capacities as measured by the Hazen-Williams C-factor are only fractions of their original values. The low carrying capacities result in low pressures in the system, especially at high flow. Where pipes are still structurally sound, cleaning and lining is usually the least costly approach to regaining carry capacity. The pressures can also be raised by using larger pumps or higher tanks or by installing new pipes. The economics of the tradeoffs are then the deciding factor.

b. Preliminary Steps. Before embarking on a pipe cleaning and lining project, the utility must first make certain that the pressure, flow, or energy consumption problem observed is indeed due to a loss in pipe carrying capacity. An overview of steps in evaluating a rehabilitation project is summarized in **Table 7-12**.

c. Economic Analysis. The economic analysis of pipe rehabilitation can be divided into two cases: pipeline or complex grid. In the case of a single pipeline between two points or a simple branched system, the design flow rates in the pipe(s) are known and an economic analysis can be performed manually. The type of economic analysis depends on the alternative to cleaning and lining; whether it is (1) increased pumping, or (2) a parallel pipe. The first case involves a tradeoff. The utility can provide adequate pressure and flow by either rehabilitating pipes or by increasing pumping equipment costs and energy consumption for the pipes that are losing carrying capacity. In the second case, simply pumping more will not provide adequate head. This is the case in gravity systems or portions of pumped systems primarily served through elevated storage during peak flow events. In the case of a complex grid network, the flow in each pipe is highly influenced by the flows in nearby pipes. For additional information on the economics of rehabilitation of water mains, see ETL 1110-2-297.

Table 7-12
Steps in Evaluating a Rehabilitation Project

Pressure or Flow Problem	Yes or No	Step to Take
Possible closed valves?	Yes	Check valve.
	No	Check pumped system.
Pumped system?	Yes	Check pump performance.
	No	Check peak flow conditions.
Problem only at peak flow?	Yes	Analyze storage adequacy.
	No	Check pipe for soundness.
Pipe structural sound?	Yes	Check pipe roughness.
	No	Replace pipe with correct size.
Pipe rough enough?	Yes	Check complex grid.
	No	Need more capacity.
Complex grid?	Yes	Use network model.
	No	Check pumped main & head at peak flow.
Pumped main & head at peak flow acceptable?	Yes	Compute rehabilitation vs. energy.
	No	Compute rehabilitation vs. parallel main.

5. Water Distribution System Models.

a. Introduction. Mathematical models of water distribution systems are commonly used to plan system enlargements, test existing systems under unusual conditions, or evaluate the system operation. Almost every large distribution system has had some type of model developed for it. While the numerical methods with the models receive the most attention in the literature, there are actually two parts of a model: (1) the computer program consisting of the input and output routines, the loop identifier routine, the initialization routine, and the numerical solution routine; and (2) the system data consisting of the length, diameter, and some coefficient required to calculate head loss for each pipe, the elevation of each node, the water elevation at each tank, the head, flow, or head-characteristic curve for each pump, a description of important valves, and water use through the system.

b. Computer Programs. Many computer programs have been developed to perform fundamental pipe network analysis computations. Appendix E and Chapter 6, Paragraph C, provide information on two of these models; KYPIPE2 and WADISO.

c. Calibration. A very important step in the development of a water distribution system model is the comparison of results predicted by the model with observations taken in the field. If the input for the model is correct, then predicted pressures and flows will match observed values. However, the data describing water use and pipe roughness are usually not perfect, so some values must be changed for the predicted and observed values to agree. The question the model user must answer is, therefore, which parameters need to be changed and by how much? Calibration of a water distribution model is a two-step process consisting of; (1) comparison of pressures and flows predicted with observed pressures and flows for known operating conditions (i.e., pump operation, tank levels, pressure reducing valve settings) and (2) adjustment of the input data for the model to improve agreement between observed and predicted valves. A model is considered calibrated for a set of operation conditions and water uses if it can predict flows and pressures with reasonable agreement. Calibration at one set of operating conditions and water use does not necessarily imply calibration in general, although confidence in the accuracy of results from the model increases with an increase in the range of conditions for which the model is calibrated.

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CHAPTER 8: *WATER SUPPLY NEEDS ANALYSIS*

A. WATER SUPPLY FORECASTING

1. Overview.

a. General. Forecasting means the estimation of conditions at a specific future time, or during a specific time interval. For example, the flow of a river at noon tomorrow, or, the next five months of inflow into a reservoir are forecasts. Forecasts are distinguished from predictions, which are the estimation of future conditions, without reference to a specific time. For example, the 100-year flood, and the 10-year, 7-day low flow are predictions. As the forecasting lead time (the time or time interval for which the forecast is made) increases, forecast accuracy usually decreases. For very long lead times, the distinction between forecasts and predictions is blurred, and most forecasts are no more accurate than those made by using the long-term statistical mean, Maidment (1993). Water supply forecasting is similar to all other types of forecasting and uncertainty grows with the length of the forecast period and continual adjustments may be necessary.

b. Relationships. The intricate relationship between water supplies and water demand can complicate matters. Spells of dry weather, for example, may not only impair supplies but also lead to higher levels of outdoor water use. Even though the hydrologic cycle is closed, fluctuations around mean values can be substantial. In this analysis, conjunctive use of surface water and groundwater is necessary to adequately determine water supply availability. The importance of conjunctive use lies in the interaction between the two characteristically different water sources. There are two main aspects of this interaction, the flow of groundwater to support river flow and the flow from the river to the groundwater. The former is a common occurrence in temperate regions, whereas the latter occur widely in arid regions.

2. Methods.

a. General Categories. For supply forecasts, the variables used in most models fall into three general categories: hydrologic, topographic, and climatic. These three general categories and their indicators are summarized in **Table 8-1**. Included under "Hydrologic Indicator Number 5," are yield estimates, water quality, and minimum flow requirements.

b. Hydrologic Methods. The U.S. Army Corps of Engineers has published a series of reports on water supply forecasting and planning. One study, Dziegielewski et al. (1983) summarized several hydrologic methods of water supply forecasting, see **Table 8-2**. Each method has different data requirements, depending on its focus, and advantages and disadvantages depending on its application. Most are highly technical in nature and limited in the sense that they focus strictly on the hydrologic supply side. Supply forecasting grows in complexity when water supplies become impaired by natural or artificial causes. Regardless of where they originate, supply forecasts are relevant in integrated approaches that combine expectations about supply with expectations about demand for planning purposes.

Table 8-1
General Water Supply Forecasting Categories

Categories	Indicators
Hydrologic	1. Reservoir rating curves 2. Drainage area 3. Streamflow 4. Raw water quality 5. The hydrologic characteristics of alternative sources
Topographic	1. Regional maps 2. Soil moisture conditions 3. The extent to which drought-tolerant landscaping is used
Climatic	1. Air temperature 2. Precipitation (rainfall and snowmelt) 3. Moisture deficit

c. Basin Climatic Index. Drought indices provide an indirect measure of relative availability of water. They are derived from comparisons of water requirements as measured by evaporation and evapotranspiration and to water supplies as measured by precipitation. One such measure, the Basin Climatic Index (BCI) method, was applied to develop drought alert procedures for Kansas (Lampe, 1982).

$$BCI_m = 115 \sum_{i=1}^{m} \left(\frac{P_i}{(T_i - 10)}\right)^{1.11}$$

Where subscript m denotes the length of the period in months, for which the index is calculated. P_i and T_i are, respectively, monthly precipitation in inches and monthly temperature in degrees Fahrenheit in month i of the m-month period. The rationale for applying the 12-month running BCI's to predict relative availability of water for public water supplies is based on dependence of supply sources on runoff, the magnitude of which can be related to the BCI. The relative simplicity of the BCI method justifies its application as the first resort technique for assessing the likelihood of storage deficiencies for systems that rely on reservoir supplies. The statewide application of this procedure requires that long-term average BCI's are determined for various regions of a state and small water supply systems can use the forecasted runoff to assess their vulnerability to water shortage. Large water supply systems can perform all evaluations for the watersheds of their sources, thus improving the accuracy of the estimates.

Table 8-2
Selected Hydrologic Water Supply Forecasting Methods

Method	Type of Forecast	Data Requirements
Basin Climatic Index (BCI)	Expected total for 12 months' runoff, with 10, 25, and 50 percent probability of occurrence.	Drainage basin or regional data, long-term average BCI's and runoff, monthly precipitation and temperature.
Position Analysis	Percent probability of complete exhaustion of the reservoir storage during drought.	Monthly inflow, withdrawals and evaporation for a reservoir, plus current reservoir storage.
Refined Position Analysis	Percent probability of a dry reservoir based on representative trace of inflows.	Historical and filled-in streamflow data.
National Weather Service River Forecasting System (NWS-RFS)	Simulated stream flows; total volume of flow; maximum, minimum, and average mean daily flow.	Hydrological parameters and initial conditions of a watershed, including moisture storage contents, snowpack water equivalents, future time-series of mean areal precipitation, and temperature (at least 10-20 years of record).
Snow Accumulation and Ablation Model	Snow cover outflow plus rain that fell on bare ground.	Air temperature, snowpack water equivalents, other snow-cover variables.
Sacramento Soil Moisture Accounting Model	Five components of water flow: direct runoff, surface runoff, lateral drainage interflow, supplementary baseflow; and primary baseflow.	Same as for the NWS-RFS model (above).
Sensitivity Approach (for NWS-RFS rain-fall-runoff procedures)	Same as for the NWS-RFS model (above).	Typical trace of 6-hour-interval rain data, current soil moisture, variance of rainfall input.
Stochastic Conceptual Hydrologic Model (based on NWS-RFS)	Streamflow forecasts 6, 12, 18, 24, 30, and 36 hours in advance	Rainfall data in 6-hour time steps and incoming real-time discharge.

d. Position Analysis. Sheer (1980) described a simple analysis of the availability of water in the Occoquan Reservoir, Virginia during the 1977 drought. His calculations assessed the risk of the reservoir having gone dry dependent upon the current reservoir storage and soil moisture of the supply system. This simulation, called "position analysis," was designed to determine in how may years in the historical record the reservoir would have gone dry if the demands had been as high as they were in 1977, and the reservoir as low as it was in 1977. For each year the current storage was added to the inflows for the next month and the expected water use and an allowance for evaporation in that month were subtracted. The calculation was then repeated for each subsequent month for each period of the historical record under consideration. The results were expressed in terms of the risk of a dry reservoir measured as a ratio of years when the reservoir would have been empty over the number of years of record. The author recommended this approach as the technique of first resort in estimating the risk of streamflow induced drought.

e. Refined Position Analysis. A more refined "position analysis" method has been performed by the staff of the U.S. Geologic Service (USGS). This analysis was based upon historical and "filled in" streamflow data for a net period of 49 years in order to find a representative trace of inflow to the Occoquan Reservoir which can be expected to occur in any given year. Twenty-seven years were removed from the 49-year record since they were judged as dissimilar to the year 1977. The remaining 22 years of record were used to determine in how many years in the historical record the reservoir would have gone dry given the demands and the reservoir storage as existed in September 1977. This analysis is described by Sheer (1980), while the full presentation of the USGS techniques can be found in Hirsch (1978).

f. National Weather Service Extended Streamflow Prediction Technique. The National Weather Service (NWS) has developed a computerized system of hydrologic forecast procedures which are referred to as the NWS Extended Streamflow Prediction (NWS-ESP) or the NWS River Forecasting Systems (NWS-RFS). The NWS-RFS procedure comprises several hydrologic forecast procedures including data acquisition and processing, computation of mean areal precipitation (MAP) in a watershed, snow accumulation and ablation, soil moisture accounting, parameter optimization and verification, and operational forecasting. All these procedures are described in several technical memoranda of the National Oceanic and Atmospheric Administration (NOAA) (Monro, 1971; Hydrologic Research Laboratory Staff, 1972; Fread, 1973, 1975; Anderson, 1973; Morris, 1975; and Peck, 1976). Overviews of the NWS-RFS procedure at various stages of development are given by Sittner (1973), Monro and Anderson (1974), Twedt, Schaake and Peck (1977), and Curtis and Schaake (1979).

g. Soil Moisture Accounting Method. The soil moisture accounting model, referred to as the Sacramento model, has been developed by the California River Forecast Center and is described by Burnash et al. (1973) and by Peck (1976). The model distinguishes two soil moisture zones: 1) the upper zone representing the upper soil layer with interception storage, and 2) the lower zone representing the bulk of the soil moisture and groundwater storage. Two forms of water are distinguished in each zone, "tension water" and "free water," the former being depleted only by evapotranspiration. The flow rate of water from the upper zone to the lower zone is a function of water content in the two zones. Generally, the model is deterministic with lumped input and lumped parameter, and is capable of generating five components of water flow which are converted to a discharge hydrograph at a 6-hour time step for a given volume of moisture input over that period. The moisture input to the model also can be determined using a snow accumulation and an ablation subroutine described by Anderson (1973). This auxiliary model utilizes air temperature as the only index to energy exchange across the air-snow boundary.

h. Sensitivity Approach.

(1). The NWS-RFS technique can be used to produce probablistic streamflows during designated time periods. The simulated streamflows serve as artificial flow records to determine total volume of flow, maximum mean daily flow, minimum mean daily flow, average mean daily flow and other statistical characteristics. The input data must include the following: 1) a set of hydrological parameters of a basin under consideration; 2) initial basin conditions that represent the current state of the catchment in terms of moisture storage in the soil, snow pack water-equivalents, and other snow cover variables, and 3) representative future time series of mean precipitation and temperature (at least 10-20 years of historical record).

(2). An application of the NWS-RFS procedures to produce the estimates of the risk of water supply shortage during the 1977 depletion of the Occoquan Reservoir has been described by Sheer (1980). Young et al. (1980) developed an alternative procedure to the NWS-RFS streamflow simulation to determine the expected yield and standard deviation yield for a given catchment. The authors proposed a sensitivity analysis of the rainfall-runoff models as used by the NWS. Instead of performing an extensive simulation of equally likely rainfall traces, the sensitivity approach uses only one typical trace of 6-hour interval rainfall data, current soil moisture estimates and variance of the rainfall input. The sensitivity analysis requires less computer time than the NWS procedure.

i. Stochastic Concept. Kitanidis and Bras (1980a, 1980b) reformulated the nonlinear conceptual rainfall-runoff model used by the NWS-RFS into a form amenable to the analysis of uncertainty and to real-time forecasting of river discharges within a stochastic process framework. The model developed by the authors is capable of processing incoming real-time discharge and rainfall information in 6-hour time steps to produce streamflow forecasts 6, 12, 18, 24, 30, and 36 hours in advance. These lead-time periods are comparable to the response time of a catchment. The mathematically rigorous approach proposed by the authors may offer a substantial improvement in water supply forecasting where more precise weather forecasts or historical rainfall information are available. For an excellent training document on stochastic analysis and drought see Goldman (1985).

3. Effect of Global Warming.

a. Introduction. The intense emphasis on climate change issues during the past decade, focusing on the social, economic and environmental consequences of global warming has created a confusing array of policy dilemmas for many governments and natural resources managers. A review of many relevant publications (e.g. Smith (ed.) et. al. 1996) and especially those of the Intergovernmental Panel on Climate Change (IPCC: 1996b.c.d. 1997) reveals that there is no set of new actions, policies or management measures that are unique to the problem of adapting water resource management to global warming. The only difference appears to be in the support of implementing conventional measures more rapidly in anticipation of the more severe consequences of global warming. This is termed the “anticipatory” versus the “reactive” strategy. In reality, “adaptive management” is one of reacting to a variety of signals and information that are constantly being monitored and fed back into a formal system of response - whether it is policies, operating procedures, new models or new design standards. The "anticipatory" philosophy rests on the foundation of the "precautionary principle" which contends that the very uncertainty underlying global warming and the potentially large adverse consequences requires the immediate implementation of preventive actions. This applies both to the prevention of greenhouse gasses as well as actions intended to ameliorate the impacts of warming on various sectors (forestry, agriculture, ecosystems, urban, etc.). This mitigation (prevention) of greenhouse gases does reflect a unique new coordinated international strategy that includes specific targets for emissions and a series of institutional mechanisms for trading emissions among developed and developing nations (Stakhiv, 1998).

b. Impact Studies. Recent climate change impact studies suggest that well-managed water resources systems can withstand all but the most severe of climate change scenarios advanced by the leading general circulation models for a doubled carbon dioxide climate. Therefore, even as the number of countries and regions that are susceptible to water scarcity, climate change and variability increase over time, there is a reasonable degree of confidence that vulnerability (the extent of harm or damage) can, at a minimum, be stabilized at current levels or in most cases, be reduced. That evidence comes from two trains of analysis: integrated regional or national economic assessments of climate change impacts [Rosenberg (ed.), 1993; Frederick and Rosenberg (eds.), 1994; and Yates and Strzepek, 1996] and a detailed analysis of the performance of several managed river basins and urban areas in relation to future water resources uses and purposes under a wide range of climate change scenarios exemplified by the work of Kaczmarek and Napiorkowski, (1996); Stakhiv, (1996); Lins, et. al. (1997); Boland, (1997); Hobbs, et. al. (1997), Wood, et. al. (1997), Georgakakos, et. al. (1998) and Lettenmaier, et. al. (1998). Climate change impact studies are problematic because they propagate large uncertainties throughout the analytical process. At best, these studies are suggestive rather than predictive in nature. Few have even come close to the ideal impact analysis recommended by the IPCC (1994). Lettenmaier, et. al., (1996) laid out a very detailed account of the various modeling problems, as did Lins, et. al. (1997) and Hobbs, et. al. (1997). (Stakhiv, 1998).

c. Uncertainties. One of the basic issues associated with global warming and climate uncertainty is whether it makes much difference to operational hydrology and design to assume a non-stationary climate over that of a stationary one. Although a great deal of resiliency and robustness can be built into a water management system through a combination of various institutional measures (insurance, conjunctive use, water conservation incentives, water codes, legal measures, regulation, etc.), at the core of water management is the guarantee of a reliable delivery of services at some predetermined level or reliability. Global warming introduces yet another large uncertainty into the search for reliability, and the question is whether the current methods of operational hydrology, oriented toward a stationary climate, can be suitably employed to accommodate the uncertainties of a non-stationary climate (Stakhiv, 1998). As outlined in IPCC (1996b), some uncertainties in assessing the effects of climate change on water resources are summarized in **Box 8-1**.

Box 8-1: Uncertainties

- Uncertainties in general circulation models and lack of regional specification of locations where consequences will occur

- Insufficient knowledge on future climate variability, which is a basic element of water management

- Uncertainties in estimating changes in basin water budgets due to changes in vegetation and in atmospheric and other conditions likely to exist 50 to 100 years from now

- Uncertainties in future demands by each water sector

- Uncertainties in the socioeconomic and environmental impacts of response measures.

Several authors, notable Fiering and Matalas (1990), Rogers and Fiering (1990) and particularly Matalas (1997) seem to think that the framework of stochastic (synthetic) hydrology, that is widely used in project planning, “can accommodate the uncertainties in water supplies induced by global warming with the operational assumption of stationarily as meaningfully as with the assumption of nonstationarity.”

d. Strategies. Nevertheless, despite an impressive array of proven methods, models and policy instruments that are available to better manage and adapt, there needs to be a firm commitment from each country to implement these mechanisms in a comprehensive and coherent manner. The uncertainties associated with climate change should provide an additional impetus to contemporary water resources planning and management to more closely align it with the “no regrets” strategy. IPCC (1997) defines the “no regrets” strategy as undertaking all the measures that would normally be justified under contemporary criteria. Stakhiv (1998) indicates that enough evidence has accumulated that the existing, highly managed watersheds of developed nations have the flexibility and robustness to withstand all but the severest climate change scenarios. The sensitivity analyses conducted on these watersheds and river basins under a variety of scenarios may help to refine the operation and design of these systems for even greater resiliency. These lessons from the more recent integrated studies should provide additional support to the principles and practices that currently comprise our understanding of effective water management.

e. Impact of Climate Change on Water Supply. As developed in IPCC (1996b), climate change is likely to have an impact on both the supply of and demand for water. Most climate-change impact studies have taken the form of sensitivity analyses by feeding climate-change scenarios into hydrological models. The outputs of these studies tend to be expressed in terms of changes in the reliable yield of the systems, changes in the volume of water that can be supplied, or changes in the risk of system failure. Virtually all of the studies have simulated what would happen in the absence of adaptation to change. In practice, however, water management authorities will adapt using existing or new management options, -- as shown to be feasible in the Great Lakes region by Chao, et al. (1994), and Hobbs, et al. (1995).--although such adaptation may incur added costs and involve tradeoffs that result in reductions in service for some water users. As shown in IPCC (1996b) there are several possible effects of global warming on the amount of water available within a catchment or water supply area; these are summarized in **Table 8-3**.

Table 8-3
Summary of Effects of Global Warming on Water Supply

Effect of Global Warming	Impact on Water Supply Reliability
Change in river runoff	Yield in direct water abstraction Yield in reservoir systems
Change in groundwater recharge	Yield of groundwater supply systems
Change in water quality	Yield of abstraction systems
Rise in sea level	Saline intrusion into coastal aquifers Movement of salt-front up estuaries, affecting freshwater abstraction points
Change in evaporation	Yield of reservoir systems

f. The Global and Regional Context.

(1). The growing interest in possible consequences of climate change on regional water resources has given rise to a wealth of studies on the sensitivity of water balance to climatic variables. A number of these studies are presented in IPCC 1996b. One such study is summarized in **Table 8-4**. This table summarizes the combined impact of population growth and climate change on water availability in selected countries, based on the IPCC (1992a) socioeconomic scenarios and the results of three transient "General Circulation Models" (GCM) runs. Theses GCM runs are "Geophysical Fluid Dynamics Laboratory" (GFDL), "United Kingdom Meteorological Office" (UKMO) and "Max Planck Institute" (MPI). The first column shows the selected countries. The second column lists per capita water availability for the present (1990); the third column shows water availability for current climatic conditions, reflecting population growth alone to the year 2050. The last column shows the range of combined effects of population growth and climate change for the three transient scenarios. The sensitivities of national water supplies to changes in temperature and precipitation were estimated by a method proposed by Kaczmarek (1990). It should be added that the future water availability data do not take into account possible changes in water resources systems development (e.g., increased storage and desalination).

(2). The results show that in all countries with high population-growth rates, future per capita water availability will decrease independent of the assumed climatic scenario. Large discrepancies may be noted among results obtained for some countries by means of various atmospheric models. This example clearly demonstrates how difficult it would be to initiate water resources adaptation actions based on currently available methods of climate predictions. It can be expected that in many regions of the world, nonclimatic factors will dictate what measures must be undertaken to secure sustainable water supply (Frederick, 1994; Rogers and Lydon, 1994). Predicted climate changes, however, could redistribute water supplies, adding a new, highly uncertain component to the challenge of managing water resources.

Table 8-4
Water Availability in 2050 (1)

Country	Present Climate (1990)	Present Climate (2050)	Scenario Range (2050)
China	2,500	1,630	1,550-1,780
Cyprus	1,280	820	620-850
France	4,110	3,620	2,510-2,970
Haiti	1,700	650	280-840
India	1,930	1,050	1,060-1,420
Japan	3,210	3,060	2,940-3,470
Kenya	640	170	210-250
Madagascar	3,330	710	480-730
Mexico	4,270	2,100	1,740-2,010
Peru	1,860	880	690-1,020
Poland	1,470	1,250	980-1,860
Saudi Arabia	310	80	30-140
South Africa	1,320	540	150-500
Spain	3,310	3,090	1,820-2,200
Sri Lanka	2,500	1,520	1,440-4,900
Thailand	3,380	2,220	590-3,070
Togo	3,400	900	550-880
Turkey	3,070	1,240	700-1,910
Ukraine	4,050	3,480	2,830-3,990
United Kingdom	2,650	2,430	2,190-2,520
Vietnam	6,880	2,970	2,680-3,140

Footnote: (1). In cubic meters per year for the present climatic conditions and for the three transient climate scenarios (GFDL, UKMO, and MPI).

g. The Planning Process.

(1). The *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G) (U.S. Water Resources Council, 1983) establish the standards and procedures that designated federal water resources agencies use for planning and evaluating water projects. Although climate change is not mentioned explicitly as a source of uncertainty and had not been routinely incorporated into water planning and project evaluation, the P&G provides guidance for assessing and dealing with uncertain climate, weather, and hydrologic events in the distant future (Frederick, et. al., 1997). Contemporary climate variability serves as the driving mechanism and rationale for ameliorating societal impacts of floods, droughts, hurricanes, and spatial water deficits. Planning and evaluation principles and methods of the P&G are flexible enough to incorporate many issues that might arise from the prospect of climate change induced by global warming. These steps and the considerations are summarized in **Table 8-5**.

Table 8-5
Principles and Guidelines and Global Warming

Step	Consideration
1. Specify Problems and Opportunities.	Prospects for and potential implications of climate change would identify at the start whether or not it is likely to be a significant issue for a particular project that should therefore be an integral part of subsequent steps in the planning process.
2. Inventory and Forecast of Conditions Without a Plan.	(If climate change is identified as a significant planning issue in step 1.) Forecast of the impacts of climate change on the region's land and water in the absence of a federal project or policy change but with adaptations that would likely occur as a result of normal human responses to the projected changes.
3. Formulate Alternative Plans.	Formulate alternative plans consisting of a system of structural and/or nonstructural measures and strategies that address, among other concerns, the projected consequences of climate change. The alternatives are not limited to those that can be implemented under the existing authority of the federal planning agencies. Nonstructural measures that might be considered include modifications in public policy, management practice, regulatory policy, and pricing policy.
4. Evaluate Effects.	Evaluation of alternatives to be based on the most likely conditions expected to exist in the future with and without the plan. The P&G specifies that plans and their effects should be examined to determine the uncertainty inherent in the data or various assumptions of future trends. Methods specified in the P&G for dealing with risk and uncertainty include reducing the irreversible or irretrievable commitment of resources and performing sensitivity analyses of the estimated benefits and costs.
5. Compare Alternative Plans.	As in any other project study.
6. Plan Selection.	As in any other project study.

(2). Having determined that the P&G planning process is sufficiently flexible to incorporate consideration of and responses to many possible climate impacts, the challenge is to determine when the prospect of climate change should be introduced and how the planning process, including field level guidance, should be altered. Introducing the potential impacts of and appropriate responses to climate change in water resource planning and project evaluation can be both expensive and time consuming. Some of the factors that might influence the desirability of incorporating climate change into the analysis are the level of planning (i.e., national, regional, local, or project), the reliability of the general circulation models, the hydrologic conditions (e.g., arid or humid), the time horizon of the plan or life of the project, and the purpose of the project (e.g., hydropower, flood protection, water supply, etc.) (ibid).

(3). The Corps of Engineers performed an analysis of water resources impacts of climate change on seven major Corps operated systems in the United States. These studies were the Potomac River Basin/Washington Metro Area System, Boland (1997); Tacoma, Washington, Wood, et. al. (1997); and the Missouri River Basin; the Columbia River System; the Savannah River System; the Appalachicola-Chattahoochee-Flint River System; and the Boston Metropolitan Area System, Lettenmaier, et. al. (1998). These studies provided the following valuable insights regarding the robustness, reliability and resiliency of managed water systems under various climate scenarios. These scenarios are summarized in **Box 8-2**.

Box 8-2: Valuable Insights

• The first is that most adequately managed systems can deal with all but the worst climate change scenarios. Efficient water management, however, is a prerequisite for, and the key to effective adaptation to climate change.

• Second, water resources is but one component of a larger socioeconomic setting which has many other compensating mechanisms that act to further reduce societal and economic vulnerability to climate change.

• Third, the general circulation model scenarios produce such widely varying results that it is simply impossible to develop a tailored, cost-effective adaptation strategy when it is not known whether there will be more or less runoff in a particular river basin in the future.

• Fourth, adaptive management is the keystone of effective water management, and is virtually in agreement with a “no regrets” adaptive strategy.

This continuous mode of adjustment serves to introduce new technologies, data, management practices and rules that serve to constantly balance demand with available supply. Well-organized institutions are the key to effective adaptive management. These practices must be more widely disseminated in developing nations as part of a persistent and directed campaign to improve water management (Stakhiv, 1998).

B. WATER DEMAND FORECASTING

1. Overview. Forecasting water demand is no simpler than forecasting any other type of demand. Moreover, the intricate relationship between water supplies and water demand can complicate matters. Forecasting serves several short-term and long term purposes. These are summarized in **Table 8-6**. Both short-term and long-term demand forecasting play a role in integrated water resource planning models.

Table 8-6
Purposes Served by Forecasting

Type of Forecast	Purpose
Short Term	1. Facilitates financial planning and management. 2. Projecting revenues to assess if and when a rate change is needed. 3. Estimating cost of service and setting rates. 4. Risk management.
Long Term	1. Plays a role in developing a long-term financial strategy for the water supplier. 2. Planning the water system. 3. Setting objectives for rates and policy.

2. Methods.

a. General. Numerous methods of forecasting are available for general planning and policy analysis purposes. Good demand forecasts are of central importance in project design and resource planning. Gardiner and Herrington, (1986) suggest three main types of forecasts; (1) judgmental, (2) causal, and (3) extrapolative. The judgmental forecast is based on personal or group knowledge. It may be purely subjective or an adjustment of a more formal forecast. The causal forecast is based on the examination of the causal relationships which influence water demand. The extrapolative forecast is based on the extension of past trends into the future and is based on past levels of water demand and may involve some form of time series analysis, McDonald and Kay (1988). There are also methods specifically designed for forecasting water demand during periods of drought, Dziegielewski, et al. (1983). For additional information on drought, see Chapter 7 of this handbook. The three approaches to forecasting covered in this chapter: Extrapolation of Time-Series Data; Statistical, Econometric, and Stochastic Models; and End-Use Methods, are described below.

b. Extrapolation of Time-Series Data.

(1). Analysts using the extrapolation method place great faith in historical demand patterns to predict future demand patterns. Estimating future demand this way usually assumes linearly or slightly curvilinear growth in demand and makes no attempt to predict deviations of a significant magnitude. One of the key problems with this method is that the period of demand used as the basis for extrapolation greatly affects demand projects, even from year to year. Unless the pattern of demand is particularly stable, using a long time series of data does not necessarily yield more reliable results. Frequent adjustments to the forecast may be required, and planning may be greatly hindered. Clearly, the different projections of water demand would lead planners to draw different conclusions about the need for supply adjustments.

(2). Another conceptually simple routinely used approach is to estimate water use (Q_t) at a future time (t) by multiplying the future population (P_t) by a per capita water use rate (r_t) as follows:

$$Q_t = r_t P_t$$

The per capita water use rate can be assumed constant or projected to change over time based on historical water use data. Per capita water use rates can be estimated based on water use records for a particular city, or alternatively, regional or national use rates can be obtained from literature.

(3). Per customer or per connection methods are a variation of the per capita approach. Future water use is the product of the projected number of customers and a projected value of water use per customer. This approach is most frequently used in conjunction with sectorally disaggregate forecasts, where water use per customer coefficients are estimated for each customer class. Thus, water use forecasts can reflect varied growth rates among the customers.

(4). Extrapolation is unconcerned about the factors underlying changes in water demand. The method is especially weak with regard to changes in different components of water use. One study (Archibald, 1986) points out, for example, that extrapolation assumes continuous growth in all use categories, including leakage and other forms of unaccounted-for water, even though this assumption is not necessarily valid. Extrapolation also does not account for efficiency gained through innovation in technologies, economies of scale, management, planning, or even regulation.

c. Statistical, Economic, and Stochastic Models.

(1). Forecasts of water demand do not have to rely solely on the pattern of historical demand. Several modeling techniques allow researchers to make forecasts based on projections of explanatory variables that are known to correlate with water demand. The Corps of Engineers has identified six variations of this type of forecasting, Boland, et al. (1983). These are shown in **Box 8-3**. The first three are statistical methods that employ only single explanatory variables. Per capita methods use population only for predicting water use. As such, they are criticized for excluding other known factors influencing water demand and possible

Box 8-3: Six Variations of Statistical, Econometric, and Stochastic Models

1. Per capita
2. Per-connection
3. Unit-use coefficient
4. Multi variate requirements models
5. Demand models
6. Contingency tree (Probabilistic) models

differences among usage categories. The per-connection method is also limited to a single explanatory variable, but has the advantages of better data availability and a closer correspondence to the number of households in the utility service territory. Analysts using this method also can draw upon other research findings about household water consumption patterns, including case studies. Unit-use methods apply single explanatory variables, other than population size or service connections, to total water use or disaggregated categories, such as residential use. An example would be a method relating the number of manufacturing sector employees to industrial water use.

(2). Requirements models and demand models (the forth and fifth categories in Box 8-1) are both econometric (or multiple-coefficient) methods that incorporate more than one explanatory variable. Requirements models use variables that are significantly correlated with water use. Demand models incorporate price, income, and other variables while emphasizing economic theory, implied causality, and the statistical significance of coefficients. The development of a causal Econometric model of water demand, (Carr et al., 1990) is shown in **Table 8-7**. Because they provide a more comprehensive picture, multi variate models are usually regarded as more useful for planning purposes. These also may be more of less complicated, which in turn affects the degree of difficulty in acquiring and analyzing the necessary data. Moreover, multi variate forecast models require forecasts of the chosen explanatory variables, such as population projections. If the population forecast is off the mark, the forecast of water demand likewise will be off, to the detriment of planning.

(3). One way to consider uncertainty in forecasting is to use a stochastic or probabilistic approach (the sixth category in Box 8-1), such as a contingency tree or a "what if" analysis, in combination with another base forecasting method. A contingency tree takes into account different combinations of variables, based on different probability assumptions, making it possible to produce alternative demand forecasts. The result actually is a range of forecasts to which different probabilities may be assigned. In a sophisticated analysis, such as one using a simulation model, both supply and demand could be manipulated to arrive at alternative forecasts. This may be an especially useful tool in planning for the possibility of drought or other water shortages. Proposed measures to mitigate the effects of a shortage, such as rationing, could be incorporated within the model to assess their impact. Probabilistic methods tend to involve significant data and computational demands. While they may enhance planning efforts, they also add a high degree of complexity to the process. Advances in computer hardware and software, however, have made multi variate modeling more accessible and less expensive. In particular, computers make it easier for analysts to conduct sensitivity, contingency, and probabilistic analyses as well as simply to "explore" the available data. Each of the methods described by the Corps of Engineers has certain advantages. A single-coefficient method, for example, may serve the purposes of preliminary assessments. Probabilistic methods are too complex for this purpose but have advantages in terms of other planning criteria, especially in dealing with uncertainty. Data requirements and availability, however, depend on the particular forecasting application.

Table 8-7
Developing a Causal Model of Water Demand

(1)	Average-day residential water use	=	*f* (time).
(2)	Average-day residential water use	=	population x per capita use.
(3)	Average-day residential water use	=	*h* [(initial population + births - deaths + net migration) x per capita use].
(4)	Births	=	*j* (age distribution).
(5)	Deaths	=	*k* (age distribution).
(6)	Net migration	=	*l* (economic activity).
(7)	Average-day residential water use	=	[initial population + *j* - *k* + *l*] x per capita water use.
(8)	Per capita water use	=	*m* (marginal price of water, household income, climate factors).
(9)	Average-day	=	[initial population + *j* - *k* + *l*] x *m*.

d. End-Use Methods.

(1). The alternative approaches to forecasting water use include end-use or component methods that emphasize estimating different water use categories and adding these to arrive at an aggregate demand forecast. A range of values is sometimes used within components and for the aggregate amount. For example, four general categories of water demand used in an end-use study by the Severn-Trent Water Authority in Great Britain are; domestic, industrial and commercial, agricultural, and unaccounted-for water, Archibald (1986). Components of these major water demands are summarized in **Table 8-8**.

Table 8-8
Components of Water Demands

Water Demand	Major Water Components
Domestic	Personal Toilet flushing Clothes washing Dish washing Other appliances Outdoor
Industrial and Commercial	Domestic Processing Direct and Indirect Processing
Agricultural	Domestic Livestock Irrigation
Unaccounted-for water	Customer connections The distribution system Trunk mains Reservoirs

(2). In an end-use model, the different components of each general category are forecast according to expectations about that type of use. Domestic use, for example, may be affected by changes in plumbing codes or the degree of market saturation for different water-using appliances. The introduction of metering or an alternative rate schedule may affect the consumption patterns of industrial and commercial users. The availability of alternative sources (such as self-operated wells) might affect agricultural use. A leak detection and repair program could affect the unaccounted-for water category. In each case, the method can accommodate these expectations and produce a range of estimates that takes into account their effect on total water consumption. End-use methods also can accommodate changes in the behavior of water users or technologies they use, such as installing low-volume toilets in a housing development or implementing water recycling at an industrial plant.

e. Summary. The best approach to water demand forecasting may be a hybrid approach that provides the policy analyst with a means of verifying the validity and reliability of the models and resulting forecasts. This is particularly important when data may be insufficient. Further, the use of any stochastic technique that allows the planner to assess alternative contingencies is likely to enhance planning capabilities. **Table 8-9** (George, 1985) compare’s time-series, econometric, end-use, and hybrid forecasting techniques in terms of certain advantages and disadvantages.

Table 8-9
Comparison of Alternative Demand Forecasting Methods

Forecasting Methods	Advantages	Disadvantages
Time-Series	• Minimal data requirements. • Low cost. • Forecast accuracy generally good in short run. • Can predict seasonal and daily patterns.	• Does not treat underlying factors explicitly. • Not useful for policy analysis. • Accuracy low in the long run.
Econometric	• Explicitly models underlying influences on demand. • Based on explicit theory of consumer behavior. • Less date-intensive than end-use models.	• High skill level required to develop models. • Difficult to address or impossible to identify individual variable impacts.
End-Use	• Good policy-analysis capabilities. • Relatively understandable.	• Often lacks endogenous behavioral component. • Data-intensive. • Costly.
Hybrid	• Better behavioral component than pure end-use models. • Better policy analysis capabilities than most econometric models.	• Date-intensive. • Costly. • Ad hoc nature can make interpretations difficult. • Can lack efficiency and elegance.

3. Data Requirements for Demand Forecasting.

a. Data Used in Demand Forecasting. Regardless of what is being modeled (requirements, demand, or end-use) and whether or not a stochastic approach is being incorporated, econometric modeling requires a set of explanatory variables. **Table 8-10** (adopted from NRRI, 1991) provides some of the variables that may be used in projecting future water needs for a given locality or water utility service territory. Each variable is thought potentially to affect water demand. Analysts, of course, choose a set of explanatory variables that they believe are the best predictors. Four major categories are identified: resource's utilization, socioeconomic, cultural/institutional, and water systems.

Table 8-10
Data Used in Demand Forecasting
(Continued on Next Page)

Category	Subunits	Variables
Resource Utilization	Land use	• Proportions of land in various use categories (e.g., urbanization, cropland, and woodland) • Agricultural production • Recreational uses
	Water use	• Water use by self-supplied industry • Water use by agricultural sector • Recreational uses • Irrigated areas
Socioeconomic	Demographic	• Population, number of households, number of connections, number of users, etc. • Household size • Characteristics of the population (e.g., age distribution)
	Economic	• Income level (persons or household)s • Assessed value of residential properties • Size of residential properties • Number of commercial and institutional establishments • Value of commercial receipts • Employee productivity • Price elasticities for water demand
	Housing	• Housing density • Type of hosing • Construction grading • Size of lots • Connections to a public sewer
Cultural / Institutional	Cultural	• Consumer preferences, habits and tastes • Acceptability of demand reduction measures by consumers • Cultural constraints or incentives • Consumer education • Policy variables
	Legal / political	• Legal barriers to implementation of alternatives • Political constraints and opposition • Historical experience

Table 8-10
Data Used in Demand Forecasting
(Continued)

Category	Subunits	Variables
Water Systems	Operational	• Historical water use • Total treated water • Total delivered water • Daily reservoir levels
	Technological	• Inspection and repair of faulty plumbing • A leak detection program • Efficiency of eater-using fixtures and appliances • Distribution pressure • Supply reliability • Allocations of water of differential quality • Industrial processes and applications • Industrial water reuse, recycling and recirculations
	Costs and Revenues	• Operation and maintenance costs of water-supply system • Investment and operation-maintenance costs for alternative water-supply sources • Water and sewer revenues (aggregated and by customer class) • Water and sewer rate structures • Width and level of price blocks

b. Variable Considerations Used in Demand Forecasting. Water planners are increasingly aware of some variables that are difficult to quantify but that may have a significant effect on water consumption and thus on determining both average and peak demand in both the short term and the long term. Prasifka (1988) suggests the factors, displayed in **Box 8-4,** should be considered. There are numerous potential sources of data for use in water demand forecasting (Boland, 1983). The water supply utility itself can provide essential data to the water planner. The National Weather Service, other Federal agencies, and universities can provide climate and weather data. In addition, demographic and socioeconomic data are available from the U.S. Department of Commerce and the Bureau of the Census as well as state and local planning, economic development, and tax assessment agencies. End-use data are more costly and require a well planned and often time-consuming research effort; the same is true for attitudinal data on consumer acceptance issues, as might be collected through a customer survey. Consultants and universities sometimes generate these types of data. For some forms of contingency analysis, it may be appropriate to use hypothetical data for certain variables, such as weather, in order to generate alternative scenarios.

Box 8-4: Variable Considerations Used in Demand Forecasting

- Fluctuations in rainfall.
- Variations in lawn irrigation demands associated with differences in residential housing density.
- Differences in greenbelt irrigation requirements and in the availability of untreated or reclaimed water for these needs.
- Differences in the degree to which structural and nonstructural water conservation measures have been implemented in the area.
- Variations in person per household.
- Effectiveness of public education programs to increase consumer awareness.
- Intensity of construction activity, such as grading and site work.

C. DEMAND FORECASTING MODELS

1. Introduction. As documented by Wurbs (1994), a tremendous amount of work has been accomplished during the past thirty years in developing computer models for use in water resources planning and management. The one model most closely associated with demand forecasting is IWR-MAIN. While the details of this program is provided below, additional information is provided in Appendix E and Chapter 6, Paragraph C.

2. IWR-MAIN.

a. Background. The IWR-MAIN Water Use Forecasting System is a software package which provides a variety of forecasting models, socioeconomic parameter generating procedures, and data management capabilities. The acronym "IWR-MAIN" stands for "Institute for Water Resources-Municipal and Industrial Needs." The IWR model was originally based on the MAIN model developed by Hittman Associates, Inc., in the late 1960's for the U.S. Office of Water Resources Research, which in turn was based on earlier work by Howe and Linaweaver (1967) and others. In the early 1980's, the Institute for Water Resources (IWR) adopted and modified MAIN and renamed the revised model IWR-MAIN. During the 1980's, IWR-MAIN evolved through several versions representing major modifications. Version 5.1 documented by Davis et al. (1991) has recently been replaced by Version 6.1. IWR-MAIN has been applied to a number of cities throughout the United States.

b. Explanation of Model.

(1). IWR-MAIN is a flexible municipal and industrial water use system. Forecasts are made for average daily water use, winter daily water use, summer daily water use, and maximum-day summer water use. IWR-MAIN provides capabilities for highly disaggregated forecasts. Water requirements are estimated separately for the residential, commercial/institutional, industrial, and public/unaccounted sectors. Within these major sectors, water use estimates are further disaggregated in categories such as metered and sewered residences, commercial establishments, and three-digit SIC manufacturing categories. A maximum of 284 categories of water use can be accommodated. Most forecasts, however, utilize approximately 130 specific categories.

(2). IWR-MAIN contains a procedure for estimating the water saving effectiveness of water conservation (demand management) programs. Conservation parameters obtained from literature sources are provided for in 14 separate measures. The impacts of one or more proposed or previously implemented conservation measures in the water service area are computed based on 1) estimates of the expected reduction in the uses of water affected by conservation, 2) the market coverage of conservation practices, and 3) expected interactions among measures that are implemented together.

(3). Preparation of an IWR-MAIN water use forecast requires two separate actions; 1) verification of the empirical equations and coefficients for estimating water use and 2) projection of future values of determinate's of water use. Model verification is accomplished by preparing independent estimates of water use for one or more historical years and comparing these estimates with actual water use conditions. If necessary, the model can be calibrated. The base year is the year from which values of explanatory variables are projected. One or more subsequent years are selected as the forecast years for which water use is predicted. Future values of water use determinants can be developed externally or can be generated by growth equations built into the program.

c. Update of Model. The recent Version 6.1 of IWR-MAIN include a module called the integrated water supply and demand plan. Capabilities are provided for selecting a least-cost combination of water supply and demand management alternatives, in response to deficits between baseline forecasts of water use and expected yields of supply sources. Tradeoffs can be evaluated between the investment in long-term demand and supply management alternatives and the costs of coping with periodic shortages of supply during drought conditions.

3. Agricultural Water Requirements. The U.S. Bureau of Reclamation (1991), describes 14 computer models categorized as water requirement models. These models deal with estimating evapotranspiration and crop water requirements and managing irrigation. Most of the models were developed by the Bureau of Reclamation. Some are site specific, but most are generalized for application to various locations. Information on these models can be obtained by contacting the Bureau of Reclamation, U. S. Department of the Interior, P.O. Box 25007, Denver, Colorado 80225.

D. INTEGRATED WATER SUPPLY AND DEMAND

1. Introduction. A new category of planning model has emerged with the capability to address the balancing of water supply and water demand providing a more holistic view of water management. Unique, regionalized models are developed to address the needs of a specific system. One model (WEAP) was found that provides a comprehensive framework for water resources assessment. Additional information on WEAP is contained in Chapter 6, Paragraph C and in Appendix E.

2. WEAP.

a. Background. The Water Evaluation and Planning System (WEAP) model, is an integrated water supply and demand modeling system which serves several purposes including data base management, forecasting, and analysis. WEAP provides a data base system for maintaining water demand and supply information. It provides capabilities for forecasting water demand, supplies, flows and storage over a long-term planning horizon. It is a simulation model for evaluating alternative water use scenarios and management strategies. The model can also be used to perform various types of analyses including sectoral water demand forecasts, supply source allocation, stream flow and reservoir storage simulation, hydropower forecasts, pollution loading estimates, and benefit-cost analysis. Operating on the basic principle of water account balancing, WEAP can be applied to single or multiple interconnected river systems at the city, regional or national level. WEAP was developed by the Tellus Institute, which is a team of scientists, planners, and policy analysts organized into a nonprofit research and consulting organization. The Tellus Institute serves as the Boston Center of the Stockholm Environment Institute, an international organization based in Sweden. The 1993 version of the WEAP model (Tellus Institute, 1993) expands the original 1990 version and continues to be refined. WEAP has been applied in studies in several countries.

b. Explanation of Model. WEAP runs on MS-DOS based microcomputers in an interactive menu-driven mode. A summary of the modules or programs is provided in **Table 8-11**.

Table 8-11
Water Evaluation and Planning System

Programs	Description
Setup	Characterizes the problem under study by defining the study time period, physical elements comprising the water demand-supply network, and their spatial relationships.
Demand	Forecasts water demands for various water uses defined in the study. Projected water demands determined in this program are passed to the next programs (distribution, supply, and evaluation) for further processing and analysis. The demand program uses the following hierarchical branching structure to manage data. • Sector - (example agriculture) • Subsector - (type of crop) • Enduse - (water requirements for different soil conditions) • Device - (irrigation techniques)
Distribution	Converts the annual demands developed in the Demand Program into monthly supply requirements by incorporating monthly variation coefficients, distribution loses, conveyance capacities, and reuse rate for each demand site.
Supply	Simulates the spatial and temporal water allocations between supply sources and demand sites.
Evaluation	Provides capabilities for comparing and evaluating alternative water use scenarios and management strategies in terms of physical demand and supply, environmental impacts, and economic benefits.

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CHAPTER 9: DECEMBER 1998
MANAGEMENT OF WATER CONTROL SYSTEMS

A. OVERVIEW

1. Introduction. The U.S. Army Corps of Engineers (Corps) operates more than 500 dam and reservoir projects constructed under the Army's Civil Works water resources program. A listing of these projects and detail authorization information is contained in "Authorized and Operating Purposes of Corps of Engineers Reservoirs," (Corps, July 1992). The water control mission of the Corps is to regulate river flow with these projects to provide national benefits of flood control, navigation, hydroelectric power generation, water supply, erosion control, environmental enhancement, and other authorized purposes. Water control plans are developed to guide project regulation activities. Those activities involved with developing water control plans, gathering and processing data in support of regulation decisions, and regulating the reservoirs in accordance with water control plans are collective referred to as "Water Control Management" (HEC, 1995). Specific Corps guidance is contained in EM 1110-2-3600 (Corps, 1987) and ER 1110-2-240 (Corps, 1994).

2. Water Control Data Systems. The Water Control Data System (WCDS) is the Automated Information System (AIS) that supports the Corps' water control mission including the hardware, software, manpower, and other resources required to acquire, develop, maintain, operate, and manage the system. The WCDS includes the collection, acquisition, retrieval, verification, storage, display, transmission, dissemination, interpretation, and archival of data and information needed to carry out the water control mission of the Corps. Typically this data and information include hydrologic, meteorologic, water quality, and project data and information. The system automatically collects data continuously from thousands of sensors throughout the nation. In addition, the system gathers and stores spatial satellite and radar imagery, graphical products, text products, and lab and field analyses of chemical, physical and biological samples. The system through its software incorporates this data and information into various user products and system outputs. The WCDS is a nationwide integrated system of hardware and software that allows user access to virtually any data and information in the system. A suite of software gives users the ability to display, manipulate, disseminate, interpret, and transmit this information throughout the Corps and to numerous other interested users (HEC, 1995).

3. Objectives and Principles of Water Control Management.

a. General. The prime objectives of the Corps' water control management plan (Corps, 1987) are to first conform with specific provisions of project-authorizing legislation and second to conform with all general-authorizing legislation (e.g., the Fish and Wildlife Coordination Act, PL 85-624; the National Environmental Policy Act of 1969, PL 91-190; the Clean Water Act of 1977, PL 95-217; etc.). A general prime requirement in project regulation is the safety of users of the facilities and the general public, both at projects and at downstream locations. The development of water control plans and the scheduling of releases at projects will be coordinated with appropriate agencies or entities, as necessary to meet commitments made in planning and design.

b. Regulation of Single Purpose Reservoirs. When reservoirs are authorized for a single purpose, their operation must be for attainment of that purpose (Corps, 1987). Flexibility, however, is allowed in order to produce significant benefits for other purposes, e.g., flood control, water quality, recreation, power or other attainable goals as long as these goals do not compromise the authorized project purpose. For single purpose projects with uncontrolled outlet works, there is no mechanism to regulate the flow, and accordingly, no mechanism to allow for changed conditions or to operate for multipurpose objectives. While it is unnecessary to prepare detailed regulation schedules for this type of project, it is necessary to define the uncontrolled operation and prepare water control documents to show its effect on downstream control and its relationship to other projects in the system.

c. Regulation of Multipurpose Reservoirs. More than one water management goal or objective can be accommodated in a multipurpose reservoir, or system of reservoirs (Corps, 1987). The degree of compatibility for each of the water uses depends upon the characteristics of the river system, water use requirements, and the ability to forecast runoff. The blending of all the specifically authorized purposes with other desirable project outputs are all reflected in the water control plan. In many cases, the uses are somewhat conflicting, and some degree of compromise is required to achieve the water management goals. There is, however, a generally recognized priority for each of the major uses under which the defined project benefits are assured to the greatest extent possible. The balancing of water use demands and priorities are defined in the water control plan.

B. DEVELOPMENT OF WATER CONTROL PLANS

1. Introduction.

a. General. Throughout the life of a water resource project it is necessary to define the water control criteria in precise terms at a particular time. This is necessary in order to assure carrying out the intended functional commitments in accordance with the authorizing documents (Corps, 1987). For this reason, documents related to water regulation are prepared during the various stages of project development to assure that the projects are regulated in accordance with the design criteria and agreed upon procedures. Throughout the nation, the variety of projects and conditions related to water control makes it impossible to develop a single set of water management rules which apply to all projects. Nevertheless, for all projects there is an overriding requirement that methods used in developing water control plans be performed in accordance with general principles and guidelines established as consistent policy for all projects.

b. Water Control Plans. The water control plan addresses the needs and methods for determining a plan of regulation considering all water management goals, (functional, environmental, social and aesthetic), as well as various techniques, organizations, systems and facilities involved in the regulation of water projects (Corps, 1987). The organization and staff required to carry out water control functions are also dealt within the water control plan. Each river basin development and Corps office has its own unique circumstances and meets its own staffing and organizational requirements for water management activities. Regulation of projects must consider all aspects of the conditions of the rivers and projects, as well as at downstream locations. Many of the functional uses have far-reaching effects on water related systems involving major industries, utilities, and agricultural developments, which are dependent in some degree upon the utilization of the water resource. Furthermore, project regulation has significant effects on the use of the waterways by the general public in relation to environmental and aesthetic considerations.

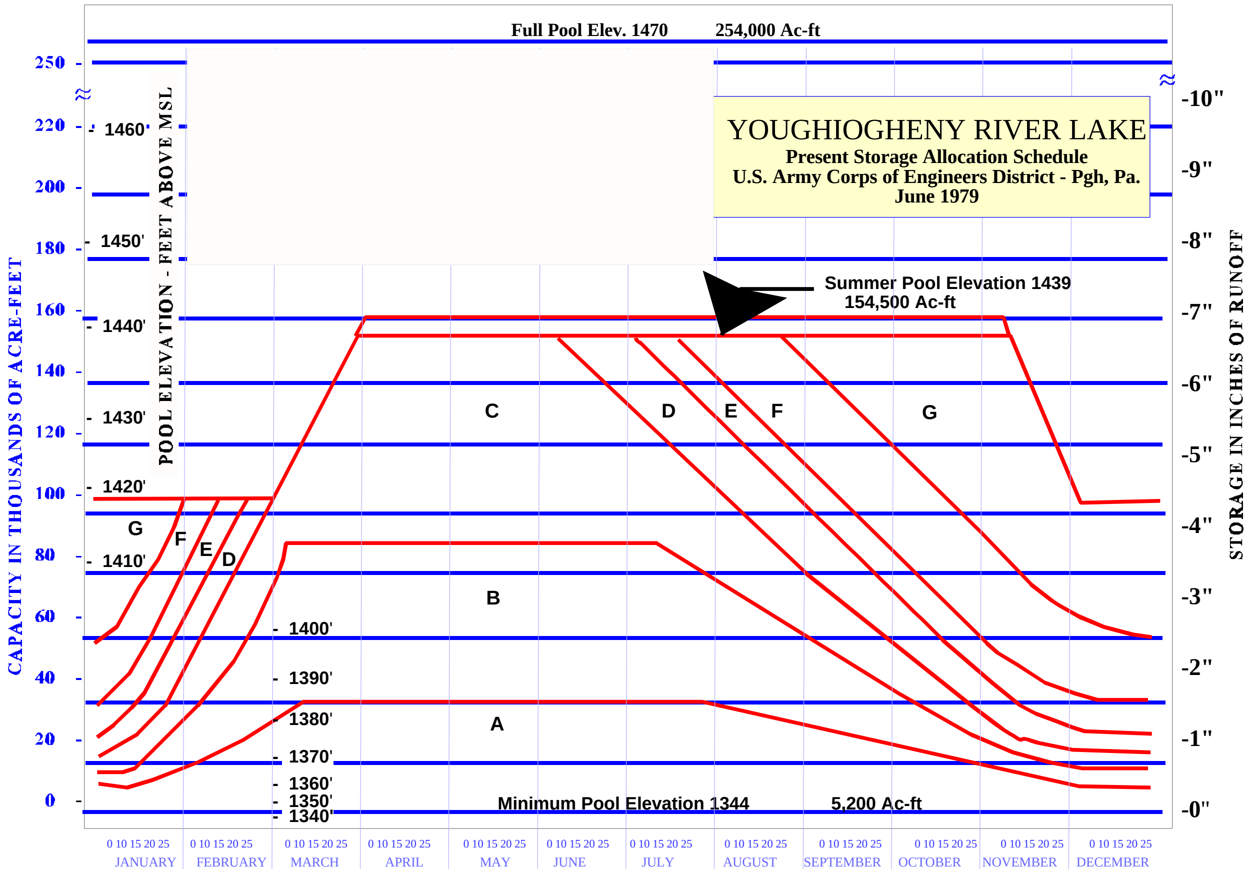
2. Development of Regulation Schedules and Water Control Diagrams.

a. Water Control Diagram. A water control diagram represents a compilation of regulation criteria, guidelines, guide curves and specifications that govern basically the storage and release functions of a water resource project. An example of a water control diagram is shown in **Figure 9-1**. These diagrams indicate pool levels and limiting rates of project releases required during various seasons of the year to meet all functional objectives of the particular project, acting separately or in combination with other projects in a system. Water control diagrams are an important element of the water control plan in that they provide the technical guidance and specific rules of regulations that are mandated as the result of studies and the review and approval processes in the planning, design, and operational phases. The diagrams, however, are only a part of the overall water control plan, which provides for adjusting project regulation on the basis of other factors that may develop in actual operation as the result of unique hydrometeorological conditions, changing water control requirements, and other factors which may influence current project regulation.

(1). Explanation of Outflow Chart. This table show the release that should be made under different conditions. For example, if the reservoir storage is in Zone "B" and the flow in Connellsville is between 100 and 300 cfs, the release should be 250 cfs.

(2). Explanation off Runoff Scale. The "Storage in Inches of Runoff" scale helps operators determine whether there is enough available storage to capture recent or threatened runoff. For example, suppose it was May, and the Lake was at the normal Summer Pool Elevation, 1439. The runoff scale shows that there is more than 3" (10+" -6.8") of available storage between the summer pool and the full pool. This is true runoff. The conversion between measured precipitation and runoff is made from experience, measured soil saturation, and expected evaporation based on cloudiness.

b. Assessments of Changed Conditions. Preparation of the water control plan (Corps, 1987) and the documentation of that plan in the water control manual must be undertaken based on current knowledge of conditions regarding river basin management, and the manual should be completed by the time the project becomes operational. These manuals must undergo periodic review and update to incorporate current concepts and conditions which include additional or new hydrologic



Source: Management of Water Control Systems, U.S. Army Corps of Engineers, HQUSACE, EM 1110-2-3600, 30 November 1987

Figure 9-1. Water Control Diagram

data and a reevaluation of any water control requirements. Besides the addition of possible new requirements, there is always a need for a periodic review of flood control regulation parameters, often required because of changed conditions with respect to seasonal downstream channel capacities, possible downstream development adjacent to the river channel, and changed economic values for flood protection.

c. Integration of Basic Seasonal Flood Control Guide Curves with Other Objectives. Development of water control diagrams (Corps, 1987) must be compatible with all water control objectives. In many reservoir systems, the multipurpose functions are compatible for joint use of the reservoir storage space, and the allocated storage space and project capabilities for all joint use functions are determined from reservoir system analysis studies. In many instances, however, storage capacity or water supply available from storage release and natural flow often is not sufficient to provide fully for all the desirable functions. Development of regulation schedules under these conditions results in a semidependence between purposes and requires that secondary consideration be given to other related functions when schedules are being developed for a specific purpose. When developing flood control guide curves with other objectives of the project, there are three separate classifications that must be considered. While these may not be present in any one project, the water control manager must be aware of their individual characteristics. These classifications and guide curve requirements are summarized in **Table 9-1**.

Table 9-1
Development of System Analysis Studies for Multipurpose Uses

Classification	Requirement of Guide Curves
Hydropower	• The month-by-month reservoir schedule and operating limits for each project as required for system power regulation. • The plant and power system capability as related to the sale of electrical energy. • The regulation of each project in the system to meet its proportional share of the electrical power system load, in conjunction with all other water management requirements.
Other functional use requirements	• To define the upper and lower limits of reservoir regulation for each of the functional use requirements as well as flood control. • Limits are usually defined as seasonally variable guide curves, which are inviolate in actual operation except as necessary to meet the specific functional goals set forth in the planning and design phase. • Usually generalized for application to all years and would thereby account for future variable hydrologic and operating conditions anticipated from the system studies. • In some cases developed individually on a year-to-year basis in order to account for specific operating criteria as defined for that particular year.
Environmental, Social and Aesthetic requirements	• May be in the form of generalized relationships and rules which apply to all years of future regulation. • May be specifically developed for a particular year or season and are changeable from year-to-year. These guide curves may be in the following form: - Storage required on a seasonal basis in conjunction with other functional water uses. - Minimum project releases which may vary seasonally or as a function of water in storage which is usable for downstream release and surplus to other needs. - Rates of change of discharge or water surface elevation, either at the project or at a point downstream. - Special short-term releases for a particular environmental or aesthetic need.

3. Testing of Water Control Plans.

a. General. Water control diagrams (Corps, 1987) are usually developed on a "hindsight" basis, using historical streamflow data, and with full or partial knowledge of runoff events that may be used in adjusting the criteria to best achieve the water management objectives. In actual operation, the runoff sequence will never duplicate those of the historical record. It is desirable, therefore, to test the guide curves and other criteria on the water control diagram using independent data, in a manner similar to actual operation. The data used for input may be historical data other than those used in developing the schedules, or it may be independently derived by statistical stochastic methods or from hypothetically derived streamflow, design floods, etc.

b. Long-term Water Utilization Analysis. Testing guide curves and other criteria on the water control diagram for long-term water utilization should be performed for those projects or systems which involve water use purposes, such as hydropower, M&I water supply, water quality control, etc. The tests are performed using system analysis techniques and generally use mean monthly streamflow data and monthly regulation criteria. The system regulation should usually be tested on data independent from those used in establishing the regulation criteria. For those projects where the water control plan uses forecasts of seasonal runoff volume as one of the parameters, the simulations should be based on forecasts of runoff volumes which have been derived from available hydrometeorological data. The simulations developed from these tests will reflect the errors in forecasting seasonal runoff volume and, accordingly, provide a realistic appraisal of system regulation under actual operating conditions. (Corps, 1987)

4. Constraints on Water Control Plans. The physical size and capacity of water control structures and other conditions that exist at the time of project design, certainly impose limitations and boundaries on water control capabilities, but are not considered to be constraints. A constraint is a condition that arises subsequently to project design that prevents (or is allowed to prevent) the achievement of a water control objective (Corps, 1987). Constraints may result from physical, social or economic impacts on residual, agricultural, industrial or environmental areas that are affected by the water control capabilities of a project. These constraints are summarized in **Table 9-2**.

Table 9-2
Constraints on Water Control Plans

Category	Constraint
Incomplete Project Development	- Inadequate, vague or complete lack of easement acquisition that prevents full use of storage space, or flowage downstream of water control structures.
	- Downstream channel capacity used for design is not provided.
Beyond the Scope of Design	- Encroachments in the flood plain downstream and in areas upstream of water control structures impose restrictions on utilization of authorized storage space and release schedules.
	- Attenuation of flows by control structures often permits and encourages low lying lands to be cleared and used, which reduces the nondamaging channel capacity.
	- Near bankfull flows and near constant pool levels for prolonged periods may increase erosion, requiring reduced or fluctuating releases and a change in pool levels.
	- Seasonal drawdown may be restricted due to development of mud flats in reservoir.
	- The time of inundation of roads and railroads may be highly restrictive on transportation and prolonged inundation in marina areas may severely hamper recreation activities.
	- The time required to notify the public may delay implementation of a release schedule during flood emergencies.
	- Earthquake potential or embankment boils may restrict or prevent use of authorized storage capacities, or structural deterioration may require reduced discharge capacities to ensure project integrity.
	- Structural rehabilitation may require significant but temporary changes in release schedules.
	- Point or non-point pollution and stratification can degrade water quality and render it unsuitable for other instream purposes.
	- Meteorological forecasts that are unauthorized may be inaccurate and may mislead the public concerning potential impacts on Corps projects.
	- Conservatively high hydrologic forecasts issued by the NWS can mislead the public, causing the public to question Corps releases and to seek water control action that is inappropriate.
	- Frequency of filling and runoff volume may increase at impoundments over pre-project conditions, requiring higher release rates from reservoirs and additional pumping capacity at local protection projects.
	- An extreme low flow event may occur that is more severe than the hydrologic record when the project was designed, which detrimentally impacts conservation purposes by restricting releases for instream use.

C. WATER CONTROL DATA SYSTEMS

1. Basic Requirements. The effective management of water control systems is dependent, in part, upon knowledge of current project and hydrologic conditions, project capabilities and restraints and water control elements in the river system that effect streamflow, water level, and water quality. The water control data system must be designed to meet the specific needs of the water control manager. The data system must include facilities to perform the functions (see **Box 9-1**). Requirements for management of water control data systems are contained in ER 1110-2-249 (Corps, 1984).

Box 9-1; Basic Requirements of a Water Control Data System

- Observation and storage of data at field stations
- Transmission of data from field stations
- Decoding and validation of transmitted data
- Storage and retrieval of data in a database
- Management of a water control database
- Providing graphical and tabular data displays
- Exchanging data with other users

2. Master Plans. Master plans for water control data systems are prepared in conformance with ER 1110-2-240. In general, master plans include all the essential information that set the requirements, justification, scope, and recommended procedures for implementing water control data systems. The procedures to be included in master plans are summarized in **Box 9-2**. The master plan is prepared by Division water control managers based on detailed studies of communication alternatives as well as all other aspects of the overall water control data system requirements. Because of the rapidly advancing technology, there is no one established method or standardization of design for a water control data communication system.

Box 9-2; Master Plans

In general, master plans include all the essential information that set the requirements, justification, scope, and recommended procedures for implementing water control data systems. Accordingly, they:

- Outline the system performance requirements, including those resulting from any expected expansions of Corps missions;
- Describe the extent to which existing facilities fulfill performance requirements;
- Describe alternative approaches that will upgrade the system to meet requirements not fulfilled by existing facilities, or are more cost effective than the existing system;
- Justify and recommend a system considering timeliness, reliability, economics and other factors deemed important; and
- Delineate system scope, implementation schedules, proposed annual capital expenditures by district, total costs, and sources of funding.

3. Water Control Data Management.

a. Data Observation. A majority of the data input into the water control data collection system is time-variable data. They represent observations of the conditions of water regulation at various projects, water levels and water quality in the river system, and those hydrometeorological elements that affect any of these conditions or elements. The time-variable data observed and collected may be classified in three broad categories as summarized in **Table 9-3**. (Corps, 1987)

b. Data Transmission. Single project river development systems, or multi project systems which are relatively small and involve only Corps projects, require much less complicated communication and data handling facilities than large, complex river developments. Manually based and semiautomatic data handling systems may be entirely adequate for the small river systems, but handling data in this manner is generally inadequate for larger systems which makes the installation of an automatic system a necessity (Corps, 1987). In recent years, full automation of field station reporting has replaced manual and semiautomatic transmission equipment in many areas. There are five automatic data transmission media available; ground based VHF radio, environmental or general purpose communication satellites, meteor-burst communication systems, land line equipment utilizing hard wire or switched commercial telephone circuits, and general purpose microwave communication systems. In general, any or all of these media may be used either singularly or in combination. Additional information on these transmission media is outlined in EM 1110-2-3600.

Table 9-3
Time-Variable Data

Variable	Description
Hydrometeorological Data	- Function is to provide current information by direct observation on all significant elements that affect runoff within a drainage basin or river system. - Elements that may be observed are: • Water levels in rivers, lakes, and reservoirs. • Precipitation as measured at ground stations or as estimated by radar, satellites, or other sensors. • Air temperature as measured at ground stations or by upper air atmospheric soundings. • Pan evaporation as measured at project sites. • Snow sensors or snow courses which measure the depth and water equivalent of the incremental snow accumulation, and/or the total accumulation of snow in the snowpack, as determined from ground measurements or remote sensors. • Snow covered area as determined from aerial or ground reconnaissance, or by remote sensors from satellites or aircraft. • Conditions of river ice, as measured at key locations to determine ice thickness and locations of ice jams. - Observations may also include measurements of soil moisture, soil temperature, and ground water and include atmospheric measurements of humidity, wind speed, wind direction, and solar radiation.
Project Data	- Hydrologic data (somewhat included in the above hydrometeorological data). - Spillway and outlet gate positions. - Power unit status and hourly power generation. - Navigation lockages, fish counts and other water control parameters.
Water Quality Data	- Essential for real-time water control management. - Field sampling and analysis of temperature, conductivity, dissolved oxygen, pH, and turbidity. - Laboratory analysis for other parameters provides data that, once evaluated, are available for support of real-time water control management. - In-situ monitors are used at projects requiring frequent water quality data for making operating decisions or to monitor their effects in terms of meeting operating objectives.

c. Coordination of Data Collection and Exchange. Nearly all water control data systems require coordination with other agencies to collect the necessary hydrologic data. The agencies which the Corps may need to coordinate with and their primary responsibilities are summarized in **Table 9-4**. In addition to these Federal agencies, state, local and private organizations may also obtain water control data needed for the operation of their individual projects. Data exchange is summarized in **Table 9-5**. For all intra-Corps and inter-agency transfers, the data should be transferred in an approved standard format. (Corps, 1987). The current adjusted format for such data transfers is the Standard Hydrological Data Exchange Format (SHEF).

Table 9-4
Water Control Management Agencies for Coordination

Agency	Data Collected
National Weather Service	Various hydrometeorological data from surface observations and satellite sensors.
U.S. Geological Survey	Water levels, streamflows, and water quality.
U.S. Soil Conservation Service	Snow water equivalent and related hydrologic parameters.
National Aeronautics and Space Administration	Data which expresses the areal extent of hydrologic elements such as snow cover, area of flooding, or soil moisture indexes as determined primarily from satellite measurements.
U.S. Department of Interior	Hydrologic and water control data.
U.S. Department of Energy	Certain types of hydrologic and power operational data needed for hydropower system operation.
Tennessee Valley Authority	Project related hydrologic, water control, and hydropower data.

Table 9-5
Data Exchange

Type	Discussion
Intra-Corps	Data exchange between Corps offices should make use of available data communications with the agency. Real-time data transfers should use dedicated communication circuits between District/Division offices. An economic analysis should be performed to evaluate when separate dedicated circuits would be appropriate compared with a shared dedicated or switch (dial-up) circuits.
Inter-Agency	Depending on the volume of data and relative location of each office, dedicated or switched circuits may be used for data transfers to other agencies.

D. MANAGEMENT OF WATER CONTROL PROJECTS

1. Basic Considerations.

a. General. During daily water control management activities, special situations or unanticipated conditions may arise. This requires that a certain degree of flexibility be maintained to depart from normal operating criteria, if necessary. However, any decision to depart from specified criteria must be approved by the Division Commander and be based on a thorough knowledge of current conditions and management goals as specified in ER 1110-2-240. In addition to the problems related to normal functional use of the projects, a water management office is often requested to perform a variety of miscellaneous regulations for special purposes such as maintaining water levels on a short-term bases for construction activities in the downstream waterway; maintaining flows for rafting, white water canoeing or river drifting; or regulating reservoir levels for improvement of wildlife habitat. All these conditions require judgmental decisions by the water control manager to adapt the operating guides to real-time management. The majority of these decisions do not have far-reaching effects on project regulation, and the decisions are approved as part of normal water management activities. However, some decisions may represent a significant departure from the water control plan or may create adverse impacts on future project regulation activities. If such is the case, recommendations for a particular operation will be referred to higher echelons for written approval as part of the decision making process. (Corps, 1987)

b. Appraisal of Current Project Regulation. Monitoring system regulation and scheduling future project regulation go hand-in-hand. The objective of monitoring project regulation is to verify that the current operation is proceeding according to the daily regulation schedules and in conformance with the regulation plan as defined by the guide curves and other regulation criteria (Corps, 1987). Each day the water control manager must appraise the current regulation by comparing actual and guide curve reservoir levels, together with the system demands for each of the functional uses. These comparisons provide the basis for analyzing regulation schedules to meet the future requirements of system regulation in concert with the operating guide curves. The guidelines for scheduling project regulation may be based on the conditions of streamflows and water levels either at downstream control points or at the project, as necessary to meet system demands. For a system of reservoirs operated together, the relative use of storage space for functional needs is defined by the operating guide curves. These guide curves must be analyzed on a daily basis together with the hydrologic and reservoir system conditions to meet the overall objectives.

c. Preparing Model Input Data. A generalized hydrologic and reservoir regulation simulation model requires various input data (Corps, 1987) and is summarized in **Table 9-6**. The project regulation criteria for each run must also be specified, which will conform to the general project regulation criteria contained in the water control plan. The water control manager prepares the specific regulation criteria for each run from knowledge of conditions as they exist and the normal or special regulation requirements. The main purpose of real-time system analysis studies is to provide the water control manager with the ability to simulate the proposed regulation and thereby anticipate the effects of operating decisions on future regulation. The simulations are based on the most complete knowledge of present and future conditions in order to analyze the effects on short- and medium-range time frames, to test the effects of various alternatives of regulation and expected weather conditions, and thereby to provide an objective and rational basis for making operating decisions and scheduling project regulation. The water control manager is, therefore, in constant touch with the actual current regulation and the projections of the regulation into the future. The computer system analysis techniques that are designed for this purpose can be operated interactively so that computed results are available in a very short period. This concept of real-time system analysis provides the opportunity to make repetitive trials of system regulation when conditions warrant. By performing these analyses routinely, the water control managers become completely familiar with the use of these techniques, so that when emergencies arise, they are able to make full use of these capabilities in a timely and efficient manner.

Table 9-6
Model Input Data

Type	Description
Non-variable data	Describes physical features such as drainage areas, watershed runoff characteristics for each component watershed, channel routing characteristics, reservoir storage and flow characteristics, and other physical parameters which define the system.
Initial condition data	Specifies current conditions of all watershed indexes, incremental flow routing values for watersheds and channels, and current reservoir lake elevations and outflows.
Time-variable data	Expressed as a time-series for representing hydrometeorological inputs and forecasts such as precipitation, air temperature, snowmelt and evapotranspiration functions, streamflow data, project regulation data, or other time-variable elements that affect runoff, project regulation and system requirements.

2. Decisions and Scheduling.

a. Need for Judgmental Determinations. While water control plans provide the general guidance for project regulation, they cannot describe the myriad of details that must be accounted for in daily regulation and project scheduling. The final decisions in formulating project schedules may, therefore, require the tempering of derived analytical values by the judgment and experience of the water control manager. Further, the analytical procedures are only an attempt to simulate the actual operation within the degree of the ability of the models to represent all processes, therefore, their results reflect uncertainties that may be evaluated in a subjective manner. On a broader scale, judgements may be required to "shade" the operation when conditions indicate a particular need, as for example, a mid-month adjustment in operating guide curves, which are specifically defined as month end values, and current analysis and projections indicate a probable change in conditions by month end. Modifications of guide curve operation must, however, be based on rational evaluation of runoff conditions that warrant such departures. When such modifications are made, the water control manager must be constantly alert to changed conditions that would require return to normal guide curve operation. (Corps, 1987)

b. Coordination and Scheduling. The management of nearly all river systems now involves multi agency or multipurpose input (Corps, 1987). See **Box 9-3** for various types of water control management agreements and plans. There are other types of input from agencies or entities outside of the Corps that is not based on formal operating procedures, but through voluntary informal arrangements. The many types of inputs covered by these operating arrangements and agreements has widely varying significance to scheduling the use of water on a daily basis, but all must be coordinated in a manner to meet the water management goals. The monitoring, coordinating, scheduling and evaluation of project regulation are normally performed on a daily basis, and the schedules usually represent an operating commitment for the ensuing 24-hour period. Although the projections of project regulation may provide longer-range outlooks, these outlooks are normally

Box 9-3; Water Control Agreements and Plans

Corps offices have the responsibility for managing projects under their jurisdiction. This responsibility is delegated to the working level through the water management functional elements within the operating office. The management of nearly all river systems now involves multi agency or multipurpose input. This input, which is usually obtained through direct communication between the requesting agency and the scheduling office, must be considered in formulating the project schedules. Some of the input is coordinated as provided for in various types of water control management agreements and plans, including:

• Interagency water control management agreements with power marketing authorities, fish and wildlife agencies, etc.;

• Electrical utility coordinated power operating plans and contractual agreements;

• Water control plans for non-Corps projects which involve flood control or navigation requirements;

• Water control plans for water regulation projects developed under international treaties; and

• Water compacts with state, regional, or local agencies or councils.

subject to change on a daily basis. It is required that all project regulation be accomplished within the operating constraints as specified in the project water control manuals. In times of flood or other types of emergencies, the project schedules must be revised as required to meet the flood regulation goals. In times of drought, contingency plans will be needed to assure that all flow requirements are met and reduction in releases are made as appropriate. The water quality aspects of project regulation requires a constant awareness of the fact that every regulation decision has an impact on the water quality of the lake and the area of influence downstream. To evaluate the impact of any operating decision requires input from as broad a range of relevant disciplines as possible. With this input the water control manager can make the best choice and derive the most benefit from the project and the resources he controls. (Corps, 1987)

c. Disseminating Regulation Schedules. Daily schedules and operating instructions must be transmitted from the water management office to each project office in a timely manner. The communication to Corps projects may be by telephone, teletype, or other electronic means. Disseminating flood control and navigation water regulation schedules to non-Corps projects is usually accomplished through the operating office of the project owner. In some cases, however, in accordance with operating agreements with the agency or utility, the instructions are transmitted directly to the project. Although the general criteria for scheduling the regulation of non-Corps projects is in accordance with the procedures described herein, the means of scheduling the regulation varies among projects and operating entities. For those agencies and entities which are not project owners or operators, but still have a need to know, (e.g., power marketing authorities, fish and wildlife agencies, etc.) the schedules are transmitted to them each day to confirm the specific water regulation for the ensuing 24-hour period. These schedules may be distributed via computer terminal or by teletype or telephone for systems that lack a comprehensive automated water data network. Distribution of the daily regulation schedules, while normally considered to be internal working directives, may be given to the general public on a need to know basis. (Corps, 1987)

3. Drought Management Plans. Engineer Regulation 1110-2-1941 requires that a drought management plan be developed and implemented as part of overall water control management responsibilities. All Corps projects having controlled storage must have documented drought management procedures. The Water Control Manual for each project will contain a section on special procedures to be followed during droughts. In addition, basin-wide drought management plans should be incorporated into Master Water Control Manuals. Detailed guidance for developing and updating Drought Contingency Plans is contained in ETL 1110-2-335. When developing a drought management plan, alternate strategies for project or basin-wide operating criteria should be formulated based on the longevity and severity of potential drought events. For additional information on drought contingency planning, see Chapter 7, Paragraph C.

E. PREPARATION OF WATER CONTROL DOCUMENTS

1. Introduction. The type of water control document required is based on the type of project and, accordingly, the complexity of the required water management (Corps, 1987). The four types of projects are summarized in **Table 9-7**.

2. Basic Documentation.

a. General. The basic documents for management of water control projects or systems fall into three main types; standing instructions to the project operator for water control, a water control plan, and a water control manual.

b. Standing Instructions to Project Operators for Water Control. These instructions are essential to ensure efficient and safe operation of the project at all times. The instructions apply to damtenders, power plant superintendents, lock masters, resources managers, etc. Any physical operating constraints should be clearly outlined to ensure that water control features are operated in a safe manner and within design limitations, during all phases of project life, including the construction phase. These instructions must be kept distinct and separate from O&M manuals and are required for all Type II, III, and IV projects. The instructions, however, should be referenced within the O&M manual. It is important that the instructions provide the only source of information on the regulation of projects for water control. The manual, therefore, must be limited to the

Table 9-7
Type of Water Control Projects by Size and Complexity

Type	Criteria	Separate Water Control Documentation Required
I	Relatively small projects that require closing or opening of water passageways, such as floodwalls and culverts using stop logs, sand bags, etc., uncontrolled weirs, fuseplugs and pump stations at small, nonhazardous impoundments, and small gated structures. Water control documentation is contained in the O&M Manual for the project.	No
II	Relative small projects that require simple, straightforward water control procedures, such as opening or closing minor floodgates or operating stationary pumping facilities. Many of these structures are unattended and usually require a full-open or full-closure action, as opposed to graduated gate operations.	Yes
III	These are reregulation structures, locks and dams as well as those projects which are completely uncontrolled. A water control plan is needed to assure that all objectives for regulation of a project are satisfactorily met and a water control manual is needed when the project is a part of a multi project system.	Yes
IV	These are major water resource projects that involve complex water control procedures, regardless of frequency of use. These projects may include reservoirs, lakes, major diversion structures, pumping facilities and floodways. Complexities may be due to project size, hydrometeorological impacts, discharge facilities, water control objectives, and constraints on water control.	Yes

"physical operation" of structures, such as the manipulation of gates, placement or removal of stoplogs, operation of pumps, etc. Thus, the operation plans will apply to physical operation and not to water control. Information to be provided in "Standing Instructions to Project Operators for Water Control" is contained as Exhibit A to EM 1110-2-3600. A summary of these instructions is provided in **Appendix F.**

c. Water Control Plans. The water control plan for the project is the principal item of documentation. An "Interim water Control Plan" is prepared when a project is under construction; a "Preliminary Water Control Plan" is prepared well before the time full-scale operation begins; and a "Final Water Control Plan" is prepared within one year after operation of a project begins (Corps, 1987). These plans are required for all Type III and IV projects. A "Preliminary Water Control Plan" is replaced by a "Final" plan for Type III projects or by a water control manual in final form for Type III and IV projects, as appropriate, within one year after the project is placed in operation. Information to be included in a "Water Control Plan" is contained as Exhibit B to EM 1110-2-3600. A summary of these instruction is provided in **Appendix F**.

d. Water Control Manuals. Water control manuals are prepared for Type III and IV projects for two main purposes. First and foremost, manuals provide documentation of the water control plan. The second main purpose of the manual is to provide a reference source for higher authority and for new personnel who will become concerned with, or responsible for, regulation of the water control projects. A separate manual is prepared for each individual project (or an appendix to a master manual) to: facilitate the use of specific information such as instructions, plates, tables, diagrams and charts for expeditious assessment of prevailing runoff events; and aid in the water control decision-making process on a real-time basis. Since the main purpose of a manual is for daily use in water control for essentially all foreseeable conditions affecting a project or system, appreciable effort should be made to prepare a usable manual. A detailed description on the preparation of water control manuals has recently been published by Headquarters as ER 1110-2-8156. A summary or these instructions and an outline for a Master Water Control Manual is contained in **Appendix F**.

F. REFERENCES

U.S. Army Corps of Engineers, HQUSACE, 15 September 1981. Drought Contingency Plans, ER 1110-2-1941.

U.S. Army Corps of Engineers, HQUSACE, 31 August 1984. Management of Water Control Data Systems, ER 1110-2-249.

U.S. Army Corps of Engineers, HQUSACE, Chapter 1, 30 April 1987, Chapter 2, 1 March 1995. Water Control Management. ER 1110-2-240.

U.S. Army Corps of Engineers, HQUSACE, 30 November 1987. Management of Water Control Systems, EM 1110-2-3600.

U.S. Army Corps of Engineers, HQUSACE, July 1992. Authorized and Operating Purposes of Corps of Engineers Reservoirs

U.S. Army Corps of Engineers, HQUSACE, 1 April 1993. Development of Drought Contingency Plans, ETL 1110-2-335.

U.S. Army Corps of Engineers, HQUSACE, 31 August 1995. Preparation of Water Control Manuals, ER 1110-2-8156.

U.S. Army Corps of Engineers, HEC, September 1995. Water Control Data Systems, Past, Present and Future, Report RD-39.

APPENDIX A

LEGISLATION PERTINENT TO THE WATER SUPPLY PROGRAM

DECEMBER 1998

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COMPENDIUM OF LEGISLATION

1. **Public Law 57-161**, The 1902 Reclamation Act, 17 June 1902. This act *established irrigation in the West as a National policy*. The Act authorized the Secretary of the Interior to locate, construct, operate and maintain works for the storage, diversion, and development of waters for the reclamation of arid and semi-arid lands in the Western States (32 Stat. 388, 43 U.S.C. 1457).

2. **Public Law 78-534**, 1944 Flood Control Act, 22 December 1944.

a. Section 6, *Contracts for Surplus Water*, authorized disposal by the Secretary of the Army, for domestic and industrial uses, of surplus water available at reservoirs (58 Stat. 890, 33 U.S.C. 708). (See Page A-5 for complete text.)

b. Section 8, *Additional Irrigation Works*, provided that Corps reservoirs may include irrigation as a purpose in 17 western states (58 Stat. 891, 43 U.S.C. 390). These provisions were modified by Section 931 of Public Law 99-662. (See Page A-7 for complete text, as amended.)

3. **Public Law 84-99**, Emergency Flood Control Work, 28 June 1955. This act *amends Section 5 of the 1941 Flood Control Act, as amended*. This act authorized an emergency fund, with replenishment on an annual basis, for flood emergency preparation, flood fighting and rescue operations or for repair or restoration of flood control work threatened or destroyed by flood including strengthening or extending deemed necessary by the Chief of Engineers (69 Stat. 186, 33 U.S.C. 701n). These provisions were modified by Section 82 of Public Law 93-251 and by Section 2 of Public Law 95-51. (See Page A-9 for complete text, as amended.)

4. **Public Law 85-500**, 1958 River and Harbor Act, 3 July 1958. Title III of this act is entitled *The Water Supply Act of 1958*. Section 301 provided that storage may be included for present and future municipal or industrial water supply in Corps or Bureau of Reclamation projects, the costs plus interest to be repaid by non-Federal entities within the life of the project but not to exceed 50 years after first use for water supply. No more than 30 percent of total project costs may be allocated to future demands. An interest-free period, until supply is first used, but not to exceed ten years, was permitted (72 Stat. 319, 43, U.S.C. 390b). These provisions were modified by Section 10 of Public Law 87-88 and Section 932 of Public Law 99-662. (See Page A-13 for complete text, as amended.)

5. **Public Law 87-88**, Water Pollution Control Act Amendments of 1961, 20 July 1961.

a. Section 2(b)(1), amended existing law to provide for the *consideration of storage in Federal projects for water quality control*, except that such storage shall not be a substitute for adequate treatment or control at the source (75 Stat. 204, 33 U.S.C. 1153). Amended by Section 102(b), Public Law 92-500.

b. Section 10, *Water Supply Act of 1958 Amendments*, modified the 1958 Water Supply Act with respect to construction cost payments for future water supply demands (75 Stat. 210).

6. **Public Law 88-140**, 16 October 1963. This law, *Permanent Right to Storage*, extended non-Federal right to use reservoir water supply storage to the physical life of the project. This removed an uncertainty as to the continued availability of the storage space after the 50-year maximum period previously allowed in contracts (77 Stat. 249, 43 U.S.C. 390-c-e). (See Page A-15 for complete text.)

7. **Public Law 90-577**, 16 October 1968. This law, the *Intergovernmental Cooperation Act of 1968*, provides for cooperation and coordination of activities among levels of government, improved administration of programs for technical services to states and local governments, intergovernmental coordination on policy and administration of development assistance programs within urban areas, and periodic congressional review of such grants-in-aid programs (82 Stat. 1098; 42 U.S.C. 4201).

8. **Public Law 91-611**, River and Harbor and Flood Control Act of 1970, 31 December 1970.

a. Section 216, *Completed Project Review*, authorized review and report to Congress of the operation of completed projects when found advisable due to significantly changed physical or economic conditions.

b. Section 221, *Written Agreement*, provides that the construction of any water resources project by the Corps shall not be commenced until each non-Federal interest has entered into a written agreement to furnish its required cooperation for the project (84 Stat. 1831, 42 U.S.C. 1962d-5b). Clarified by Section 4 of Public Law 92-222 and amended by Section 912(a) of Public Law 99-662. (See Page A-17 for complete text, as amended.)

9. **Public Law 92-222**, River Basin Monetary Authorization Act of 1971, 23 December 1971. Section 4, *Written Agreement*, clarifies that Section 221 of Public Law 91-611 does not apply to storage for future water supply (85 Stat. 799).

10. **Public Law 93-251**, Water Resources Development Act of 1974, 7 March 1974.

a. Section 22, *Planning Assistance to States*, provides authority for cooperating with any state in preparation of comprehensive plans for water resources development, utilization, and conservation (88 Stat. 21, 42 U.S.C. 1962d-16). This section has been amended by Section 168 of Public Law 94-587 (increase of monetary limits only), Section 605 of Public Law 96-597, Section 921 of Public Law 99-662 (increase in monetary limits only), Section 319 of Public Law 101-640, Section 208 of Public Law 102-580, and Section 221 of Public Law 104-303. (See Page A-19 for complete text, as amended.)

b. Section 82, *Emergency Water Supplies*, modified Section 5 of the 1941 Flood Control Act, as amended, to authorize providing emergency supplies of clean drinking water when contaminated supplies are a threat to public health and welfare of locality. Contamination must result from flood (88 Stat. 34).

11. **Public Law 95-51**, Disaster Relief Act of 1974 Appropriations, 20 June 1977. Section 2 amends Section 5 of the 1941 Flood Control Act, as amended by Public Law 84-99 (Emergency Flood Control Funds, 28 June 1955), to allow the Corps to provide *Emergency Supplies of Water* and to construct wells in drought areas (91 Stat. 233).

12. **Public Law 96-597**, Appropriations Act, U.S. Insular Areas. Section 605 amends the provisions of Section 22, Public Law 93-251 *(Planning Assistance to States)*, applicable to Guam, American Samoa, the Virgin Islands, the Northern Marianas, and the Trust Territory of the Pacific Islands (94 Stat. 3482).

13. **Public Law 99-662**, Water Resources Development Act of 1986, 17 November 1986.

a. Section 103 (c), *Construction Cost Sharing*, established new cost sharing requirements for municipal and industrial water supply and for agricultural water supply (100 Stat. 4085).

b. Section 105, *Study Cost Sharing*, established a requirement that, for Corps feasibility studies, appropriate non-Federal interests contribute 50 percent of the study costs (100 Stat. 4088).

c. Section 912(a), *Section 221 Agreements,* amends Section 221 of the Flood Control Act of 1970 with respect to written agreements for local cooperation and has added provisions designed to enforce local fulfillment of the agreement (100 Stat. 4189).

d. Section 707, *Capital Investment Needs for Water Resources*, authorized the Assistant Secretary of the Army for Civil Works to estimate long term capital investment needs for, among other things, municipal and industrial water supply (100 Stat. 4158). This section together with Section 729 of Public Law 99-662, provided the impetus for the *National Drought Study*.

e. Section 729, *Study of Water Resources Needs of River Basins and Regions*, requires the Assistant Secretary of the Army for Civil Works, in coordination with the Secretary of the Interior and in consultation with other governmental agencies, to study "water resources needs of river basins and regions of the United States." This section specifically requires consultation with "State, interstate, and local governments" (100 Stat. 4164). This section together with Section 707 of Public Law 99-662, provided the impetus for the *National Drought Study*.

f. Section 917, *Emergency and Disaster Authority*, further amends Section 5 of the 1941 Flood Control Act, as amended, to authorize provision of emergency supplies of clean water, whether for drinking or other critical need (100 Stat. 4192).

g. Section 931, *Interim Use of Water Supply for Irrigation*, amends Section 8 of the 1944 Flood Control Act to authorize interim allocation of future municipal and industrial water supply storage in Corps reservoirs for irrigation purposes (100 Stat. 4196).

h. Section 932, *Water Supply Act Amendments*, amends the 1958 Water Supply Act in the following respects; eliminates the 10-year interest free period for future water supply; modifies the interest rate formula; limits the repayment period to 30 years; and requires allocated annual operation, maintenance and replacement costs to be reimbursed annually. These amendments apply only to Corps projects and not to Bureau of Reclamation projects (100 Stat. 4196).

i. Section 1203, *Dam Safety*, requires non-Federal interests which are participating in reimbursable purposes of a project to share in the costs of modifying Corps dams and related facilities resulting from changes deemed necessary for safety purposes (100 Stat. 4263).

14. **Public Law 101-640**, Water Resources Development Act of 1990, approved 28 November 1990.

a. Section 310(b), *Public Participation*, directs the Secretary of the Army to ensure that significant opportunities for public participation are provided in developing or revising reservoir operating manuals.

b. Section 319, *Fees for Development of State Water Plans.* Amends Section 22 of Public Law 93-251, as amended, to require fees for the development of state water plans, the establishment of a collection procedure, a phase-in for the fees, and how the fees are to be deposited and used (104 Stat. 4642).

c. Section 322, *Reduced Price for Certain Water Supply Storage*, provides that a small amount of water supply storage in Corps reservoir projects may be made available for low income communities at a reduced price (104 Stat. 4643, 33 U.S.C. 2324). (See Page A-21 for complete text.)

15. **Public Law 102-580**, Water Resources Development Act of 1992, 31 October 1992. Section 208 *(Fees for Development of State Water Plans)*, amends Section 22 of Public Law 93-251, as amended, to provide for a credit for in-kind services and to include "Indian Tribes" as available for assistance under this law (106 Stat. 4829).

16. **Public Law 104-303**, Water Resources Development Act of 1996, 12 October 1996. Section 221, *Planning Assistance to States*, amends Section 22 of the Water Resources Development Act of 1974, as amended, to expand the areas of planning effort to include watersheds and ecosystems, and expands the annual program budget to $10,000,000 and the per state expenditure to $500,000.

TEXT OF MAJOR LEGISLATIVE LANDMARKS

PUBLIC LAW 78-534
1944 FLOOD CONTROL ACT
33 U.S.C. § 708

Section 6; Contracts for Surplus Water (58 Stat. 890). That the Secretary of War is authorized to make contracts with States, municipalities, private concerns, or individuals, at such prices and on such terms as he may deem reasonable, for domestic and industrial uses for surplus water that may be available at any reservoir under the control of the War Department: *Provided,* That no contracts for such water shall adversely affect then existing lawful uses of such water. All moneys received from such contracts shall be deposited in the Treasury of the United States as miscellaneous receipts.

Approved December 22, 1944.

PUBLIC LAW 78-534
1944 FLOOD CONTROL ACT
43 U.S.C. § 390

Section 8; Additional Irrigation Works, as amended (58 Stat. 891). Hereafter, whenever the Secretary of War determines, upon recommendation by the Secretary of the Interior that any dam and reservoir project operated under the direction of the Secretary of War may be utilized for irrigation purposes, the Secretary of the Interior is authorized to construct, operate and maintain, under the provisions of the Federal reclamation laws (Act of June 17, 1902, 32 Stat. 388, and Acts amendatory thereof or supplementary thereto), such additional works in connection therewith as he may deem necessary for irrigation purposes. Such irrigation works may be undertaken only after a report and findings thereon have been made by the Secretary of the Interior as provided in said Federal reclamation laws and after subsequent specific authorization of the Congress by an authorization Act; and, within the limits of the water users' repayment ability such report may be predicated on the allocation to irrigation of an appropriate portion of the cost of structures and facilities used for irrigation and other purposes. Dams and reservoirs operated under the direction of the Secretary of War may be utilized hereafter for irrigation purposes only in conformity with the provisions of this section, but the foregoing requirement shall not prejudice lawful uses now existing: *Provided*, That this section shall not apply to any dam or reservoir heretofore constructed in whole or in part by the Army engineers, which provides conservation storage of water for irrigation purposes. In the case of any reservoir project constructed and operated by the Corps of Engineers, the Secretary of the Army is authorized to allocate water which was allocated in the project purpose for municipal and industrial water supply and which is not under contract for delivery, for such periods as he may deem reasonable, for the interim use for irrigation purposes of such storage until such storage is required for municipal and industrial water supply. No contracts for the interim use of such storage shall be entered into which would significantly affect then-existing uses of such storage.

Approved December 22, 1944.

As amended by Section 931, Public Law 99-662 (100 Stat. 4196).

PUBLIC LAW 84-99
EMERGENCY FLOOD CONTROL WORK
33 U.S.C. § 701n
(69 Stat. 186)

An act to amend section 5 of the Flood Control Act of August 18, 1941 (55 Stat. 650), as amended, pertaining to flood emergencies; extraordinary wind, wave, or water damage to federally authorized hurricane or shore protective structures; emergency supplies of water; cost and benefit feasibility assessment factors; drought; well construction; and water transportation.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That: Section 5 of the Flood Control Act of August 18, 1941, as amended, is hereby further amended to read as follows:

(a)(1) There is authorized an emergency fund to be expended in preparation for emergency response to any natural disaster, in flood fighting and rescue operations, or in the repair or restoration of any flood control work threatened or destroyed by flood, including the strengthening, raising, extending, or other modification thereof as may be necessary in the discretion of the Chief of Engineers for the adequate functioning of the work for flood control; in the emergency protection of federally authorized hurricane or shore protection being threatened when in the discretion of the Chief of Engineers such protection is warranted to protect against imminent and substantial loss to life and property; in the repair and restoration of any federally authorized hurricane or shore protective structure damaged or destroyed by wind, wave, or water action of other than an ordinary nature when in the discretion of the Chief of Engineers such repair and restoration is warranted for the adequate functioning of the structure for hurricane or shore protection. The emergency fund may also be expended for emergency dredging for restoration of authorized project depths for Federal navigable channels and waterways made necessary by flood, drought, earthquake, or other natural disasters. In any case in which the Chief of Engineers is otherwise performing work under this section in an area for which the Governor of the affected State has requested a determination that an emergency exists or a declaration that a major disaster exists under the Disaster Relief and Emergency Assistance Act [42 U.S.C.A. § 5121 et seq.], the Chief of Engineers is further authorized to perform on public and private lands and waters for a period of ten days following the Governor's request, any emergency work made necessary by such emergency or disaster which is essential for the preservation of life and property, including, but not limited to, channel clearance, emergency shore protection, clearance and removal of debris and wreckage endangering public health and safety, and temporary restoration of essential public facilities and services. The Chief of Engineers, in the exercise of his discretion, is further authorized to provide emergency supplies of clean water, on such terms as he determines to be advisable, to any locality which he finds is confronted with a source of contaminated water causing or likely to cause a substantial threat to the public health and welfare of the inhabitants of the locality. The appropriation of such moneys for the initial establishment of this fund and for its replenishment on an annual basis, is hereby authorized: *Provided,* That pending the appropriation of sums to such emergency fund, the Secretary of the Army may allot, from existing flood-control appropriations, such sums as may be necessary for the immediate prosecution of the work herein authorized, such appropriations to be reimbursed from the appropriation herein authorized when made. The Chief of Engineers is authorized, the prosecution of work in connection with rescue operations, or in conducting other flood emergency work, to acquire on rental basis such motor vehicles, including passenger cars and buses, as in his discretion are deemed necessary.

(2) In preparing a cost and benefit feasibility assessment for any emergency project described in paragraph (1), the Chief of Engineers shall consider the benefits to be gained by such project for the protection of -

(A) residential establishments;

(B) commercial establishments, including the protection of inventory; and

(C) agricultural establishments, including the protection of crops.

(b)(1) The Secretary, upon a written request for assistance under this paragraph made by any farmer, rancher, or political subdivision within a distressed area, and after a determination by the Secretary that (A) as a result of the drought such farmer, rancher, or political subdivision has an inadequate supply of water, (B) an adequate supply of water can be made available to such farmer, rancher, or political subdivision through the construction of a well, and (C) as a result of the drought such well could not be constructed by a private business, the Secretary, subject to paragraph (3) of this subsection, may enter into an agreement with such farmer, rancher, or political subdivision for the construction of such well.

(2) The Secretary, upon a written request for assistance under this paragraph made by any farmer, rancher, or political subdivision within a distressed area, and after a determination by the Secretary that as a result of the drought such farmer, rancher, or political subdivision has an inadequate supply of water and water cannot be obtained by such farmer, rancher, or political subdivision, the Secretary may transport water to such farmer, rancher, or political subdivision by methods which include, but are not limited to, small-diameter emergency water lines and tank trucks, until such time as the Secretary determines that an adequate supply of water is available to such farmer, rancher, or political subdivision.

(3)(A) Any agreement entered into by the Secretary pursuant to paragraph (1) of this subsection shall require the farmer, rancher, or political subdivision for whom the well is constructed to pay to the United States the reasonable cost of such construction, with interest, over such number of years, not to exceed thirty, as the Secretary deems appropriate. The rate of interest shall be that rate which the Secretary determines would apply if the amount to be repaid was a loan made pursuant to section 636(b)(2) of Title 15.

(B) The Secretary shall not construct any well pursuant to this subsection unless the farmer, rancher, or political subdivision for whom the well is being constructed has obtained, prior to construction, all necessary State and local permits.

(4) The Federal share for the transportation of water pursuant to paragraph (2) of this subsection shall be 100 per centum.

(5) For purposes of this subsection -

(A) the term “construction” includes construction, reconstruction, or repair;

(B) the term “distressed area” means an area which the Secretary determines due to drought conditions has an inadequate water supply which is causing, or is likely to cause, a substantial threat to the health and welfare of the inhabitants of the area including threat of damage or loss of property;

(C) the term “political subdivision” means a city, town, borough, county, parish, district, association, or other public body created by or pursuant to State law and having jurisdiction over the water supply of such public body;

(D) the term “reasonable cost” means the lesser of (i) the cost to the Secretary of constructing a well pursuant to this subsection exclusive of the cost of transporting equipment used in the construction of wells or (ii) the cost to a private business of constructing such well;

(E) the term “Secretary” means the Secretary of the Army, acting through the Chief of Engineers; and

(F) the term “State” means a State, the District of Columbia, the Commonwealth of Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Trust Territory of the Pacific Islands.

Approved June 28, 1955;
As amended by:
Section 82, Public Law 93-251 (88 Stat. 34); and
Section 2, Public Law 95-51 (91 Stat. 233).

PUBLIC LAW 85-500
1958 RIVER AND HARBOR ACT
TITLE III; WATER SUPPLY ACT OF 1958, as amended
43 U.S.C. § 390b
(72 Stat. 319)

Sec. 301. (a) It is hereby declared to be the policy of the Congress to recognize the primary responsibilities of the States and local interests in developing water supplies for domestic, municipal, industrial, and other purposes and that the Federal Government should participate and cooperate with States and local interests in developing such water supplies in connection with the construction, maintenance, and operation of Federal navigation, flood control, irrigation, or multiple purpose projects.

(b) In carrying out the policy set forth in this section, it is hereby provided that storage may be included in any reservoir project surveyed, planned, constructed or to be planned, surveyed and/or constructed by the Corps of Engineers or the Bureau of Reclamation to impound water for present or anticipated future demand or need for municipal or industrial water, and the reasonable value thereof may be taken into account in estimating the economic value of the entire project: *Provided*, That the cost of any construction or modification authorized under the provisions of this section shall be determined on the basis that all authorized purposes served by the project shall share equitably in the benefits of multiple purpose construction, as determined by the Secretary of the Army or the Secretary of the Interior, as the case may be; *Provided further,* That before construction or modification of any project including water supply provisions for present demand is initiated, State or local interests shall agree to pay for the cost of such provisions in accordance with the provisions of this section; *And provided further,* That (1) for Corps of Engineers projects, not to exceed 30 percent of the total estimated cost of any project may be allocated to anticipated future demands, and (2) for Bureau of Reclamation projects, not to exceed 30 percentum of the total estimated cost of any project may be allocated to anticipated future demands where State or local interests give reasonable assurances, and there is reasonable evidence, that such demands for the use of such storage will be made within a period of time which will permit paying out the costs allocated to water supply within the life of the project; *And provided further,* That for Corps of Engineers projects, the Secretary of the Army may permit the full non-Federal contribution to be made, without interest, during construction of the project, or, with interest over a period of not more than thirty years from the date of completion, with repayment contracts providing for recalculation of the interest rate at five-year intervals, and for Bureau of Reclamation projects the entire amount of the construction costs, including interest during construction, allocated to water supply shall be repaid within the life of the project but in no event to exceed fifty years after the project is first used for the storage of water for water supply purposes, except that (1) no payment need be made with respect to storage for future water supply until such supply is first used, and (2) no interest shall be charged on such cost until such supply is first used, but in no case shall the interest-free period exceed ten years. For Corps of Engineers projects, all annual operation, maintenance, and replacement costs for municipal and industrial water supply storage under the provisions of this section shall be reimbursed from State or local interests on an annual basis. For Corps of Engineers projects, any repayment by a State or local interest shall be made with interest at a rate to be determined by the Secretary of the Treasury, taking into consideration the average market yields on outstanding marketable obligations of the United States with remaining periods to maturity comparable to the reimbursement period, during the month preceding the fiscal year in which costs for the construction of the project are first incurred (or, when a recalculation is made), plus a premium of one-eight of one percentage point for transaction costs. For Bureau of Reclamation projects, the interest rate used for purposes of computing interest during construction and interest on the unpaid balance shall be determined by the Secretary of the Treasury, as of the beginning of the fiscal year in which construction is initiated, on the basis of the computed average interest rate payable by the Treasury upon its outstanding marketable public obligations, which are neither due nor callable for redemption for fifteen years from date of issue. The provisions of this subsection insofar as they relate to the Bureau of Reclamation and the Secretary of Interior shall be alternative to and not a substitute for the provisions of the Reclamation Projects Act of 1939 (58 Stat.1187) relating to the same project.

(c) The provisions of this section shall not be construed to modify the provision of section 1 and section 8 of the Flood Control Act of 1944 (58 Stat. 887), as amended and extended, or the provisions of section 8 of the Reclamation Act of 1902 (32 Stat. 390).

(d) Modifications of a reservoir project heretofore authorized, surveyed, planned, or constructed to include storage as provided in subsection (b), which would seriously affect the purposes for which the project was authorized, surveyed, planned, or constructed, or which would involve major structural or operational changes, shall be made only upon the approval of Congress as now provided by law.

Sec. 302. Title III of this Act may be cited as the "Water Supply Act of 1958".

Approved July 3, 1958;

As amended by Section 10, Public Law 87-88 (79 Stat. 210); and

As amended by Section 932 of Public Law 99-662 (100 Stat. 4196).

PUBLIC LAW 88-140
PERMANENT RIGHTS TO STORAGE
43 U.S.C. § 390-c-e
(77 Stat. 249)

An act defining the interest of local public agencies in water reservoirs constructed by the Government which have been financed partially by such agencies.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That, cognizant that many States and local interests have in the past contributed to the Government, or have contracted to pay to the Government over a specified period of years, money equivalent to the cost of providing for them water storage space at Government-owned dams and reservoirs, constructed by the Corps of Engineers of the United States Army, and that such practices will continue, and, that no law defines the duration of their interest in such storage space, and realizing that such States and local interests assume the obligation of paying substantially their portion of the cost of providing such facilities, their right to use may be continued during the existence of the facility as hereinafter provided.

Sec. 2. That this Act be applicable to all dams and reservoirs heretofore or hereafter constructed by the United States Government (acting through the Corps of Engineers of the United States Army) wherein either a part of the construction cost thereof shall have been contributed or may be contributed by States or local interests (hereinafter called "local interests") or local interests have acquired or may acquire rights to utilize certain storage space thereof by making payments during the period of such use as specified in the agreement with the Government and wherein the amount of money paid, exclusive of interest, is equivalent to the cost of providing that part of such dam and reservoir which is allocated to such use, whether such share of cost, shall have been determined by the "incremental cost" method or by the "separable costs-remaining benefits" method or by any other method. Included among the dams and reservoirs affected by this Act are those constructed by the Corps of Engineers of the Department of the Army, but nothing in this Act shall be construed to affect or modify section 8 of the Flood Control Act of 1944.

Sec. 3. The right thus acquired by any such local interest is hereby declared to be available to the local interest so long as the space designated for that purpose may be physically available, taking into account such equitable reallocation of reservoir storage capacities among the purposes served by the project as may be necessary due to sedimentation, and not limited to the term of years which may be prescribed in any lease agreement or other agreement with the Government, but the enjoyment of such right will remain subject to performance of its obligations prescribed in such lease agreement or agreement executed in reference thereto. Such obligations will include continued payment of annual operation and maintenance costs allocated to water supply. In addition, local interests shall bear the costs allocated to the water supply of any necessary reconstruction, rehabilitation, or replacement of project features which may be require to continue satisfactory operation of the project. Any affected local interest may utilize such facility so long as it is operated by the Government. In the event that the Government concludes that it can no longer usefully and economically maintain and operate such facility, the responsible department or agency of the Government is authorized to negotiate a contract with the affected local interest under which the local interest may continue to operate such part of the facility as is necessary for utilization of the storage space allocated to it, under terms which will protect the public interest and provided that the Government is effectively absolved from all liability in connection with such operation.

Sec. 4. Upon application of any affected local interest its existing lease or agreement with the Government will be revised to evidence the conversion of its rights to the use of the storage as prescribed in this Act.

Approved October 16, 1963.

PUBLIC LAW 91-611
1970 RIVER AND HARBOR AND FLOOD CONTROL ACT
42 U.S.C. § 1962d-5b

Section 221; Water Resources Projects; Written Requirements, as amended (84 Stat. 1831).

(a) After December 31, 1970, the construction of any water resources project, or an acceptable separable element thereof, by the Secretary of the Army, acting through the Chief of Engineers, or by a non-Federal interest where such interest will be reimbursed for such construction under the provisions of section 1962d-5a of this title or under any other provision of law, shall not be commenced until each non-Federal interest has entered into a written agreement with the Secretary of the Army to furnish its required cooperation for the project or the appropriate element of the project, as the case may be. In any such agreement entered into by a State, or a body politic of the State which derives its powers from the State constitution, or a governmental entity created by the State legislature, the agreement may reflect that it does not obligate future State legislative appropriations for such performance and payment when obligation future appropriations would be inconsistent with State constitutional or statutory limitations.

(b) A non-Federal interest shall be a legally constituted public body with full authority and capability to perform the terms of its agreement and to pay damages, if necessary in the event of failure to perform.

(c) Every agreement entered into pursuant to this section shall be enforceable in the appropriate district court of the United States.

(d) After commencement of construction of a project, the Chief of Engineers may undertake performance of those items of cooperation necessary to the functioning of the project for its purposes, if he has first notified the non-Federal interest of its failure to perform the terms of its agreement and has given such interest a reasonable time after such notification to so perform.

(e) The Secretary of the Army, acting through the Chief of Engineers, shall maintain a continuing inventory of agreements and the status of their performance, and shall report thereon annually to Congress.

(f) This section shall not apply to any project the construction of which was commenced before January 1, 1972, or the assurances for future demands required by the Water Supply Act of 1958, as amended [43 U.S.C.A. § 390b].

Approved December 31, 1970.

Amended by:

Section 4, Public Law 92-222, 85 Stat. 799; and

Section 912(a), Public Law 99-662, 100 Stat. 4189.

PUBLIC LAW 93-251
1974 WATER RESOURCES DEVELOPMENT ACT
42 U.S.C. § 1962d-16

Section 22; Planning Assistance to States, as amended (88 Stat. 21).

(a) The Secretary of the Army, acting through the Chief of Engineers, is authorized to cooperate with any State in the preparation of comprehensive plans for the development, utilization, and conservation of the water and related resources of drainage basins, watersheds, or ecosystems located within the boundaries of such State and to submit to Congress reports and recommendations with respect to appropriate Federal participation in carrying out such plans.

(b) Fees.-

(1) Establishment and Collection. - For the purpose of recovering 50 percent of the total cost of providing assistance pursuant to this section, the Secretary of the Army is authorized to establish appropriate fees, as determined by the Secretary, and to collect such fees from States and other non-Federal public bodies to whom assistance is provided under this section.

(2) In-Kind Services.- Up to ½ of the non-Federal contribution for preparation of a plan subject to the cost sharing program under this subsection may be made by the provision of services, material, supplies, or other in-kind services necessary to prepare the plan.

(3) Deposit and Use. - Fees collected under this subsection shall be deposited into the account in the Treasury of the United States entitled, "Contributions and Advances, Rivers and Harbors, Corps of Engineers 8862" and shall be available until expended to carry out this section.

(c) There is authorized to be appropriated not to exceed $10,000,000 annually to carry out the provisions of this section except that not more than $500,000 shall be expended in any one year in any one State.

(d) For the purposes of this section, the term "State" means the several States of the United States, Indian tribes, the Commonwealth of Puerto, Guam, American Samoa, the Virgin Islands, the Commonwealth of the Northern Marianas, and the Trust Territory of the Pacific Islands.

Approved March 7, 1974.

As amended by:

Section 168, Public Law 94-587, 90 Stat. 2936;
Section 605, Public Law 96-597, 94 Stat. 3482;
Section 921, Public Law 99-662, 100 Stat. 4194;
Section 319, Public Law 101-640, 104 Stat. 4642;
Section 208, Public Law 102-580, 106 Stat. 4829; and
Section 221, Public Law 104-303 (WRDA '96)

PUBLIC LAW 101-640
1990 WATER RESOURCE DEVELOPMENT ACT
33 U.S.C. § 2324

Section 322; Reduced Price for Certain Water Supply Storage (104 Stat. 4643).

(a) Provision of Storage Space.--If a low income community requests the Secretary to provide water supply storage space in a water resources development project operated by the Secretary and if the amount of space requested is available or could be made available through reallocation of water supply storage space in the project or through modifications to operation of the project, the Secretary may provide such space to the community at a price determined under subsection (c).

(b) Maximum Amount of Storage Space.--The maximum amount of water supply storage space which may be provided to a community under this section may not exceed an amount of water supply storage space sufficient to yield 2,000,000 gallons of water per day.

(c) Price.--The Secretary shall provide water supply storage space under this section at a price which is the greater of --

(1) the updated construction cost of the project allocated to provide such amount of water supply storage space or $100 per acre foot of storage space, whichever is less; and

(2) the value of the benefits which are lost as a result of providing such water supply storage space.

(d) Determinations.--For purposes of subsection (c), the determinations of updated construction costs and value of benefits lost shall be made by the Secretary on the basis of the most recent information available.

(e) Inflation Adjustment of Dollar Amount.--The $100 amount set forth in subsection (c) shall be adjusted annually by the Secretary for changes in the Consumer Price Index of All Urban Consumers published by the Bureau of Labor Statistics.

(f) Non-Federal Responsibilities.--Nothing in this section shall be construed as affecting the responsibility of non-Federal interests to provide operation and maintenance costs assigned to water supply storage provided under this section.

(g) Low Income Community Defined.--The term "low income community" means a community with a population of less than 20,000 which is located in a county with a per capita income less than the per capita income of two-thirds of the counties in the Unites States.

Approved November 28, 1990.

APPENDIX B

MODEL FORMATS FOR AGREEMENTS AND PERMITS

DECEMBER 1998

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MODEL FORMAT FOR WATER SUPPLY STORAGE AGREEMENTS (also see ER 1105-2-100, Appendix K, dated 15 January 1998)

WATER STORAGE AGREEMENT
BETWEEN THE UNITED STATES OF AMERICA
AND

____
FOR
WATER STORAGE SPACE IN _______________________________________

THIS AGREEMENT, entered into this ____ day of _____________, 19___, by and between THE UNITED STATES OF AMERICA (hereinafter called the "Government") represented by the District Engineer executing this agreement, and ___________ ____________________ (hereinafter called the "User"*);

WITNESSETH THAT:

WHEREAS, the **____________ Act of l9 ___ (Public Law ___, ___Congress), authorized the construction, operation, and maintenance of the [Project]*** on [Waterway], [State], (hereinafter called the "Project"); and

WHEREAS, the User desires to enter into an agreement with the Government for the use of storage [included in the Project] [added to the Project by action of ________] for municipal and industrial water supply, and for payment of the cost thereof in accordance with the provisions of the Water Supply Act of 1958, as amended (43 U.S.C. 390b-f); and

WHEREAS, the User as shown in Exhibit "A: attached to and made a part of this agreement, is empowered to enter into an agreement with the Government and is vested with all necessary powers of accomplishment of the purposes of this agreement, [including those required by Section 221 of the Flood Control Act of 1970 (42 U.S.C. 1962d-5d) (as amended);]

(For use in agreements with reallocation of storage.)
[WHEREAS, provided as Exhibit "_": attached to and made a part of this agreement, is a reallocation report entitled "__________________________," dated: ______, which provides information pertinent to the reallocation of storage space in the Project for use by the User;]

NOW, THEREFORE, the Government and the User agree as follows:

<u>ARTICLE 1 - Water Storage Space</u>.

a. <u>Project Construction</u>. The Government, subject to the directions of Federal law and any limitations imposed thereby, [shall design and construct] [has designed and constructed] [shall modify] [has modified] the Project so as to include therein space for the storage of water by the User.

____

* Other appropriate terms may be used in lieu of User here and uniformly throughout the agreement.
** Use correct authorization citation (e.g., WRDA of 19__, Public Law __-__).
*** Language in [ ] brackets is to be used or deleted as appropriate.

b. Rights of User.

(l) The User shall have the right to utilize an undivided ___ percent (estimated to contain ________ acre-feet after adjustment for sediment deposits) of the usable storage space in the Project between elevations _______ feet and _______ feet above National Geodetic Vertical Datum, which usable conservation storage space is estimated to contain _________ acre-feet after adjustment for sediment deposits. This storage space is to be used to impound water for [present] [present and anticipated future] [anticipated future] demand or need for municipal and industrial water supply. [______ percent (an estimated _____ acre-feet) of the space which User has a right to utilize is for present use water storage and _______ percent (an estimated ________ acre-feet) is for future use water storage.]

(2) The User shall have the right to withdraw water from the lake, or to request releases to be made by the Government through the outlet works in the Dam, subject to the provisions of Article lc and to the extent the aforesaid storage space will provide; and shall have the right to construct all such works, plants, pipelines, and appurtenances as may be necessary and convenient for the purpose of diversion or withdrawals, subject to the approval of the District Engineer as to design and location. The grant of an easement for right-of-way, across, in and upon land of the Government at the Project shall be by a separate instrument in a form satisfactory to the Secretary of the Army, without additional cost to the User, under the authority of and in accordance with the provisions of l0 U.S.C. 2669 and such other authorities as may be necessary. Subject to the conditions of such easement, the User shall have the right to use so much of the Project land as may reasonably be required in the exercise of the rights and privileges granted under this agreement.

c. Rights Reserved. The Government reserves the right to control and use all storage in the project in accordance with authorized Project purposes. The Government further reserves the right to take such measures as may be necessary in the operation of the Project to preserve life and/or property, including the right not to make downstream releases during such periods of time as are deemed necessary, in its sole discretion, to inspect, maintain, or repair the Project.

d. Quality or Availability of Water. The User recognizes that this agreement provides storage space for raw water only. The Government makes no representations with respect to the quality or availability of water and assumes no responsibility therefor, or for the treatment of the water.

e. Sedimentation Surveys.

(1) Sedimentation surveys will be made by the District Engineer during the term of this agreement at intervals not to exceed fifteen (15) years unless [the District Engineer determines that such surveys are unnecessary] [otherwise agreed to in writing by both parties]. When, in the opinion of the District Engineer, the findings of such survey indicate any Project purpose will be affected by unanticipated sedimentation distribution, there shall be an equitable redistribution of the sediment reserve storage space among the purposes served by the Project including municipal and industrial water supply. The total available remaining storage space in the Project will then be divided among the various Project features in the same ratio as was initially utilized. Adjusted pool elevations will be rounded to the nearest one-half foot. Such findings and the storage space allocated to municipal and industrial water supply shall be defined and described as an exhibit which will be made a part of this agreement and the water control manual will be modified accordingly.

(2) The Government assumes no responsibility for deviations from estimated rates of sedimentation, or the distribution thereof. Such deviations may cause unequal distribution of sediment reserve storage greater than estimated, and/or encroachment on the total storage at the Project.

<u>ARTICLE 2 - Regulation of and Right to Use of Water</u>. The regulation of the use of water withdrawn or released from the aforesaid storage space shall be the sole responsibility of the User. The User has the full responsibility to acquire in accordance with State laws and regulations, and, if necessary, to establish or defend, any and all water rights needed for utilization of the storage provided under this agreement. The Government shall not be responsible for diversions by others, nor will it become a party to any controversies involving the use of the storage space by the User except as such controversies may affect the operations of the Project by the Government.

<u>ARTICLE 3 - Operation and Maintenance</u>. The Government shall operate and maintain the Project and the User shall pay to the Government a share of the costs of such operation and maintenance as provided in Article 5. The User shall be responsible for operation and maintenance of all installations and facilities which it may construct for the diversion or withdrawal of water, and shall bear all costs of construction, operation and maintenance of such installations and facilities.

<u>ARTICLE 4 - Measurement of Withdrawals and Releases</u>. The User agrees to furnish and install, without cost to the Government, suitable meters or measuring devices satisfactory to the District Engineer for the measurement of water which is withdrawn from the Project by any means other than through the Project outlet works. The User shall furnish to the Government monthly statements of all such withdrawals. Prior to the construction of any facilities for withdrawal of water from the Project, the User will obtain the District Engineer's approval of the design, location and installation of the facilities including the meters or measuring devices. Such devices shall be available for inspection by Government representatives at all reasonable times. Releases from the water supply storage space through the Project outlet works shall be made in accordance with written schedules furnished by the User and approved by the District Engineer and shall be subject to Article lc. The measure of all such releases shall be by means of a rating curve of the outlet works, or by such other suitable means as may be agreed upon prior to use of the water supply storage space.

<u>ARTICLE 5 - Payments</u>. In consideration of the right to utilize the aforesaid storage space [and the water supply conduit] in the Project for municipal and industrial water supply purposes, the User shall pay the following sums to the Government:

a. <u>Project Investment Costs</u>. (Include appropriate paragraph from the following.)

[(a) <u>Project Investment Costs</u>. (Option 1. For projects where municipal and industrial water supply storage space was operational or under construction as of 17 November 1986.)

(1) The User shall repay to the Government [in a lump sum payment,_____] [at the times and with interest on the unpaid balance as hereinafter specified, the amounts stated below] which, as shown in Exhibit "B" attached to and made a part of this agreement, constitute the entire [estimated] [actual] amount of the investment costs, including interest during construction and interest accrued following the end of the 10-year interest free period [date], allocated to the water storage [and the water supply conduit] right acquired by the User under

this agreement. The interest rate to be used for purposes of computing interest during construction and [interest on the unpaid balance] [accrued interest] will be the coupon rate as determined by the Secretary of the Treasury on the basis set forth in the Water Supply Act of 1958, Title III of PL 85-500. For the Project, construction of which was initiated in FY ___ this interest rate is __ percent.

The User shall repay:

100 percent of the construction cost of specific water supply facilities, [estimated at} (Revise percentage as necessary if there is more than one user of the water supply conduit in the Project or delete if inappropriate.)	$
____ percent of the total Project joint-use construction costs, [estimated at]	$
Interest during construction, [estimated at]	$
Total [estimated] amount of Project investment costs allocated to the User	$

(2) The Project investment costs allocated to the storage space indicated in Article 1b(1) as being provided for present demand [and the water supply conduit] is [currently estimated at] $______, on the basis of the costs presented in Exhibit "B". The amount of the Project investment costs allocated to the storage for present demand shall be paid within the life of the Project in not to exceed 30 years from [the plant-in-service date, ____] [the date the first agreement for water supply storage space in the Project was approved by the Secretary of the Army, _____] [the date of approval of this agreement by the Secretary of the Army]. The payments shall be in equal consecutive annual installments, the first of which shall be due and payable within 30 days after the User is notified by the Contracting Officer [that the project is completed and operational for water supply purposes]. [of approval of this contract by the Secretary of the Army]. Annual installments thereafter will be due and payable on the anniversary date of the date of notification. Except for the first payment which will be applied solely to the retirement of principal, all installments shall include accrued interest on the unpaid balance at the rate provided above. The last annual installment shall be adjusted upward or downward when due to assure repayment of all of the investment costs allocated to the storage for present demand within 30 years from the above date.

(3) The Project investment costs allocated to the storage space indicated in Article 1b(1) as being provided for future demand, is [currently estimated at] $________ on the basis of the costs presented in Exhibit "B". No principal or interest payment with respect to this storage for future water supply is required to be made during the first 10 years following the plant-in-service date unless all or a portion of such storage is used during this period. The amount to be paid for any portion of such storage which is used shall be determined by multiplying the percentage of the total storage for future water supply which is placed in use by the total amount of the Project investment costs allocated to future water supply. Interest at the rate provided above will be charged on the amount of Project investment costs allocated to the storage for future water supply which is not being used from the tenth (10th) year following the plant-in-service date until the time when such storage is first used. The User will annually pay the interest as it becomes due until the storage is used. When

any portion of the storage for future water supply is used, payment of both principal and interest for the portion used must be started, and the amount of the Project investment costs allocated thereto, with interest on the unpaid balance as provided above, shall be paid within the life of the Project in not to exceed 30 years from the date established in Article 5a(2). The payment for each portion shall be in equal consecutive annual installments [beginning within 30 days after the date of first use of such portion.] [commencing with the next anniversary of the notification date as stipulated in Article 5a(2). The first payment shall include interest on the investment cost of such portion from the date of first use of such portion to the next anniversary date as stipulated in Article 5a(2).] Annual installments thereafter will be due and payable on the anniversary date of the date of first use. Except for the first payment which will be applied solely to the retirement of principal, all installments shall include accrued interest on the unpaid balance at the rate provided above. The last annual installment for any portion of the storage for future water supply shall be adjusted upward or downward when due to assure repayment of all of the investment costs allocated to such portion within the repayment period.

(4) An estimated schedule of annual payments for the water supply storage [and the water supply conduit] provided for present demand is attached as Exhibit "C" of this agreement. The annual payments as provided therein shall be made subject to Article 6. [Payment schedules for the storage provided for future water supply demands will be furnished by the Contracting Officer when use of such storage is started, and if based on estimated costs will be subject to Article 6.]

[(a) Project Investment Costs. (Option 2. For projects where municipal and industrial water supply storage is being added through reallocations of storage)

(1) The User shall repay to the Government, at the times and with interest on the unpaid balance as hereinafter specified, the amounts stated below which, as shown in Exhibit "B" attached to and made a part of this agreement, constitute the entire actual amount of costs allocated to the water storage right acquired by the User under this contract. The amount of costs is based on [revenues foregone] [benefits foregone] [replacement cost] [updated cost of storage] [provisions of Section 322 of Public Law 101-640] [(other as appropriate)]. The interest rate to be used for purposes of computing interest on the unpaid balance will be the yield rate adjusted at five-year intervals as determined by the Secretary of the Treasury on the basis set forth in Section 932 of the 1986 Water Resources Development Act. For this agreement, the starting interest rate shall be that rate in effect at the time the agreement is approved. For FY ___, such rate is ___ percent. Should the agreement not be signed in FY _____, the amounts due herein will be adjusted to reflect the application of the appropriate rate.

(2) The cost allocated to the storage space indicated in Article 1b(1) is currently estimated at $ ____________ on the basis of the costs presented in Exhibit "B". These costs shall be repaid within the life of the Project in not to exceed 30 years from the date of approval of this agreement by the Secretary of the Army. The payments shall be in equal consecutive annual installments, adjusted a 5-year intervals as shown in Exhibit "C". The first payment shall be due and payable within 30 days after the User is notified by the District Engineer [of approval of this agreement by the Secretary of the Army] [that the project modification is completed and operational for water supply purposes.] Annual installments thereafter will be due and payable on the anniversary date of the date of notification. Except for the first payment which will be applied solely to the retirement of principal all installments shall include accrued interest on the unpaid balance at the rate provided above. The last annual

installment shall be adjusted upward or downward when due to assure repayment of all of the investment costs allocated to the storage within 30 years from the above date.]

(3) The Project construction costs allocated to the storage space indicated in Article 1b(1) as being provided for present demand [and the water supply conduit] is currently estimated at $________, on the basis of the costs presented in Exhibit "B". The costs shall be repaid during the period of construction in the following manner. (Fill in as appropriate). The last payment shall be adjusted upward or downward as appropriate to assure repayment of all the construction cost allocated to the Users storage right during the period of construction.

b. Repair, Rehabilitation, and Replacement Costs. The User will be required to pay [_____ percent of the cost of any repair, rehabilitation, or replacement of specific water supply facilities. In addition, the User will be required to pay]___ percent of the cost of joint-use repair, rehabilitation, or replacement of Project features. Payment of these costs shall be made either incrementally during construction or in lump sum (including interest during construction) upon completion of construction.

c. Annual Operation and Maintenance (O&M) Expense.

(1) Present Use Storage. The User will be required to pay [_____ percent of the annual O&M expense of specific water supply facilities. In addition, the User will be required to pay] ______ percent of the annual experienced joint-use O&M expense of the Project.

[(2) Future Use Storage. (This paragraph may be appropriate only for those projects operational or under construction as of 17 November 1986). [If storage for future water supply demands is used during the ten-year interest-free period, the share of the annual joint-use O&M expense which the User will be required to pay, [in addition to ______ percent of the annual O&M expense of specific water supply facilities,] will be increased commensurate with the User's percentage of future water supply storage being used, up to a total, for both present and future storage space, of ______ percent of such expense. Upon expiration of the ten-year interest free period, the User's share of such expense shall immediately become (the above maximum) percent.] [Since the ten-year interest-free period has expired the User shall be required to pay, [in addition to ____ percent of the annual O&M expense of specific water supply facilities,] ____ percent of the annual joint-use O&M expense.]

(3) Payment. Payments for O&M expense are due and payable in advance [on the plant-in-service date] [on the date for payment of Project investment costs as set forth in Article 5a(2)] and shall be based on O&M expense for the Project in the Government fiscal year most recently ended. The amount of each annual payment will be the actual experienced O&M expense ([specific plus] allocated joint-use) for the preceding fiscal year or an estimate thereof when actual expense information is not available. (The following bracketed language may be appropriate only for those projects operational or under construction as of 17 November 1986) [Should future increment usage during the ten-year interest-free period commence on other than the anniversary date of present usage, O&M expense for that portion of a year would be prorated by months in use prior to said anniversary date on the basis of the actual experienced joint-use O&M expense for the preceding Government fiscal year. The first payment, in such a case, shall be due and payable within 30 days from the date of scheduled first use of storage space. Subsequent annual payments shall be made on the date for payment of project investment costs as set forth in Article 5a(2).]

d. Prepayment. The User shall have the right at any time to prepay the indebtedness under this Article, subject to redetermination of costs as provided for in Article 6, in whole or in part, with accrued interest thereon to the date of such prepayment.

e. Delinquent Payments. If the User shall fail to make any of the aforesaid payments when due, then the overdue payments shall bear interest compounded annually until paid. The interest rate to be used for overdue payments due under the provisions of Articles 5a, 5b, 5c and 5d above shall be that determined by the Department of Treasury's Treasury Fiscal Requirements Manual (1 TFRM 6-8000, "Cash Management"). The amount charged on payments overdue for a period of less than one year shall be figured on a monthly basis. For example, if the payment is made within the first month after being overdue after a 15-day grace period from the anniversary date of the date of notification, one month's interest shall be charged. Thereafter a month's interest will be charged for any portion of each succeeding month that the payment is delinquent. This provision shall not be construed as giving the User a choice of either making payments when due or paying interest, nor shall it be construed as waiving any other rights of the Government, at law or in equity, which might result from any default by the User.

[f. Credit. (This paragraph may be appropriate only for those projects operational or under construction as of 17 November 1986 and is not applicable for interim use for agriculture.) If storage under future-use agreement is used for other beneficial purposes during the interim between the end of the ten-year interest-free period and the time water supply use is initiated and the Federal Government receives payments for such interim use, then the User shall be credited with an appropriate share of payments made under Article 5b and 5c.]

ARTICLE 6 - Adjustment to Project Investment Cost. (In reallocations of storage, this article should be deleted). (This paragraph may be appropriate only for those projects operational or under construction as of 17 November 1986). The investment cost shown in this agreement and the exhibits is based on [[the Governments' best estimates. At the plant-in-service date and again within five years after such date, the District Engineer shall make a revised interim estimated determination of investment costs.] [actual costs at the plant-in-service date. Five years after such date, the District Engineer shall make a revised interim estimated determination of investment costs.] [actual costs five years from the plant-in-service date.] Further interim determinations of cost will be made at intervals considered necessary by the District Engineer. All interim cost estimates will take into account the actual costs to the extent they are then known. Such further interim determinations will be performed at such periods so as to keep the User reasonably informed as to the required payment. On each occasion of a cost adjustment, the annual payments thereafter due shall be adjusted upward or downward so as to provide for repayment of the balance due in equal installments during the remaining life of the repayment period. The last such investment cost adjustment will be made when the last of the construction general funds have been expended. Such final determination will include the Government's approved estimate of any pending real estate items and any known claims not previously accrued.] [actual final construction costs of the project.] Any further investment cost accruing to the User's water storage right shall be repaid under reconstruction, rehabilitation and replacement costs if capitalized or under operation and maintenance expense if not capitalized.

ARTICLE 7 - Duration of Agreement. This agreement shall become effective when approved by the Secretary of the Army or his duly authorized representative and shall continue in full force and effect for the life of the Project.

ARTICLE 8 - Permanent Rights to Storage. Upon completion of payments by the User, as provided in Article 5a herein, the User shall have a permanent right, under the provisions of the Act of 16 October 1963 (Public Law 88-140, 43 U.S.C. 390e), to the use of the water supply storage space in the Project as provided in Article 1, subject to the following:

a. The User shall continue payment of annual operation and maintenance costs allocated to water supply.

b. The User shall bear the costs allocated to water supply of any necessary reconstruction, rehabilitation, or replacement of Project features which may be required to continue satisfactory operation of the Project. Such costs will be established by the District Engineer and repayment arrangements shall be in writing in accordance with the terms and conditions set forth in Article 5b for reconstruction, rehabilitation, and replacement costs, and be made a part of this agreement.

c. Upon completion of payments by the User as provided in Article 5a, the District Engineer shall redetermine the storage space for municipal and industrial water supply in accordance with the provisions of Article 1e. Such redetermination of reservoir storage capacity may be further adjusted from time to time as the result of sedimentation resurveys to reflect actual rates of sedimentation and the exhibit revised to show the revised storage space allocated to municipal and industrial water supply.

d. The permanent rights of the User under this agreement shall be continued so long as the Government continues to operate the Project. In the event the Government no longer operates the Project, such rights may be continued subject to the execution of a separate agreement or additional supplemental agreement providing for:

(1) Continued operation by the User of such part of the facility as is necessary for utilization of the water supply storage space allocated to it;

(2) Terms which will protect the public interest; and,

(3) Effective absolvement of the Government by the User from all liability in connection with such continued operation.

ARTICLE 9 - Release of Claims. (Project documents for certain projects require a specific hold and save harmless agreement from the water supply sponsor. In those cases, the project document language should be used). The User shall hold and save the Government, including its officers, agents and employees harmless from liability of any nature or kind for or on account of any claim for damages which may be filed or asserted as a result of the storage in the Project, or withdrawal or release of water from the Project, made or ordered by the User or as a result of the construction, operation, or maintenance of the water supply facilities and appurtenances thereto owned and operated by the User except for damages due to the fault or negligence of the Government or its contractors.

ARTICLE 10 - Transfers and Assignments.

a. The User shall not transfer or assign this agreement nor any rights acquired thereunder, nor suballot said water supply storage space or any part thereof, nor grant any interest, privilege or license whatsoever in connection with this agreement, without the approval of the Secretary of the Army, or his duly authorized representative provided that, unless contrary to the public interest, this restriction shall not be construed to apply to any water that may be obtained from the water supply storage space by the User and furnished to any third party or parties, nor any method of allocation thereof.

b. Regarding approval of assignments, references to restriction of assignments shall not apply to any transfer or assignment to the Rural Economic Community Development (RECD, formerly Farmers Home Administration) or its successor agency, or nominee, given in connection with the pledging of this water storage agreement as security for any loans or arising out of the foreclosure or liquidation of said loans. The User will notify the Corps in writing 15 days prior to applying for a RECD loan. A copy of the final loan instrument will be furnished to the Corps for their record.

<u>ARTICLE 11 - Officials Not to Benefit</u>. No member of or delegate to Congress, or Resident Commissioner, shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this agreement if made with a corporation for its general benefit.

<u>ARTICLE 12 - Covenant Against Contingent Fees</u>. The User warrants that no person or selling agency has been employed or retained to solicit or secure this agreement upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bona fide established commercial or selling agencies maintained by the User for the purpose of securing business. For breach or violation of this warranty the Government shall have the right to annul this agreement without liability or in its discretion to add to the price or consideration, or otherwise recover the full amount of such commission, percentage, brokerage, or contingent fee.

<u>ARTICLE 13 - Protective Covenant</u>. (Should be deleted when not applicable).

a. In order to utilize the water storage space, the User must acquire a loan from ____________. Pending approval of this loan, the Government shall reserve for the User ______ acre-feet of storage for municipal and industrial water supply purposes for a period of up to _____ months. For this privilege, the User shall pay the Government $1.00 per acre-foot of storage space per year for a total of $______. The payment is not refundable and shall be due and payable within 30 days after the User is notified by the District Engineer that the agreement has been approved. Should the User be unable to secure said loan it shall notify the District Engineer of said failure and the agreement shall be considered terminated at that time.

b. In the event of any termination pursuant to this Article, the User shall, upon request of the District Engineer, promptly remove at User's own expense, any facilities constructed on Project land for water withdrawal and restore premises around the removed facilities to a condition satisfactory to the District Engineer.

<u>ARTICLE 14 - Environmental Quality</u>. During any construction, operation, and maintenance by User of any facilities, specific actions will be taken to control environmental pollution which could result from such activity and to comply with applicable Federal, State, and local laws and regulations concerning environmental pollution. Particular attention should be given to:

a. Reduction of air pollution by control of burning, minimization of dust, containment of chemical vapors, and control of engine exhaust gases, and of smoke from temporary heaters;

b. Reduction of water pollution by control of sanitary facilities, storage of fuels and other contaminants, and control of turbidity and siltation from erosion;

c. Minimization of noise levels;

d. On-site and off-site disposal of waste and spoil; and,

e. Prevention of landscape defacement and damage.

ARTICLE 15 - Federal and State Laws.

a. Compliance. In acting under its rights and obligations hereunder, the User agrees to comply with all applicable Federal and State laws and regulations, including but not limited to the provisions of the Davis-Bacon Act (40 U.S.C. 276a et seq.); the Contract Work Hours and Safety Standards Act (40 U.S.C. 327-333); Title 29, Code of Federal Regulations, Part 3; and Sections 210 and 305 of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of l970 (PL 91-646).

b. Civil Rights Act. The User furnishes, as part of this agreement, an assurance (Exhibit D) that it will comply with Title VI of the Civil Rights Act of 1964 (78 Stat. 241, 42 U.S.C. 2000d, et seq.) and Department of Defense Directive 5500.11 issued pursuant thereto and published in Part 300 of Title 32, Code of Federal Regulations.

c. Regulatory Program. Any discharges of water or pollutants into a navigable stream or tributary thereof resulting from the User's facilities and operations undertaken under this agreement shall be performed only in accordance with applicable Federal, State, and local laws and regulations.

d. Lobbying Activities. The User furnishes, as part of this agreement, a certification (Exhibit E and if applicable, a Disclosure of Lobbying Activities) that it will comply with Title 31 U.S.C. Section 1352 of the limitation on use of appropriated funds to influence certain Federal contracting and financial transactions (Public Law 101-121, October 23, 1989) and Federal Acquisition Regulation 52.203-12 issued pursuant thereto.

ARTICLE 16 - Definitions. (Delete those inappropriate)

a. Project [construction] [investment] costs. The initial cost of the Project, including: land acquisition; construction; [interest during construction on the value of land, labor, and materials used for planning and construction of the Project].

b. Interest Payments.

(1). Interest during construction. An amount of interest which accrues on expenditures for the establishment of Project services during the period between the actual outlay and the time the Project is first made available for water storage.

(2). Interest on the Unpaid Balance. An amount of interest which is computed on the unpaid balance in the amortization schedule. When payments are made in “lump sum,” there is no amortization schedule and therefore, no “interest on the unpaid balance.”

(3). Accrued Interest. An amount of interest compounded following the end of the 10-year interest free period until payments begin to be made. If payments are made in “lump sum” following completion of construction, “accrued Interest” will be applicable.

c. Specific costs. The costs of Project features normally serving only one particular Project purpose.

d. Joint-use costs. The costs of features used for any two or more Project purposes.

e. Plant-in-service date. This date is the date that the Project is physically available to initiate deliberate impoundment for water supply purposes.

f. Annual operation and maintenance (O&M) expense. Annual expenses funded under the O&M, General account. These expenses include the daily Project O&M costs as well as those O&M costs which are not capitalized.

g. Repair, rehabilitation and replacement. Costs funded in part under the Operation and Maintenance, General, or Construction, General accounts but not associated with initial Project investment costs. Such expenditures are for costly, infrequent work and are intended to ensure continued satisfactory operation of the Project.

h. Fiscal Year. Refers to the Government's fiscal year. This year begins on 1 October and ends on 30 September. The September calendar year corresponds to the fiscal year.

i. Life of the Project. This is the physical life of the Project.

j. District Engineer. Refers to the District Engineer of the _____ District of the United States Army Corps of Engineers, or his/her successor or designee.

ARTICLE 17 - Approval of Agreement. This agreement shall be subject to the written approval of the Secretary of the Army or his duly authorized representative and shall not be binding until so approved.

IN WITNESS WHEREOF, the parties have executed this agreement as of the day and year first above written.

APPROVED: THE UNITED STATES OF AMERICA

______________________ By ________________________
1/ (District Engineer)

DATE: _______________

[Insert name of User]

By __________________________
[Title]

(Necessary approvals and countersignatures required by State and local law with respect to execution on behalf of the User must be ascertained by the District Engineer and his Counsel and added to the signature block.)

1/ Fill-in Title of appropriate approving government official if other than District Commander. The approving official for HQUSACE is the Director of Civil Works.

EXHIBIT-A
CERTIFICATION

I _________________________, Attorney for the _________________________,
have reviewed the foregoing agreement executed by _________________,
and as principal legal officer of/for the ____________________ certify that [I have considered the legal effect of Section 221 of the 1970 Flood Control Act (Public Law 9l-6ll) and find that] _________________________________ is legally and financially capable of entering into the contractual obligations contained in the foregoing agreement and that, upon acceptance, it will be legally enforceable.
Given under my hand, this ______________ day of _______________ l9__

____
Attorney for the ___________________

EXHIBIT B COST COMPUTATIONS

I - LAKE STORAGE

Feature	Elevation (ft., NGVD)	Usable Storage* (ac. ft.)	Percent of Conservation Storage	Percent of Water Supply Storage
Flood control	_____ - _____	_______		
Conservation	_____ - _____	_______	100.00	
Water Supply	_____ - _____	(_______)	______	100.00
User		(_______)	______	______
Present		(_______)	______	______
Future		(_______)	______	______
Others		(_______)	______	______
Other purposes	_____ - _____	(_______)	______	
Other purposes	_____ - _____	_______		
Total		_______		

*Storage remaining after l00 years of sedimentation from the date the project is operational.

II - ALLOCATION OF ESTIMATED CONSTRUCTION COST

Feature	Cost ($)	Percent of Project Joint-Use Construction Cost
Flood control	_______	
Specific	(_______)	
Joint-use	(_______)	_______
Recreation	_______	
Specific	(_______)	
Joint-use	(_______)	_______
Water Supply	_______	
Specific	(_______)	
Joint-use	(_______)	_______
Other Purposes	_______	
Specific	(_______)	
Joint-use	(_______)	_______
Road Betterments (specific	_______	
Cultural Resources (specific)	_______	
Total	_______	100.00

EXHIBIT B (CONT)

III - INVESTMENT COSTS TO BE REPAID BY USER FOR WATER SUPPLY STORAGE

Present Use: l/

Cost of_________ acre-feet of water supply storage (____ % X $______)	=	$_________
Cost of specific facilities	=	_________
Subtotal	=	_________
Interest during construction 2/	=	_________
Total investment present use		$_________

Future Use:3/

Cost of _______ acre-feet of water supply storage (____ % X $______)	=	$_________
Interest during construction2/	=	$_________
Total investment future use	=	$_________

Total investment cost under this agreement = $_________
Present Use plus Future Use = $_________

Notes:

1/ If appropriate, add to present use costs, the cost of interest due to the lapse of the l0-year interest free period.

2/ Include which ever of the following is applicable:
"Based on preliminary cost estimate of $_____ X interest rate of ____% X l/2 the estimate construction period of _____ years."
or)
"Based on actual construction expenditures by quarter and an interest rate of ____ %."

3/ Costs cannot exceed 30 per centrum of the total estimated project construction cost as determined in Exhibit B-II.

EXHIBIT B (CONT)

IV - TOTAL ANNUAL COST TO USER FOR PRESENT USE OF WATER SUPPLY STORAGE

Interest and amortization

$_____ X _____ factor based on _____ payments,
_____ with interest at ____ %. = $________

Operation and maintenance1/

Joint-use [estimated] [actual for FY]
_____% X ______ %2/ X $______ = ________

Specific water supply facilities
100% X $______ [estimated] [actual for FY] = ________

Repair, rehabilitation and replacement3/

Joint-use
_____% X ______ X4/ X $______ = ________

Specific water supply facilities
100% X $_____ [estimated] [actual for FY____] = ________

TOTAL ESTIMATED ANNUAL COST $_________

Notes:

1/ Payment due and payable on the date specified in Article 5(a)(2).

2/ Percent of Project joint-use operation and maintenance cost allocated to water supply.

3/ Repair, rehabilitation and replacement costs are payable only when incurred as specified in Article 5(b). It is suggested that the amount shown be placed in a reserve or sinking fund for future contingency.

4/ Percent of Project joint-use repair, rehabilitation and replacement cost allocated to water supply.

EXHIBIT C
AMORTIZATION SCHEDULE
PRESENT DEMAND 1/

TOTAL COST	______
NUMBER OF PAYMENTS	30
INTEREST RATE, PERCENT 2/	______

			APPLICATION	
ANNUAL PAYMENT NUMBER	AMOUNT OF PAYMENT	INTEREST	ALLOCATED COST	BALANCE ALLOCATED COST
	$	$	$	$
l				
2				
.				
.				
.				
.				
.				
30	3/			

Notes:

1/ This 30 year amortization schedule is applicable to:

a. Those projects not operational or under construction as of 17 November 1986 which will be repaid over time in lieu of during construction; and
b. All reallocations.

2/ In accordance with Section 932 of the Water Resources Development Act of 1986, this interest rate will be adjusted at five year intervals throughout the repayment period. The rate is the yield rate as determined by the Secretary of the Treasury plus 1/8 %.

3/ The last (30th) payment will be adjusted upward or downward to assure all costs are repaid within 30 years of approval of the agreement.

EXHIBIT D
ASSURANCE OF COMPLIANCE

ASSURANCE OF COMPLIANCE WITH THE DEPARTMENT OF DEFENSE DIRECTIVE UNDER TITLE VI OF THE CIVIL RIGHTS ACT OF 1964, AS AMENDED; THE AGE DISCRIMINATION ACT OF 1975; AND THE REHABILITATION ACT OF 1973, AS AMENDED

The party executing this assurance, being the applicant recipient of Federal financial assistance under the instrument to which this assurance is attached; HEREBY AGREES THAT, as a part of its obligations under the aforesaid instrument, it will comply with Title VI of the Civil Rights Act of 1964 (P.L. 88-352), as amended (42 U.S.C. 2000d), and all requirements imposed by or pursuant to the Directive of the Department of Defense (32 CFR Part 300), issued as Department of Defense Directive 5500.11 (December 28, 1964), pursuant to that title; The Age Discrimination Act of 1975 (42 U.S.C. 5102); the Rehabilitation Act of 1973, as amended (29 U.S.C. 794), to the end that in accordance with the aforementioned Title, Directive and Acts, no person in the United States shall on the ground of race, color, age, sex, religion, handicap or national origin be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity for which the Applicant-Recipient receives Federal financial assistance from the Department of the Army and HEREBY GIVES ASSURANCE THAT it will immediately take any measures necessary to effectuate this agreement.

If any personal property or real property, or interest therein, or structure thereon is provided or improved with the aid of Federal financial assistance extended to the applicant-recipient by the Department of the Army, or if such assistance is in the form of personal property or real property, or interest therein or structure thereon, then this assurance shall obligate the applicant-recipient or in the case of any transfer of such property, any transferee, for the period during which the property is used for a purpose for which the Federal financial assistance is extended or for another purpose involving the provision of similar services or benefits, or for the period during which it retains ownership or possession of the property whichever is longer. In all other cases, this assurance shall obligate the applicant-recipient for the period during which the Federal financial assistance is extended to it by the Department of the Army. The Department of the Army representatives will be allowed to visit the recipient's facilities. They will inspect the facilities to ensure that there are no barriers to impede the handicap's accessibility in either programs or activities.

THIS ASSURANCE is given in consideration of and for the purpose of obtaining any and all Federal grants, loans, contracts, property, discounts or other Federal financial assistance extended after the date hereof to the applicant-recipient by the Department of the Army, including installment payments after such date on account of arrangements for Federal financial assistance which were approved before such date. The applicant-recipient recognizes and agrees that such Federal financial assistance will be extended in reliance on the representations and agreements made in this assurance, and that the United States shall have the right to seek judicial enforcement of this assurance. This assurance is binding on the applicant-recipient, its successors, transferees, and assignees, and the person or persons whose signatures appear below are authorized to sign this assurance on behalf of the applicant.

Date ____________________ ____________________

(Applicant-Recipient)

By ____________________

____________________________________ Title ______________

____

(Applicant-Recipient's Mailing Address)

EXHIBIT E
CERTIFICATION REGARDING LOBBYING

[Project Name]

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1. The undersigned certifies, to the best of their knowledge and belief, that:

a. No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

b. If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress or an employee of a Member of Congress in connection with the water supply agreement for the [project name], the undersigned shall complete and submit Standard Form-LLL, "Disclosure of Lobbying Activities", in accordance with its instructions. This form is available to users by requesting it telephonically at (202)761-0116, or by writing to HQUSACE (CECW-A), 20 Massachusetts Avenue, NW, Washington, D.C., 20314-1000.

c. The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans and cooperative agreements) and that all subrecipients shall certify and disclose accordingly.

2. This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by Section 1352, Title 31 U.S.C. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

SPONSOR

BY ________________________________

DISCLOSURE OF LOBBYING ACTIVITIES

Complete this form to disclose lobbying activities pursuant to 31 U.S.C. 1352
(See continuation sheet for public burden disclosure)

1. Type of Federal Action:
☐ a. contract
b. grant
c. cooperative agreement
d. loan
e. loan guarantee
f. loan insurance

2. Status of Federal Action:
☐ a. bid/offer application
b. initial award
c. post-award

3. Report Type:
☐ a. initial filing
b. material change
For Material Change Only:
year ______ quarter _______
date of last report __________

4. Name and Address of Reporting Entity:
☐ Prime ☐ Subawardee
Tier _______, *if known*:

Congressional District, *if known:*

5. If Reporting Entity in No. 4 is Subawardee, Enter Name and Address of Prime:

Congressional District, *if known*:

6. Federal Department'/Agency

7. Federal Program Name/Description

CFDA Number, *if applicable*: __________

8. Federal Action Number, *if known*

9. Award Amount, *if known:*
$

10 a. Name and Address of Lobbying Entity
(if individual, last name, first name, MI):

(attach Continuation Sheet(s) if necessary)

10 b. Individuals Performing Services *(including address if different from No. 10 a)*
(last name, first name, MI):

(attach Continuation Sheet(s) if necessary)

11. Amount of Payment *(check all that apply)*:
$ _________________ ☐ actual ☐ planned

12. Form of Payment *(check all that apply)*:
☐ a. cash
☐ b. in-kind; specify: nature ___________________
value ___________________

13. Type of Payment *(check all that apply)*:
☐ a. retainer
☐ b. one-time fee
☐ c. commission
☐ d. contingency fee
☐ e. deferred
☐ f. other; specify: ___________________________

14. Brief Description of Services Performed and Dates(s) of Service, including officer(s), employee(s), or member(s) contacted, for Payment Indicated in Item 11:

(attach Continuation Sheet(s) if necessary)

15. Continuation Sheet(s) attached: ☐ **Yes** ☐ **No**

16. Information requested through this form is authorized by title 31 U.S.C. section 1352. This disclosure of lobbying activities is a material representation of fact upon which reliance was place by the tier above when the transaction was made or entered into. This disclosure is required pursuant to 3l U.S.C. 1352. This information will be reported to the Congress semiannually and will be available for public inspection. Any person who fails to file the required disclosure shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Signature: ____

Print Name: ______________________________________

Title: ____

Telephone No.: ________________ **Date:** ____________

Federal Use Only:

Authorized for Local Reproduction Standard Form - LLL

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DISCLOSURE OF LOBBYING ACTIVITIES
CONTINUATION SHEET

Reporting Entity: ____ Page ___ of ___

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Standard Form - LLL-A

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INSTRUCTIONS FOR COMPLETION OF SF-LLL, DISCLOSURE

This disclosure form hall be completed by the reporting entity, whether subawardee or prime Federal recipient, at the initiation or receipt of a covered Federal action, or a material change to a previous filling, pursuant to title 31 U.S.C. section 1352. The filing of a form is required for each payment or agreement to make payment to any lobbing entity for influencing or attempting to influence an office or employee of any agency, a Member of Congress, an office or employee of Congress, or an employee of a Member of Congress in connection with a covered Federal action. Use the SF-LLL-A Continuation Sheet for additional information if the space on the form is inadequate. Complete all items that apply for both the initial filing and material change report. Refer to the implementing guidance published by the Office of Management and Budget for additional information.

1. Identify the type of covered Federal action for which lobbing activity is and/or has been secured to influence the outcome of a covered Federal action.

2. Identify the status of the covered Federal action.

3. Identify the appropriate classification of this report. If this is a follow-up report caused by a material change to the information previously reported, enter the year and quarter in which the change occurred. Enter the date of the last preciously submitted report by this reporting entity for this covered Federal action.

4. Enter the full name, address, city, state and zip code of the reporting entity. Include Congressional District, if known., Check the appropriate classification of the reporting entity that designates if it is, or expects to be, a prime or subaward recipient. Identify the tier of the subawardee, e.g., the first subawardee of the prime is the St. tier. Subawards include but are not limited to subcontracts, subgrants and contract awards under grants.

5. If the organization filing the report in item 4 checks, "Subawardee," then enter the full name, address, city, state and zip code of the prime Federal recipient. Include Congressional District, if known.

6. Enter the name of the Federal agency making the award or loan commitment. Include at least one organizational level below agency name, if know. For example, Department of Transportation, United States Coast Guard.

7. Enter the Federal program name or description for the covered Federal action (item 1). If know, enter the full Catalog of Federal Domestic Assistance (CFDA) number for grants, cooperative agreements, loans, and loan commitments.

8. Enter the most appropriate Federal identifying number available for the Federal action identified in item 1 (e.g., Request for Proposal (RFP) number; invitation for Bid (IFB) number; grant announcement number; the contract, grant, or loan award number; the application/proposal control number assigned by the Federal agency). Include prefixes, e.g., "RFP-DE-90-001."

9. For a covered Federal action where there has been an award or loan commitment by the Federal agency, enter the Federal amount of the award loan commitment for the prime entity identified in item 4 or 5.

10. (a). Enter the full name, address, city, state and zip code of the lobbying entity engaged by the reporting entity identified in item 4 to influence the covered Federal action.

(b). Enter the full names of the individual(s) performing services, and include full address if different from 10 (a). Enter Last Name, First Name, and Middle initial (MI).

11. Enter the amount of compensation paid or reasonably expected to be paid by the reporting entity (item 4) to the lobbying entity (item 10). Indicate whether the payment has been made (actual) or will be made (planned). Check all boxes that apply. If this is a material change report, enter the cumulative amount of payment made or planned to be made.

12. Check the appropriate box(es). Check all boxes that apply. If payment is made through an in-kind contribution. Specify the nature and value of the in-kind payment.

13. Check the appropriate box(es). Check all boxes that apply., If other, specify nature.

14. Provide a specific and detailed description of the services that the lobbyist has performed, or will be expected to perform, and the date(s) of any services rendered. Include all preparatory and related activity, not just time spent in actual contact with Federal officials. Identify the Federal official(s) or employee(s) contacted or the officer(s), employee((s), or Member(s) of Congress that were contacted.

15. Check whether or not a SF-LLL-A Continuation Sheet(s) is attached.

16. The certifying official shall sign and date the form, print his/her name, title, and telephone number.

Copied from ER 1105-2-100, Page Q-5, dated 28 December 1990

MODEL FORMAT
FOR SURPLUS WATER AGREEMENTS
(also see ER 1105-2-100, Appendix K, dated 15 January 1998)

PART 2: SURPLUS WATER AGREEMENT
BETWEEN THE UNITED STATES OF AMERICA
AND
____
FOR
SURPLUS OF WATER FROM ______________________________

THIS AGREEMENT, entered into this _______ day of __________, l9__, by and between the UNITED STATES OF AMERICA (hereinafter called the "Government") represented by the District Engineer executing this agreement, and ___________ ____________, (hereinafter called the "User"*);

WITNESSETH THAT:

WHEREAS, pursuant to **Public Law ________, ________ the Congress, _____ Session, approved ____________________ l9__, the Government has constructed and is operating _______________, (hereinafter called the "Project"); and,

WHEREAS, Section 6 of the Flood Control Act of 1944 (Public Law 78-534), as amended, provides that the Secretary of the Army is authorized to enter into agreements with states, municipalities, private concerns, or individuals, at such prices and on such terms as he may deem reasonable, for domestic and industrial uses for surplus water that may be available at any reservoir under his control provided that no agreements for such water shall adversely affect the existing lawful uses of such water;

WHEREAS, the User desires to enter into an agreement with the Government for the privilege of withdrawing surplus water from the Project; and

WHEREAS, provided as Exhibit "_": attached to and made a part of this agreement, is a letter report entitled "_____________________," dated: _______, which provides information pertinent to the use of surplus water in the Project by the User;

NOW, THEREFORE, the parties do mutually agree as follows:

ARTICLE 1 - Water Supply and Withdrawals.

a. The Government will reserve ______ acre feet of storage space in the Project in order to meet the water demands of the User. From this storage space the User shall have the privileges of withdrawing water at a rate not to exceed ___________ during the term of this contract as specified in Article 6 hereof.

* Other appropriate terms may be used in lieu of User here and uniformly throughout the agreement.
**Use correct authorization citation (e.g., WRDA of l9__, Public Law __-____).

b. The User shall have the right to construct, operate and maintain installations and facilities, or to enter into agreements with third parties therefor, for the purpose of withdrawing water from the Project, subject to the approval of the District Engineer as to design and location of such installation and facilities. All costs associated with such installations and facilities or any modifications thereof or any future construction in connection therewith, shall be without expense to the Government.

c. The Government reserves the right to control and use all storage in the project in accordance with authorized Project purposes. The Government further reserves the right to take such measures as may be necessary in the operation of the Project to preserve life and/or property, including the right not to make downstream releases during such periods of time as are deemed necessary, in its sole discretion, to inspect, maintain, or repair the Project.

d. The User recognizes that this agreement provides storage space for raw water only. The Government makes no representation with respect to the quality or availability of water and assumes no responsibility therefor, or for treatment of the water. The water level of the Project will be maintained at elevations which the Government deems will best serve the authorized purposes of the Project, and this agreement shall not be construed as giving the User any rights to have the water level maintained at any elevation. The User further recognizes that it is acquiring no permanent right to the use of storage in the Project.

<u>ARTICLE 2 - Metering</u>. For the purpose of maintaining an accurate record of the water withdrawn from the Project, the User agrees to furnish and install, or cause to be installed, meters or measuring devices satisfactory to the District Engineer, without cost to the Government. As required, the User agrees to furnish to the District Engineer advance estimates of need and records of the quantity of water actually withdrawn. Such devices shall be available for inspection by Government representatives at all reasonable times.

<u>ARTICLE 3 - Regulation of the Use of Water</u>. The regulation of the use of and water rights needed for the water withdrawn or released from the storage space shall be the sole responsibility of the User and under the sole authority of the User in accord with Federal, State, and local laws and shall not be considered a part of this agreement. The Government shall not be responsible for the use of water by the User, nor will it become a party to any controversies involving the water use, except as such controversies may affect the operations of the Project.

<u>ARTICLE 4 - Consideration and Payment</u>. (To be determined by the pricing policy as described in paragraph B-5 of Chapter 2 of this "Water Supply Handbook" and detailed in the letter report provided as Exhibit "____" to this agreement. Derivation of costs and storage volumes need to be provided in an exhibit similar to that used in storage agreements (see pages B-13, B-14 and B-15 of this appendix).

(a) In consideration of the right to withdraw _____ acre-feet per calendar year for [not to exceed five (5) years] from the Project for municipal and industrial water supply purposes, the User shall pay the Government $______ [per year, the first of] which shall be due and payable within thirty (30) days of the effective date of the agreement as set forth in Article 5 herein. [Future payments thereafter will be due and payable on [the anniversary date the first payment is due.][(day and month) each following year, beginning in (year).]]

(b) The repayment amount shown in Article 4(a) is based [upon joint use and specific water supply construction costs updated to October 19___ price levels using appropriate indices and the Fiscal Year 19____ water supply interest rate of ________________ percent as computed by the Secretary of the Treasury in accordance with Section 932 of the Water Resources Development Act of 1986 (Public Law 99-662)] [on the provisions of Section 322 of the Water Resources Development Act of 1990 (Public Law 101-640)].

(c) If the User shall fail to make any payment under this agreement within thirty (30) days of the date due, interest thereon shall accrue at the rate as determined by the Department of Treasury's Treasury Fiscal Requirements Manual (1 TFRM 6-8000, "Cash Management") and shall compound annually from the date due until paid. This provision shall not be construed as waiving any other rights the Government may have in the event of default by the User, including but not limited to the right to terminate this agreement for default.

<u>ARTICLE 5 - Duration of Agreement</u>. This agreement shall become effective as of the date of the approval by the [Secretary of the Army or his duly authorized representative] [District Engineer], and shall continue in full force and effect under the conditions set forth herein, for a period of not to exceed five (5) years from the said date of approval. Upon expiration, this agreement may be extended by mutual agreement for additional periods of not to exceed five (5) years each. All such agreement extensions shall be subject to recalculation of reimbursement. Nothing in this agreement, nor in any extension thereto, shall imply a permanent right to utilize the storage space.

<u>ARTICLE 6 - Termination of Agreement</u>.

a. Either party may terminate this agreement and the privilege of withdrawing water upon [period] written notice. In the event of termination under this paragraph, the Government will make pro rata refund for any balance of the agreement term for which payment has been made and the User will pay all charges which have accrued through the date of the termination.

b. The Government may terminate this agreement and the privilege of withdrawing water upon ninety (90) days written notice, if the User shall default in performance of any obligation of this agreement. Upon such a termination, User shall continue to be liable to the Government for any monies owned and for any costs incurred by the Government as a result of the default.

c. In the event of any termination pursuant to this Article or Article 5, User shall, upon request of the District Engineer, promptly remove, at User's own expense, any facilities constructed on Project land for water withdrawal and restore premises around the removed facilities to a condition satisfactory to the District Engineer.

<u>ARTICLE 7 - Rights-of-Way</u>. Occupancy and use of Project lands shall be in accordance with any permits, rights-of-way, or easements granted to the User by the Government.

<u>ARTICLE 8 - Release of Claims</u>. The User shall hold and save the Government, including its officers, agents, and employees, harmless from liability of any nature or kind for or on account of any claim for damages which may be filed or asserted as a result of the withdrawal or release of water from the Project made or ordered by the User, or as a result of the construction, operation or maintenance of any facilities or appurtenances owned and operated by the User except for damages due to the fault or negligence of the Government or its contractors.

ARTICLE 9 - Transfer or Assignment. The User shall not transfer or assign this agreement nor any rights acquired thereunder, nor suballot said water or storage space or any part thereof, nor grant any interest, privilege or license whatsoever in connection with this agreement, without the approval of the Secretary of the Army or his duly authorized representative provided that, unless contrary to public interest this restriction shall not be construed to apply to any water which may be withdrawn or obtained from the water supply storage space by the User and furnished to any third party or parties or to the rates charged therefor.

ARTICLE 10 - Officials Not to Benefit. No member of or delegate to Congress, or Resident Commissioner, shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this agreement if made with a corporation for its general benefit.

ARTICLE 11 - Covenant Against Contingent Fees. The User warrants that no person or selling agency has been employed or retained to solicit or secure this agreement upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bona fide established commercial or selling agencies maintained by the User for the purpose of securing business. For breach or violation of this warranty, the Government shall have the right to annul this agreement without liability, or in its discretion, to add to the agreement price or consideration the full amount of such commission, percentage, brokerage, or contingent fee.

ARTICLE 12 - Environmental Quality. During any construction, operation, and maintenance by the User of any facilities, specific actions will be taken to control environmental pollution which could result from such activity and to comply with applicable Federal, State and local laws and regulations concerning environmental pollution. Particular attention should be given to (1) reduction of air pollution by control of burning, minimization of dust, containment of chemical vapors, and control of engine exhaust gases, and of smoke from temporary heaters; (2) reduction of water pollution by control of sanitary facilities, storage of fuels and other contaminants, and control of turbidity and siltation from erosion; (3) minimization of noise levels; (4) onsite and offsite disposal of water and spoil; and (5) prevention of landscape defacement and damage.

ARTICLE 13 - Federal and State Laws.

a. The User shall utilize the water withdrawn from the Project in a manner consistent with Federal, State, and local laws.

b. The User furnishes, as part of the agreement, an "Assurance of Compliance" (see pages B-17 and B-18 of this appendix) with Title VI of the Civil Rights Act of l964 (78 Stat. 252; 42 U.S.C. 2000d, et seq) and Department of Defense Directive 5500.11 issued pursuant thereto and published in Part 300 of Title 32, Code of Federal Regulations.

c. Any discharges of water or pollutants into a navigable stream or tributary thereof resulting from the User's facilities and operations undertaken under this agreement shall be performed only in accordance with applicable Federal, State and local laws and regulations.

ARTICLE 14 - Approval of Agreement. This agreement shall be subject to the written approval of the Secretary of the Army or his duly authorized representative and shall not be binding until so approved.

IN WITNESS WHEREOF, the parties have executed this agreement as of the day and year first above written.

APPROVED: THE UNITED STATES OF AMERICA

________________________________ By ___________________________

1/ (District Engineer)

[Insert name of User]

DATE:____________ By ___________________________

[Title]

1/ Fill-in Title of appropriate approving Government official if other than the District Engineer.

(Necessary approvals and countersignatures required by State and local law with respect to execution on behalf of the User must be ascertained by the District Engineer and his Counsel and added to the signature block.)

MODEL FORMAT
FOR WATER WITHDRAWAL PERMITS
(also see ER 1105-2-100, Appendix K, dated 15 January 1998)

PART 3: WATER WITHDRAWAL PERMIT
___________ LAKE

Pursuant to the authority contained in Section 6 of the Flood Control Act of 1944 and in recognition of the declaration of emergency in the State of ____________, as declared by the Governor, this permit grants permission to ___________________ to withdraw water subject to the following conditions:

a. Payment of ___________ 1/ for the withdrawal of up to ___________ 2/ gallons of water during ____________ 3/. User will report the amount of each withdrawal to the Project Office.

b. Right-of-entry and permission to withdraw water is granted only at the location(s) designated by the Corps of Engineers.

c. Should facilities, such as roads, etc. be damaged by the User as a result of emergency uses, the User may be assessed and billed a follow up charge to help in the cost of necessary repairs.

d. Your copy of this permit must be displayed during water withdrawal.

f. The User certifies that water withdrawn from the project is for domestic and/or industrial purposes and will not be used for crop irrigation purposes.

g. The User agrees to comply with appropriate State laws concerning water rights and uses and will obtain permits as are required.

h. The User shall hold and save the Government, including its officer, agents, and employees, harmless from liability of any nature or kind for or on account of any claim for damages which may be filed or asserted as a result of the withdrawal of water from the Project by the User, or as a result of the operation or maintenance of any facilities or appurtenances owned and operated by the User.

User's Name ______________________________ Government Approval:________________
(Print) (Project Manager)

Address ______________________________ Today's Date:_____
Telephone ______________________________
User's Signature _________________________

Government Approval _____________________
(Project Manager)

Today's Date __________________

1/ The dollar value of the storage utilized as determined by the pricing policy, or $25., whichever is larger. The $25. represents the minimum cost for storage that will be marketed.

2/ The number of gallons that the storage utilized yields on an annual basis. The minimum amount being the yield represented by a cost of $25.

3/ Explain the time period allowed for the withdrawal as well as other time related specifications for the withdrawal, such as a maximum rate over any given time period. The period shall not exceed one year.

APPENDIX C

DATABASES

DECEMBER 1998

Table of Contents

DATABASE I
RESERVIORS[1] WITH M&I WATER SUPPLY AS AN AUTHORIZED AND/OR OPERATING PURPOSE

[1] Definition and list of reservoirs from U.S. Army Corps of Engineers Report entitled "Authorized and Operating Purposes of Corps of Engineers Reservoirs," Appendix E, dated July 1992.

Database I
Reservoirs with M&I Water Supply as an Operating and/or Authorized Purpose

Division	District	Project	State	Operating Purpose	Authorized Purpose	M&I Storage Space
NAD	New England	Colebrook	CT / MA	Yes	Yes	Yes
		East Brimfield	MA	Yes	Yes	Yes
		Littlefield	MA	Yes	Yes	Yes
	Philadelphia	Beltzville	PA	Yes	Yes	Yes
		Blue Marsh	PA	Yes	Yes	Yes
		Francis E. Walter	PA	Yes	Yes	No
	Baltimore	Cowanesque	PA	Yes	Yes	Yes
		Jennings Randolph	MD/ WV	Yes	Yes	Yes
		Stillwater Lake	PA	Yes	Yes	No
SAD	Wilmington	B. Everet Jordan	NC	Yes	Yes	Yes
		Falls Lake	NC	Yes	Yes	Yes
		John H. Kerr	VA/NC	Yes	Yes	Yes
		Philpott	VA	Yes	Yes	No
		W. Kerr Scott	NC	Yes	Yes	Yes
	Savannah	Hartwell	SC/GA	Yes	Yes	Yes
		J. Strom Thurmond	SC/GA	Yes	Yes	Yes
		New Savannah Bluff	SC/GA	Yes	No	No
		Richard B. Russell	SC/GA	Yes	Yes	Yes
	Jacksonville	Central & Southern FL	FL	Yes	Yes	No
		Cerrillos D&R	PR	Yes	Yes	Yes
		Four River Basins	FL	Yes	Yes	No
		Portuges D&R	PR	No	Yes	No
	Mobile	Allatoona	GA	Yes	Yes	Yes
		Bay Springs L&D	MS	Yes	No	No
		Bufort Dam- L. Sidney Lanier	GA	Yes	Yes	No
		Jim Woodruff L&D	FL	Yes	No	No
		Okatibbee Lake	MS	No	Yes	Yes
		West Point	GA	Yes	No	No
LRD	Detroit	Menasha L&D	WI	Yes	No	No
	Pittsburgh	Berlin Lake	OH	Yes	Yes	Yes
		Michael J. Kirwan	OH	Yes	Yes	Yes
		Mosquito Creek	OH	Yes	Yes	Yes
		Stonewall Jackson	WV	Yes	Yes	Yes
		Tygart River Lake	WV	Yes	Yes	No
	Huntington	Alum	OH	Yes	Yes	Yes
		John W. Flannagan	VA	Yes	Yes	Yes
		North Fork of Pound Lake	VA	Yes	Yes	Yes
		Paint	OH	Yes	Yes	Yes
		Tom Jenkins Dam	OH	Yes	Yes	Yes
	Louisville	Barren River Lake	KY	Yes	Yes	Yes
		Brookville	IN	Yes	Yes	Yes
		Caesar	OH	Yes	Yes	Yes
		Green River	KY	Yes	Yes	Yes
		Monroe	IN	Yes	Yes	Yes
		Nolin	KY	Yes	Yes	No
		Patoka	IN	Yes	Yes	Yes
		Rough River Lake	KY	Yes	Yes	Yes
		William H. Harsha Lake	OH	Yes	Yes	Yes

Division	District	Project	State	Operating Purpose	Authorized Purpose	M&I Storage Space
LRD (cont.)	Nashville(1)	Barkley	KY	Yes	No	No
		Center Hill Lake	TN	Yes	No	No
		Cheatham L&D	TN	Yes	No	No
		Cordell Hull L&D	TN	Yes	No	No
		J. Percy Priest	TN	Yes	No	No
		Martin	KY	Yes	No	No
		Old Hickory L&D	TN	Yes	No	No
		Wolf Creek Dam	KY	Yes	No	No

(1) Although storage space is not allocated for water supply on either a permanent (PL 85-500) or temporary (PL 78-534) basis, water is being withdrawn by municipalities and industries for M&I purposes. Consequently, during drought, consideration is given to keeping lake levels above supply pipe intakes.

Division	District	Project	State	Operating Purpose	Authorized Purpose	M&I Storage Space
MVD	Rock Island	Coralville	IA	No	Yes	No
		Red Rock	IA	No	Yes	No
		Saylorville	IA	Yes	Yes	Yes
	St. Paul	Gull	MN	Yes	Yes	No
		Homme	ND	Yes	Yes	No
		Leech Lake Dam	MN	Yes	Yes	No
		Orwell	MN	Yes	Yes	No
		Pine River Dam	MN	Yes	Yes	No
		Pokegama Dam	MN	Yes	Yes	No
		Sandy Lake Dam	MN	Yes	Yes	No
		Winnibigoshish Dam	MN	Yes	Yes	No
	St. Louis	Carlyle	IL	Yes	Yes	Yes
		Clarence Cannon Dam	MO	Yes	Yes	Yes
		Lake Shelbyville	IL	Yes	Yes	Yes
		Rend Lake	IL	Yes	Yes	Yes
	Vicksburgh	Caddo	LA	No	Yes	No
		DeGray	AR	Yes	Yes	Yes
NWD	Seattle	Howard A. Hanson	WA	No	Yes	No
		Wynoochee	WA	Yes	Yes	Yes
	Portland	Lost Creek	OR	Yes	Yes	Yes
		Willow Creek	OR	No	Yes	No
	Omaha	Big Bend Dam, L. Sharpe	SD	Yes	Yes	No
		Bowman-Haley	ND	No	Yes	Yes
		Chatfield	CO	Yes	Yes	No
		Ft. Peck Dam	MT	Yes	Yes	No
		Ft. Randall Dam	SD	Yes	Yes	No
		Garrison Dam	ND	Yes	Yes	Yes
		Gavins Point Dam	SD/NE	Yes	Yes	No
		Oahe Dam	ND/SD	Yes	Yes	No
	Kansas City	Clinton	KS	Yes	Yes	Yes
		Hillsdale	KS	Yes	Yes	Yes
		Kanopolis	KS	Yes	Yes	No
		LongBranch	MO	Yes	Yes	Yes
		Melvern	KS	No	Yes	No
		Milford	KS	Yes	Yes	Yes
		Perry	KS	Yes	Yes	Yes
		Pomme De Terre Lake	MO	No	Yes	No
		Pomona	KS	Yes	Yes	Yes
		Rathbun	IA	Yes	Yes	Yes
		Smithville	MO	Yes	Yes	Yes
		Stockton	MO	No	Yes	No
		Tuttle	KS	Yes	Yes	No

Division	District	Project	State	Operating Purpose	Authorized Purpose	M&I Storage Space
SWD	Little Rock	Arthur V. Ormand L&D	AR	No	Yes	No
		Beaver	AR	Yes	Yes	Yes
		Blue Mountain	AR	Yes	No	Yes
		Bull Shoals	AR	Yes	Yes	Yes
		Dardanelle L&D	AR	No	Yes	No
		David D. Terry L&D	AR	No	Yes	No
		DeQueen	AR	Yes	Yes	Yes
		Dierks	AR	Yes	Yes	Yes
		Emmitt Sanders L&D	AR	No	Yes	No
		Gillham	AR	Yes	Yes	Yes
		Greers Ferry	AR	Yes	Yes	Yes
		James W. Trimble L&D	AR	No	Yes	No
		L&D #3 - Arkansas River	AR	No	Yes	No
		L&D #5 - Arkansas River	AR	No	Yes	No
		Millwood Lake	AR	Yes	Yes	Yes
		Murray L&D	AR	No	Yes	No
		Nimrod	AR	Yes	Yes	Yes
		Norfork	AR	Yes	Yes	Yes
		Norrvell L&D	AR	No	Yes	No
		Ozard Jetta - Taylor L&D	AR	No	Yes	No
		Table Rock	MO	Yes	Yes	No
		Toad Suck Ferry L&D	AR	No	Yes	No
		Wilber D. Mills L&D	AR	No	Yes	No
	Ft. Worth	Aquilla	TX	Yes	Yes	Yes
		Bardwell	TX	Yes	Yes	Yes
		Belton	TX	Yes	Yes	Yes
		Benbrook	TX	Yes	Yes	Yes
		Canyon	TX	Yes	Yes	Yes
		Cooper	TX	Yes	Yes	Yes
		Ferrell's Bridge Dam	TX	Yes	Yes	Yes
		Granger	TX	Yes	Yes	Yes
		Grapevine	TX	Yes	Yes	Yes
		Hords Creek	TX	Yes	Yes	Yes
		Joe Po ol	TX	Yes	Yes	Yes
		Lavon	TX	Yes	Yes	Yes
		Lewisville	TX	Yes	Yes	Yes
		Navarro Mills	TX	Yes	Yes	Yes
		North San Gabriel Dam	TX	Yes	Yes	Yes
		O. C. Fisher	TX	Yes	Yes	Yes
		Proctor	TX	Yes	Yes	Yes
		Ray Roberts	TX	Yes	Yes	Yes
		Sam Rayburn	TX	Yes	Yes	Yes
		Somerville	TX	Yes	Yes	Yes
		Stillhouse Hollow	TX	Yes	Yes	Yes
		Town Bluff Dam	TX	Yes	Yes	Yes
		Waco	TX	Yes	Yes	Yes
		Whitney	TX	Yes	Yes	Yes
		Wright Patman	TX	Yes	Yes	Yes

Division	District	Project	State	Operating Purpose	Authorized Purpose	M&I Storage Space
SWD	Tulsa	Arcadia	OK	Yes	Yes	Yes
(cont.)		Birch	OK	Yes	Yes	Yes
		Broken Bow	OK	Yes	Yes	Yes
		Canton	OK	Yes	Yes	Yes
		Copan	OK	Yes	Yes	Yes
		Council Grove	KS	Yes	Yes	Yes
		Denison Dam, L. Texoma	OK/TX	Yes	Yes	Yes
		El Dorado	KS	Yes	Yes	Yes
		Elk City	KS	Yes	Yes	Yes
		Eufaula	OK	Yes	Yes	Yes
		Fall	KS	No	Yes	No
		Fort Supply	OK	Yes	No	Yes
		Heyburn	OK	Yes	Yes	Yes
		Hugo	OK	Yes	Yes	Yes
		Hulah	OK	Yes	Yes	Yes
		John Redmond	KS	Yes	Yes	Yes
		Kaw	OK	Yes	Yes	Yes
		Keystone	OK	Yes	Yes	Yes
		Marion	KS	Yes	Yes	Yes
		Oologah	OK	Yes	Yes	Yes
		Optima (1)	OK	No	Yes	No
		Pat Mayse	TX	Yes	Yes	Yes
		Pearson-Skubitz, Big Hill	KS	Yes	Yes	Yes
		Pine Creek	OK	Yes	Yes	Yes
		Sardis	OK	Yes	Yes	Yes
		Skiatook	OK	Yes	Yes	Yes
		Tenkiller Ferry Lake	OK	Yes	Yes	Yes
		Toronto	KS	Yes	Yes	Yes
		Waurika	OK	Yes	Yes	Yes
		Wister	OK	Yes	Yes	Yes

(1) Optima Lake was designed for 76,200 acre-feet of water supply storage. However, due to changed conditions, the lake has never filled. Optima has no storage or yield.

Division	District	Project	State	Operating Purpose	Authorized Purpose	M&I Storage Space
SPD	Sacramento	Coyote Valley	CA	Yes	Yes	No
		Dry Creek (Warm Springs)	CA	Yes	Yes	Yes
		Martis Creek	CA	No	Yes	No
		New Hogan	CA	Yes	Yes	No
	Los Angeles	Alamo	AZ	Yes	Yes	No
	Albuquerque	Abiquiu	NM	Yes	Yes	Yes

Database I - Summary
Reservoirs with M&I Water Supply as an Operating and/or Authorized Purpose

Division	Number of Projects	Number with M&I as an Operating Purpose	Number with M&I as an Authorized Purpose	Number of Different States	Number with M&I Storage Agreements
NAD	9	9	9	5	7
SAD	19	17	15	6	10
LRD	29	29	19	7	17
MVD	17	14	17	7	6
NWD	25	19	25	10	12
SWD	78	64	76	5	63
SPD	6	5	6	3	2
TOTAL	183	157	167	36	117

DATABASE II
M&I WATER SUPPLY STORAGE SPACE BY PROJECT

Database II
M&I Water Supply Storage Space

Division	District / Reservoir	Present Use (acre-feet)	Future Use Under Contract (acre-feet)	Future Use Not Under Contract (acre-feet)	Total Storage Space (acre-feet)
NAD	**New England**				
	Colebrook	30,700	0	0	30,700
	East Brimfield	1,140	0	0	1,140
	Littleville	9,400	0	0	9,400
	subtotal district	41,240	0	0	41,240
	Philadelphia				
	Beltzville	27,880	0	0	27,880
	Blue Marsh	4,000	4,000	0	8,000
	subtotal district	31,880	4,000	0	35,880
	Baltimore				
	Cowanesque	24,335	0	0	24,335
	Jennings Randolph	40,995	0	0	40,995
	subtotal district	65,330	0	0	65,330
	Total Division	**138,450**	**4,000**	**0**	**142,450**
SAD	**Wilmington**				
	B. Everett Jordan	0	45,800	0	45,800
	Falls Lake	11,300	33,700	0	45,000
	John H. Kerr	10,823	0	0	10,823
	W. Kerr Scott	33,000	0	0	33,000
	subtotal district	55,123	79,500	0	134,623
	Savannah				
	Hartwell	7,507	17,240	0	24,747
	J. Strom Thurmond	381	0	0	4,179
	Richard B. Russell	381	0	0	381
	subtotal district	12,067	17,240	0	29,307
	Jacksonville				
	Cerrillos D & R	25,200	0	0	25,200
	subtotal district	25,200	0	0	25,200
	Mobile				
	Allatoona	15,136	0	0	15,136
	Okatibbee	13,100	0	0	13,100
	subtotal district	28,236	0	0	28,236
	Total Division	**120,626**	**96,740**	**0**	**217,366**

Division	District / Reservoir	Present Use (acre-feet)	Future Use Under Contract (acre-feet)	Future Use Not Under Contract (acre-feet)	Total Storage Space (acre-feet)
LRD	**Pittsburgh**				
	Berlin	19,400	0	0	19,400
	Michael J. Kirwan	52,900	0	0	52,900
	Misquito Creek	11,000	0	0	11,000
	Stonewall Jackson	0	0	2,200	2,200
	subtotal district	83,300	0	2,200	85,500
	Huntington				
	Alum Creek	29,700	49,500	0	79,200
	John W. Flannagan	356	1,769	0	2,125
	North Fork of Pound	62	0	0	62
	Paint Creek	721	0	0	721
	Tom Jenkins	5,690	0	0	5,690
	subtotal district	36,529	51,269	0	87,798
	Louisville				
	Barren River	681	0	0	681
	Brookville	89,300	0	0	89,300
	Caesar Creek	39,100	0	0	39,100
	Green River	3,460	0	0	3,460
	Monroe	160,000	0	0	160,000
	Patoka	129,800	0	0	129,800
	Rough River Lake	270	0	0	270
	William H. Harsha	35,500	0	0	35,500
	subtotal district	458,111	0	0	458,111
	Total Division	577,940	51,269	2,200	631,409
MVD	**Rock Island**				
	Saylorville Lake	14,900	0	0	14,900
	subtotal district	14,900	0	0	14,900
	St. Louis				
	Carlyle	33,000	0	0	33,000
	Clarence Cannon	0	0	20,000	20,000
	Lake Shelbyville	25,000	0	0	25,000
	Rend Lake	109,000	0	0	109,000
	subtotal district	167,000	0	20,000	187,000
	Vicksburg				
	DeGray	0	0	167,750	167,750
	subtotal district	0	0	167,750	167,750
	Total Division	**181,900**	**0**	**187,750**	**369,650**

Division	District / Reservoir	Present Use (acre-feet)	Future Use Under Contract (acre-feet)	Future Use Not Under Contract (acre-feet)	Total Storage Space (acre-feet)
NWD	**Seattle**				
	Wynoochee	26,400	18,200	0	44,600
	subtotal district	26,400	18,200	0	44,600
	Portland				
	Lost Creek	400	0	9,600	10,000
	subtotal district	400	0	9,600	10,000
	Omaha				
	Bowman-Haley	15,500	0	0	15,500
	Garrison	21,000	0	0	21,000
	subtotal district	36,500	0	0	36,500
	Kansas City				
	Clinton	53,520	35,680	0	89,200
	Hillsdale	7,500	45,500	0	53,000
	Long Branch	4,400	13,800	6,200	24,400
	Milford	46,650	253,350	0	300,000
	Perry	0	150,000	0	150,000
	Pomona	1,000	0	0	1,000
	Rathbun	3,340	0	0	3,340
	Smithville	4,650	14,850	75,700	95,200
	subtotal district	121,060	513,180	81,900	716,140
	Total Division	**184,360**	**531,380**	**91,500**	**807,240**
SWD	**Little Rock**				
	Beaver	44,093	77,000	0	121,093
	Blue Mountain Lake	1,550	0	0	1,550
	Bull Shoals	880	0	0	880
	DeQueen	610	0	17,275	17,885
	Dierks	190	9,910	0	10,100
	Gillham	323	20,277	0	20,600
	Greers Ferry Lake	4,901	0	0	4,901
	Millwood Lake	44,544	105,456	0	150,000
	Nimrod	143	0	0	143
	Norfolk	2,400	0	0	2,400
	subtotal district	99,634	212,643	17,275	329,552
	Ft. Worth				
	Aquilla	3,360	30,240	0	33,600
	Bardwell	32,100	10,700	0	42,800
	Belton	372,700	0	0	372,700
	Benbrook	72,500	0	0	72,500
	Canyon	366,400	0	0	366,400
	Cooper	63,950	209,050	0	273,000
	Ferrell's Bridge Dam	250,000	0	0	250,000

(Ft. Worth continued on next page)

Division	District / Reservoir	Present Use (acre-feet)	Future Use Under Contract (acre-feet)	Future Use Not Under Contract (acre-feet)	Total Storage Space (acre-feet)
SWD (cont.)	**Ft. Worth (cont.)**				
	Granger	0	37,900	0	37,900
	Grapevine	161,250	0	0	161,250
	Hords Creek	5,780	0	0	5,780
	Joe Pool	0	142,900	0	142,900
	Lavon	380,000	0	0	380,000
	Lewisville	436,000	0	0	436,000
	Navarro Mills	53,200	0	0	53,200
	N. Sam Gabriel Dam	4,961	24,239	0	29,200
	O.C. Fisher	80,400	0	0	80,400
	Procter	31,400	0	0	31,400
	Ray Roberts	567,180	359,600	0	926,780
	Sam Rayburn	43,000	0	0	43,000
	Somerville	143,900	0	0	143,900
	Stillhouse Hollow	204,900	0	0	204,900
	Town Bluff Dam	94,200	0	0	94,200
	Waco	151,626	0	0	151,626
	Whitney	50,000	0	0	50,000
	Wright Patman	91,263	0	0	91,263
	subtotal district	3,660,070	814,629	0	4,474,699
	Tulsa				
	Arcadia	8,460	14,630	0	23,090
	Birch Lake	0	0	7,630	7,630
	Broken Bow	4,301	4,054	144,145	152,500
	Canton	90,000	0	0	90,000
	Copan	250	4,750	2,500	7,500
	Council Grove	24,400	0	0	24,400
	Denison	140,960	0	0	140,960
	El Dorado	51,459	91,341	0	142,800
	Elk Creek	24,300	0	0	24,300
	Eufaula	10,663	1,890	42,492	55,045
	Fort Supply	400	0	0	400
	Heyburn	2,000	0	0	2,000
	Hugo	8,742	36,660	2,198	47,600
	Hula	19,800	0	0	19,800
	John Redmond	34,900	0	0	34,900
	Kaw	16,001	74,988	80,211	171,200
	Keystone	12,501	5,500	1,999	20,000
	Marion	38,300	0	0	38,300
	Oologah	326,145	860	15,595	342,600
	Optima (1)	0	0	0	0
	Pat Mayse	43,800	65,800	0	109,600
	Pearson-Skubitz, Big Hil	9,200	16,500	0	25,700
	Pine Creek	17,640	11,160	20,600	49,400
	Sardis	141,700	155,500	0	297,200

(Tulsa District continued on next page)

Division	District / Reservoir	Present Use (acre-feet)	Future Use Under Contract (acre-feet)	Future Use Not Under Contract (acre-feet)	Total Storage Space (acre-feet)
SWD (cont.)	**Tulsa (cont.)**				
	Skiatook	11,003	4,245	47,652	62,900
	Tenkiller Ferry Lake	20,735	0	5,005	25,740
	Toronto	400	0	0	400
	Waurika	41,800	0	109,600	151,400
	Wister	13,653	0	347	14,000
	subtotal district	1,113,513	487,878	479,974	2,081,365
	Total Division	**4,873,217**	**1,515,150**	**497,249**	**6,885,616**

Footnote: (1) Optima Lake in the Tulsa District was designed for 76,200 acre-feet of water supply storage. However, due to changed conditions, the lake has never filled. Optima has no storage or yield.

Division	District / Reservoir	Present Use (acre-feet)	Future Use Under Contract (acre-feet)	Future Use Not Under Contract (acre-feet)	Total Storage Space (acre-feet)
SPD	**Sacramento**				
	Dry Creek (Warm Springs)	88,000	212,000	0	300,000
	subtotal district	88,000	212,000	0	300,000
	Albuquerque				
	Abiquiu	170,900	0	0	170,900
	subtotal district	170,900	0	0	170,900
	Total Division	**258,900**	**212,000**	**0**	**470,900**

DATABASE III
M&I WATER SUPPLY
STORAGE INVESTMENT COST
BY PROJECT

Database III
M&I Water Supply Storage Investment Cost

Division	District / Reservoir	Present Use ($000)	Future Use Under Contract ($000)	Future Use Not Under Contract ($000)	Total Storage Space ($000)
NAD	**New England**				
	Colebrook	5,281.2	0	0	5,281.2
	East Brimfield	24.5	0	0	24.5
	Littleville	2,202.2	0	0	2,202.2
	subtotal district	7,507.9	0	0	7,507.9
	Philadelphia				
	Beltzville	6,500.0	0	0	6,500.0
	Blue Marsh	7,500.0	7,500.0	0	15,000.0
	subtotal district	14,000.0	7,500.0	0	21,500.0
	Baltimore				
	Cowanesque	39,414.0	0	0	39,414.0
	Jennings Randolph	66,211.0	0	0	66,211.0
	subtotal district	105,625.0	0	0	105,625.0
	Total Division	**127,132.9**	**7,500.0**	**0**	**134,632.9**
SAD	**Wilmington**				
	B. Everett Jordan	0	4,388.0	0	4,388.0
	Falls Lake	1,025.0	3,078.0	0	4,103.0
	John H. Kerr	2,431.5	0	0	2,431.5
	W. Kerr Scott	999.5	0	0	999.5
	subtotal district	4,456.0	7,466.0	0	11,922.0
	Savannah				
	Hartwell	926.5	2,120.0	0	3,046.5
	J. Strom Thurmond	775.0	0	0	775.0
	Richard B. Russell	419.0	0	0	419.0
	subtotal district	2,120.5	2,120.0	0	4,240.5
	Jacksonville				
	Cerrillos D & R	98,670.0	0	0	98,670.0
	subtotal district	98,670.0	0	0	98,670.0
	Mobile				
	Allatoona	1,445.4	0	0	1,445.4
	Okatibbee	1,292.0	0	0	1,292.0
	subtotal district	2,737.4	0	0	2,737.4
	Total Division	**107,983.9**	**9,586.0**	**0**	**117,569.9**

Division	District / Reservoir	Present Use ($000)	Future Use Under Contract ($000)	Future Use Not Under Contract ($000)	Total Storage Space ($000)
LRD	**Pittsburgh**				
	Berlin	1,365.0	0	0	1,365.0
	Michael J. Kirwan	5,200.0	0	0	5,200.0
	Misquito Creek	467.0	0	0	467.0
	Stonewall Jackson	0	0	4,300.0	4,300.0
	subtotal district	7,032.0	0	4,300.0	11,332.0
	Huntington				
	Alum Creek	6,847.5	11,412.6	0	18,260.1
	John W. Flannagan	57.1	283.6	0	340.7
	North Fork of Pound	37.9	0	0	37.9
	Paint Creek	189.7	0	0	189.7
	Tom Jenkins	785.0	0	0	785.0
	subtotal district	7,917.2	11,696.2	0	19,613.4
	Louisville				
	Barren River	22.3	0	0	22.3
	Brookville	7,541.0	0	0	7,541.0
	Caesar Creek	5,742.0	0	0	5,742.0
	Green River	92.1	0	0	92.1
	Monroe	8,015.0	0	0	8,015.0
	Patoka	14,023.0	0	0	14,023.0
	Rough River Lake	21.4	0	0	21.4
	William H. Harsha	3,987.0	0	0	3,987.0
	subtotal district	39,443.8	0	0	39,443.8
	Total Division	**54,393.0**	**11,696.2**	**4,300.0**	**70,389.2**
MVD	**Rock Island**				
	Saylorville Lake	4,811.6	0	0	4,811.6
	subtotal district	4,811.6	0	0	4,811.6
	St. Louis				
	Carlyle	3,635.0	0	0	3,635.0
	Clarence Cannon	0	0	13,000.0	13,000.0
	Lake Shelbyville	4,310.0	0	0	4,310.0
	Rend Lake	10,000.0	0	0	10,000.0
	subtotal district	17,945.0	0	13,000.0	30,945.0
	Vicksburg				
	DeGray	0	0	5,904.0	5,904.0
	subtotal district	0	0	5,904.0	5,904.0
	Total Division	**22,756.6**	**0**	**18,904.0**	**41,660.6**

Division	District / Reservoir	Present Use ($000)	Future Use Under Contract ($000)	Future Use Not Under Contract ($000)	Total Storage Space ($000)
NWD	**Seattle**				
	Wynoochee	11,281.0	7,772.0	0	19,053.0
	subtotal district	11,281.0	7,772.0	0	19,053.0
	Portland				
	Lost Creek	269.7	0	5,730.3	6,000.0
	subtotal district	269.7	0	5,730.3	6,000.0
	Omaha				
	Bowman-Haley	825.0	0	0	825.0
	Garrison	630.0	0	0	630.0
	subtotal district	1,455.0	0	0	1,455.0
	Kansas City				
	Clinton	3,873.4	2,582.3	0	6,455.7
	Hillsdale	3,314.2	20,107.5	0	23,421.7
	Long Branch	1,118.3	3,507.2		1,575.7
					6,201.2
	Milford	2,028.6	11,017.0	0	13,045.6
	Perry	0	9,208.3	0	9,208.3
	Pomona	71.0	0	0	71.0
	Rathbun	331.0	0	0	331.0
	Smithville	1,289.8	4,123.1	21,000.0	26,412.9
	subtotal district	12,026.3	50,545.4	22,575.7	85,147.4
	Total Division	**25,032.0**	**58,317.4**	**28,306.0**	**111,655.4**
SWD	**Little Rock**				
	Beaver	2,256.7	3,477.1	0	5,733.8
	Blue Mountain Lake	417.2	0	0	417.2
	Bull Shoals	85.0	0	0	85.0
	DeQueen	249.5	0	4,942.4	5,191.9
	Dierks	40.6	2,110.1	0	2,150.7
	Gillham	167.2	5,251.0	0	5,418.2
	Greers Ferry Lake	559.1	0	0	559.1
	Millwood Lake	4,318.7	10,089.8	0	14,408.5
	Nimrod	23.2	0	0	23.2
	Norfolk	196.4	0	0	196.4
	subtotal district	8,313.6	20,928.0	4,942.4	34,184.0
	Ft. Worth				
	Aquilla	1,257.0	11,316.0	0	12,573.0
	Bardwell	2,468.0	823.0	0	3,291.0
	Belton	5,286.0	0	0	5,286.0
	Benbrook	3,100.0	0	0	3,100.0
	Canyon	8,080.0	0	0	8,080.0
	Cooper	13,821.0	45,179.0	0	59,000.0
	Ferrell's Bridge Dam	1,753.0	0	0	1,753.0

(Ft. Worth District continued on next page)

Division	District / Reservoir	Present Use ($000)	Future Use Under Contract ($000)	Future Use Not Under Contract ($000)	Total Storage Space ($000)
SWD (cont.)	**Ft. Worth (cont.)**				
	Granger	0	12,865.0	0	12,865.0
	Grapevine	2,747.0	0	0	2,747.0
	Hords Creek	100.0	0	0	100.0
	Joe Pool	0	57,955.0	0	57,955.0
	Lavon	36,296.3	0	0	36,296.3
	Lewisville	3,927.0	0	0	3,927.0
	Navarro Mills	2,176.0	0	0	2,176.0
	Norh Sam Gabriel Dam	1,022.0	4,992.0	0	6,014.0
	O.C. Fisher	860.0	0	0	860.0
	Procter	1,314.0	0	0	1,314.0
	Ray Roberts	88,362.0	81,565.0	0	169,927.0
	Sam Rayburn	526.0	0	0	526.0
	Somerville	7,197.0	0	0	7,197.0
	Stillhouse Hollow	6,983.0	0	0	6,983.0
	Town Bluff Dam	2,000.0	0	0	2,000.0
	Waco	20,819.4	0	0	20,819.4
	Whitney	1,181.4	0	0	1,181.4
	Wright Patman	1,788.0	0	0	1,788.0
	subtotal district	213,064.1	214,695.0	0	427,759.1
	Tulsa				
	Arcadia	16,253.6	27,790.0	0	44,043.6
	Birch Lake	0	0	2,209.0	2,209.0
	Broken Bow	163.3	107.6	3,827.0	4,097.9
	Canton	2,806.9	0	0	2,806.9
	Copan	268.7	5,105.2	2,686.9	8,060.8
	Council Grove	1,400.0	0	0	1,400.0
	Denison, L. Texoma	18,560.3	0	0	18,560.3
	El Dorado	13,206.3	23,441.2	0	36,647.5
	Elk City	2,076.0	0	0	2,076.0
	Eufaula	904.8	179.7	3,433.7	4,518.2
	Fort Supply	38.8	0	0	38.8
	Heyburn	120.9	0	0	120.9
	Hugo	501.4	2,102.0	126.0	2,729.4
	Hula	795.2	0	0	795.2
	John Redmond	4,488.0	0	0	4,488.0
	Kaw	3,625.7	17,065.0	18,427.9	39,118.6
	Keystone	1,094.8	481.7	175.2	1,751.7
	Marion	1,566.0	0	0	1,566.0
	Oologah	10,545.2	27.7	504.2	11,077.1
	Optima (1)	0	0	4,884.0	4,884.0
	Pat Mayse	1,284.0	1,926.0	0	3,210.0
	Pearson-Skubitz, Big Hill	2,490.5	4,465.3	0	6,955.8
	Pine Creek	1,663.0	1,052.0	1,942.0	4,657.0
	Sardis	7,766.0	8,522.0	0	16,288.0

(Tulsa District continued on next page)

Division	District / Reservoir	Present Use ($000)	Future Use Under Contract ($000)	Future Use Not Under Contract ($000)	Total Storage Space ($000)
SWD (cont.)	**Tulsa (cont.)**				
	Skiatook	3,102.0	1,196.8	13,434.9	17,733.7
	Tenkiller Ferry Lake	457.6	0	647.5	1,105.1
	Toronto	32.4	0	0	32.4
	Waurika	2,802.2	0	8,042.0	10,844.2
	Wister	275.7	0	116.0	391.7
	subtotal district	98,289.3	93,462.2	60,456.3	252,207.8
	Total Division	**319,667.0**	**329,085.2**	**65,398.7**	**714,150.9**

Footnote: (1) Optima Lake in the Tulsa District was designed for 76,200 acre-feet of water supply storage. However, due to changed conditions, the lake has never filled. Optima has no storage or yield.

Division	District / Reservoir	Present Use ($000)	Future Use Under Contract ($000)	Future Use Not Under Contract ($000)	Total Storage Space ($000)
SPD	**Sacramento**				
	Dry Creek (Warm Springs)	8,290.0	96,624.9	0	104,914.9
	subtotal district	8,290.0	96,624.9	0	104,914.9
	Albuquerque				
	Abiquiu	0	0	0	0
	subtotal district	0	0	0	0
	Total Division	**8,290.0**	**96,624.9**	**0**	**104,914.9**

DATABASE IV
M&I WATER SUPPLY
CONDUIT INVESTMENT COST
BY PROJECT

Database IV
M&I Water Supply Conduit Investment Cost

Division	District / Reservoir	Present Use ($000)	Future Use Under Contract ($000)	Future Use Not Under Contract ($000)	Total Storage Space ($000)
NAD	**Total Division**	**0**	**0**	**0**	**0**
SAD	**Mobile**				
	Allatona Lake	219.0	0	0	219.0
	subtotal district	219.0	0	0	219.0
	Total Division	**219.0**	**0**	**0**	**219.0**
LRD	**Pittsburgh**				
	Berlin Lake	1.3	0	0	1.3
	Mosquito Creek	67.0	0	0	67.0
	subtotal district	68.3	0	0	68.3
	Total Division	**68.3**	**0**	**0**	**68.3**
MVD	**Total Division**	**0**	**0**	**0**	**0**
NWD	**Kansas City**				
	Clinton Lake	312.4	0	0	312.4
	Smithville	53.0	0	2,331.0	2,384.0
	subtotal distict	365.4	0	2,331.0	2,696.4
	Total Division	**365.4**	**0**	**2,331.0**	**2,696.4**
SWD	**Little Rock**				
	DeQueen	6.6	0	186.9	193.5
	Dierks	181.7	0	0	181.7
	Gillham	79.0	0	0	79.0
	Millwood Lake	110.5	0	0	110.5
	subtotal district	377.8	0	186.9	564.7
	Fort Worth				
	Benbrook	36.0	0	0	36.0
	Hords Creek Lake	5.0	0	0	5.0
	Joe Pool Lake	80.0	0	0	80.0
	Navarro Mills	28.0	0	0	28.0
	Ray Roberts	258.0	0	0	258.0
	Waco	216.0	0	0	216.0
	subtotal district	623.0	0	0	623.0

Division	District / Reservoir	Present Use ($000)	Future Use Under Contract ($000)	Future Use Not Under Contract ($000)	Total Storage Space ($000)
SWD	**Tulsa**				
(cont.)	Arcadia	266.6	0	0	266.6
	Birch	23.0	0	0	23.0
	Broken Bow	6.2	0	108.1	114.3
	Copan	0	0	24.7	24.7
	Council Grove	62.0	0	0	62.0
	El Dorado	838.2	0	0	838.2
	Elk City	71.0	0	0	71.0
	Eufaula	2.8	0	15.2	18.0
	Heyburn	51.2	0	0	51.2
	Hugo	30.0	0	0	30.0
	Hula	5.3	0	0	5.3
	John Redmond	11.0	0	0	11.0
	Kaw	388.0	0	0	388.0
	Keystone	0	0	28.3	28.3
	Marion	10.0	0	0	10.0
	Oologah	391.5	0	0	391.5
	Optima (1)	0	0	0	0
	Pat Mayse	0	0	10.0	10.0
	Pearson-Skubitz, Big Hill	21.3	0	0	21.3
	Pine Creek	0	0	148.0	148.0
	Sardis	111.0	0	0	111.0
	Skiatook	704.0	0	0	704.0
	Tenkiller Ferry	11.6	0	0	11.6
	Waurika	213.0	0	0	213.0
	subtotal conduit	3,217.7	0	334.3	3,552.0
	Waurika Water Conveyance Facilities	30,781.6	0	0	30,781.6
	subtotal district	33,999.3	0	334.3	34,333.6
	Total Division	**35,000.1**	**0**	**521.2**	**35,521.3**

Footnote: (1) Optima Lake in the Tulsa District was designed for 76,200 acre-feet of water supply storage. However, due to changed conditions, the lake has never filled. Optima has no storage or yield.

SPD	**Total Division**	**0**	**0**	**0**	**0**

DATABASE V
M&I WATER SUPPLY
DIVISION AND DISTRICT SUMMARIES
OF STORAGE SPACE AND INVESTMENT COST

NORTH ATLANTIC DIVISION

New England District: Number of projects with water supply, 3. Number of contracts, 3.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	41,240	0	41,240	7,508	0	0	7,508
Not Under Contract		0	0	0	0	0	0
Total	41,240	0	41,240	7,508	0	0	7,508

Philadelphia District:: Number of projects with water supply, 2. Number of contracts 2.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	31,880	4,000	35,880	14,000	7,500	0	21,500
Not Under Contract	0	0	0	0	0	0	0
Total	31,880	4,000	35,880	14,000	7,500	0	21,500

Baltimore District: Number of projects with water supply, 2. Number of contracts 3.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	65,330	0	65,330	105,625	0	0	105,625
Not Under Contract	0	0	0	0	0	0	0
Total	65,330	0	65,330	105,625	0	0	105,625

NORTH ATLANTIC DIVISION TOTAL: Number of projects with water supply, 7. Number of contracts 8.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	138,450	4,000	142,450	127,133	7,500	0	134,633
Not Under Contract	0	0	0	0	0	0	0
Total	138,450	4,000	142,450	127,133	7,500	0	134,633

SOUTH ATLANTIC DIVISION

Wilmington District: Number of projects with water supply, 4. Number of contracts, 6.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	55,123	79,500	134,623	4,456	7,466	0	11,922
Not Under Contract	0	0	0	0	0	0	0
Total	55,123	79,500	134,623	4,456	7,466	0	11,922

Savannah District: Number of projects with water supply, 3. Number of contracts, 9.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	12,067	17,240	29,307	2,121	2,120	0	4,241
Not Under Contract	0	0	0	0	0	0	0
Total	12,067	17,240	29,307	2,121	2,120	0	4,241

Jacksonville District: Number of projectsz with water supply, 1. Number of contracts, 1.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	25,200	0	25,200	98,670	0	0	98,670
Not Under Contract	0	0	0	0	0	0	0
Total	25,200	0	25,200	98,670	0	0	98,670

Mobile District: Number of projects with water supply, 2. Number of contracts, 3.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	28,236	0	28,236	2,737	0	219	2,956
Not Under Contract	0	0	0	0	0	0	0
Total	28,236	0	28,236	2,737	0	219	2,956

SOUTH ATLANTIC DIVISION TOTAL: Number of projects with water supply, 10. Number of contracts, 19.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	120,626	96,740	217,366	107,984	9,586	219	117,789
Not Under Contract	0	0	0	0	0	0	0
Total	120,626	96,740	217,366	107,984	9,586	219	117,789

GREAT LAKES AND OHIO RIVER DIVISION

Pittsburgh District: Number of projects with water supply, 4. Number of contracts, 4.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	83,300	0	83,300	7,032	0	68	7,100
Not Under Contract	0	2,200	2,200	0	4,300	0	4,300
Total	83,300	2,200	85,500	7,032	4,300	68	11,400

Huntington District: Number of projects with water supply, 5. Number of contracts, 5.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	36,529	51,269	87,798	7,917	11,696	0	19,613
Not Under Contract	0	0	0	0	0	0	0
Total	36,529	51,269	87,798	7,917	11,696	0	19,613

Louisville District: Number of projects with water supply, 8. Number of contracts, 9.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	458,111	0	458,111	39,444	0	0	39,444
Not Under Contract	0	0	0	0	0	0	0
Total	458,111	0	458,111	39,444	0	0	39,444

GREAT LAKES AND OHIO RIVIER DIVISION TOTAL: Number of projects with water supply, 17. Number of contracts, 18.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	577,940	51,269	629,209	54,393	11,696	68	66,157
Not Under Contract	0	2,200	2,200	0	4,300	0	4,300
Total	577,940	53,469	631,409	54,393	15,996	68	70,457

MISSISSIPPI VALLEY DIVISION

Rock Island District: Number of projects with water supply, 1. Number of contracts, 1.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	14,900	0	14,900	4,812	0	0	4,812
Not Under Contract	0	0	0	0	0	0	0
Total	14,900	0	14,900	4,812	0	0	4,812

St. Louis District: Number of projects with water supply, 4. Number of contracts, 3.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	167,000	0	167,000	17,945	0	0	17,945
Not Under Contract	0	20,000	20,000	0	13,000	0	13,000
Total	167,000	20,000	187,000	17,945	13,000	0	30,945

Vicksburg District: Number of projects with water supply, 1. Number of contracts, 0.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	0	0	0	0	0	0	0
Not Under Contract	0	167,750	167,750	0	5,904	0	5,904
Total	0	167,750	167,750	0	5,904	0	5,904

MISSISSIPPI VALLEY DIVISION TOTAL: Number of projects with water supply, 6. Number of contracts, 4.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	181,900	0	181,900	22,757	0	0	22,757
Not Under Contract	0	187,750	187,750	0	18,904	0	18,904
Total	181,900	187,750	369,650	22,757	18,904	0	41,661

NORTHWESTERN DIVISION

Seattle District: Number of projects with water supply, 1. Number of contracts, 1.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	26,400	18,200	44,600	11,281	7,772	0	19,053
Not Under Contract	0	0	0	0	0	0	0
Total	26,400	18,200	44,600	11,281	7,772	0	19,053

Portland District: Number of projects with water supply, 1. Number of contracts, 1.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	400	0	400	270	0	0	270
Not Under Contract	0	9,600	9,600	0	5,730	0	5,730
Total	400	9,600	10,000	270	5,730	0	6,000

Omaha District: Number of projects with water supply, 2. Number of contracts, 2.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	36,500	0	36,500	1,455	0	0	1,455
Not Under Contract	0	0	0	0	0	0	0
Total	36,500	0	36,500	1,455	0	0	1,455

Kansas City District: Number of projects with water supply, 8. Number of contracts, 11.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	121,060	513,180	634,240	12,026	50,545	365	62,936
Not Under Contract	0	81,900	81,900	0	22,576	2,331	24,907
Total	121,060	595,080	716,140	12,026	73,121	2,696	87,843

NORTHWESTERN DIVISION TOTAL: Number of projects with water supply, 12. Number of contracts, 15.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	184,360	531,380	715,740	25,032	58,317	365	83,714
Not Under Contract	0	91,500	91,500	0	28,306	2,331	30,637
Total	184,360	622,880	807,240	25,032	86,623	2,696	114,351

SOUTHWESTERN DIVISION

Little Rock District: Number of projects with water supply, 10. Number of contracts, 15.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	99,634	212,643	312,277	8,314	20,928	378	29,620
Not Under Contract	0	17,275	17,275	0	4,942	187	5,129
Total	99,634	229,918	329,552	8,314	25,870	565	34,749

Ft. Worth District: Number of projects with water supply, 25. Number of contracts, 42.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	3,660,070	814,629	4,474,699	213,064	214,695	623	428,382
Not Under Contract	0	0	0	0	0	0	0
Total	3,660,070	814,629	4,474,699	213,064	214,695	623	428,382

Tulsa District: Number of projects with water supply, 28. Number of contracts, 111.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	1,113,513	487,878	1,601,391	98,289	93,462	34,070	225,821
Not Under Contract	0	479,974	479,974	0	60,456	334	60,790
Total	1,113,513	967,852	2,081,365	98,289	153,918	34,404	286,611

SOUTHWESTERN DIVISION TOTAL: Number of projects with water supply, 63. Number of contracts, 168.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	4,873,217	1,515,150	6,388,367	319,667	329,085	35,071	683,823
Not Under Contract	0	497,249	497,249	0	65,398	521	65,919
Total	4,873,217	2,012,399	6,885,616	319,667	394,483	35,592	749,742

SOUTH PACIFIC DIVISION

Scramento District: Number of projects with water supply, 1. Number of contracts, 2.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	88,000	212,000	300,000	8,290	96,625	0	104,915
Not Under Contract	0	0	0	0	0	0	0
Total	88,000	212,000	300,000	8,290	96,625	0	104,915

Albuquerque District: Number of projects with water supply, 1, Number of contracts, 1.

Item	Storage Space (Acre Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	170,900	0	170,900	0	0	0	0
Not Under Contract	0	0	0	0	0	0	0
Total	170,900	0	170,900	0	0	0	0

SOUTH PACIFIC DIVISION: Number of projects with water supply, 2. Number of contracts, 3.

Item	Storage Space (Acre-Feet)			Contract Price ($000)			
	Present Use	Future Use	Total	Present Use	Future Use	Conduit	Total
Under Contract	258,900	212,000	470,900	8,290	96,625	0	104,915
Not Under Contract	0	0	0	0	0	0	0
Total	258,900	212,000	470,900	8,290	96,625	0	104,915

DATABASE VI
M&I WATER SUPPLY AGREEMENTS BY PROJECT AND AGREEMENT

Note: Investments costs are those construction costs plus interest during construction for which the sponsor is currently responsible. These costs can vary over time in any one contract and they also can vary over time between contracts in the same project. Therefore, all costs are in varying price levels.

NORTH ATLANTIC DIVISION

NEW ENGLAND DISTRICT

☆ COLEBROOK RIVER LAKE
CWIS No. 03650
West Branch Farmington River
Litchfield County, Connecticut

Contractor: The Meto Dist
Present Storage (a-f): 30,700.
Future Storage (a-f): 0.
Present Investment ($000): 5,281.2
Future Investment ($000): 0
Conduit Cost ($000): 0
Date Contract Approved: Mar 65
Type:

☆ EAST BRIMFIELD LAKE
CWIS No. 05120
Quinebaug River
Worcester County, Massachusetts

Contractor: American Optic Co.
Present Storage (a-f): 1,140.
Future Storage (a-f): 0.
Present Investment ($000): 24.5
Future Investment ($000): 0
Conduit Cost ($000): 0
Date Contract Approved: Aug 62
Type:

☆ LITTLEVILLE LAKE
CWIS No. 10000
Middle Branch Westfield River Hampshire County, Massachusetts

Contractor: City of Springfield
Present Storage (a-f): 9,400.
Future Storage (a-f): 0.
Present Investment ($000): 2,202.2
Future Investment ($000): 0
Conduit Cost ($000): 0
Date Contract Approved: Jul 68
Type:

PHILADELPHIA DISTRICT

☆ BELTZVILLE LAKE
CWIS No. 01340
Pohopoco Creek
Carbon and Monroe Counties, Pennsylvania

Contractor: Delaware RBC
Present Storage (a-f): 27,880.
Future Storage (a-f): 0.
Present Investment ($000): 6,500.
Future Investment ($000): 0
Conduit Cost ($000): 0
Date Contract Approved: Sep 80
Type:

☆ BLUE MARSH LAKE
CWIS No. 01780
Tulpehocken Creek
Lebanon and Berks Counties, Pennsylvania

Contractor: Delaware RBC
Present Storage (a-f): 4,000.
Future Storage (a-f): 4,000.
Present Investment ($000): 7,500.
Future Investment ($000): 7,500.
Conduit Cost ($000): 0
Date Contract Approved: Jun 71
Type:

BALTIMORE DISTRICT

☆ COWANESQUE LAKE

CWIS No. 04150
Cowanesque River
Tioga County, Pennsylvania

Contractor: Susquehanna River Basin Comm

Present Storage (a-f): 24,335.
Future Storage (a-f): 0.
Present Investment ($000): 39,414.
Future Investment ($000): 0
Conduit Cost ($000): 0
Date Contract Approved: Jun 86
Type: Reallocation of Flood Control storage

☆ JENNINGS RANDOLPH LAKE

CWIS No. 01770
North Branch Potomac River
Mineral County, West Virginia

Contractor: DC; WSSC; FCWA

Present Storage (a-f): 7,158.
Future Storage (a-f): 0.
Present Investment ($000): 11,477.
Future Investment ($000): 0
Conduit Cost ($000): 0
Date Contract Approved: Nov 70
Type:

Contractor: DC; WSSC; FCWA

Present Storage (a-f): 33,837.
Future Storage (a-f): 0.
Present Investment ($000): 54,734.
Future Investment ($000): 0
Conduit Cost ($000): 0
Date Contract Approved: Aug 82
Type:

SOUTH ATLANTIC DIVISION

WILMINGTON DISTRICT

☆ B. EVERETT JORDAN DAM AND LAKE
CWIS No. 12410
Haw River
Chatham, Wake, Orange and Durham Counties, North Carolina

Contractor: State of North Carolina
Present Storage (a-f): 0
Future Storage (a-f): 45,800
Present Investment ($000): 0
Future Investment ($000): 4,388.0
Conduit Cost ($000): 0
Date Agreement Approved: Apr 88
Type: Water supply storage

☆ FALLS LAKE
CWIS No. 05800
Neuse River
Wake, Durham & Granville Counties, NC

Contractor: City of Raleigh
Present Storage (a-f) : 11,300.
Future Storage (a-f): 33,700.
Present Investment ($000): 1,025
Future Investment ($000): 3,078
Conduit Cost ($000): 0
Date Contract Approved: Feb 72
Type: Water supply storage

☆ JOHN H. KERR DAM AND RESERVOIR
CWIS No. 08350
Roanoke River
Mecklenburg, Charlotte, Halifax Counties, VA

Contractor: Virginia Beach
Present Storage (a-f): 10,200.
Future Storage (a-f): 0.
Present Investment ($000): 2,275.7
Future Investment ($000): 0
Conduit Cost ($000): 0
Date Contract Approved: Jan 84
Type: Reallocation of hydropower storage

Contractor: Commonwealth of Virginia
Present Storage (a-f): 23
Future Storage: (a-f) 0
Present Investment ($000): 5.6
Future Investment: ($000): 0
Conduit Cost ($000): 0
Date Agreement Approved: Jan 89
Type: Reallocation of hydropower storage

Contractor: Mecklenburg Cogeneration Limited Partners
Present Storage (a-f): 600
Future Storage (a-f): 0
Present Investment ($000): 150.2
Future Investment: ($000): 0
Conduit Cost ($000): 0
Date Agreement Approved: Jun 91
Type: Reallocation of hydropower storage

☆ W. KERR SCOTT DAM AND RESERVOIR
CWIS No. 19220
Yadkin River
Wilkes and Caldwell Counties, North Carolina

Contractor: Wilkes Co. & Winston-Salem
Present Storage (a-f): 33,000.
Future Storage (a-f): 0.
Present Investment ($000): 999.5
Future Investment ($000): 0
Conduit Cost ($000): 0
Date Contract Approved: Jun 60
Type:

SAVANNAH DISTIRCT

☆ HARTWELL DAM AND LAKE
CWIS No. 07380
Savannah, Tugaloo and Seneca Rivers
Hart, Franklin, Stephens Counties, Georgia

Contractor: Duke Power Co.
Present Storage (a-f): 7,380.
Future Storage (a-f): 17,240.
Present Investment ($000): 905.
Future Investment ($000): 2,120.
Conduit Cost ($000,): 0.
Date Contract Approved: Jul 76
Type:

Contractor: Franklin County, GA
Present Storage (a-f): 127
Future Storage (a-f): 0
Present Investment ($000): 21.5
Future Investment ($000): 0
Conduit Cost ($000): 0
Date Agreement Approved: Feb 90
Type: Reallocation from hydropower

☆RICHARD B. RUSSELL DAM AND LAKE
CWIS No. 18530
Savannah River
Elbert County, Georgia and Abbeville and Anderson Counties, South Carolina

Contractor: City of Elberton
Present Storage (a-f): 381
Future Storage (a-f): 0
Present Investment ($000): 419.0
Future Investment ($000): 0
Conduit Cost ($000): 0
Date Agreement Approved: Sep 90
Type: Reallocation from hydropower

☆ J. STROM THURMOND DAM AND LAKE
CWIS No. 03350
Savannah River
McCormick County, South Carolina

Contractor: City of Lincolnton, GA
Present Storage (a-f): 92.
Future Storage (a-f): 0.
Present Investment ($000): 0.3
Future Investment ($000): 0.
Conduit Cost ($000): 0.
Date Contract Approved: May 64
Type:

Contractor: City of McCormick
Present Storage (a-f): 1800.
Future Storage (a-f): 0.
Present Investment ($000): 75.
Future Investment ($000): 0.
Conduit Cost ($000): 0.
Date Contract Approved: Sep 71
Type:

Contractor: Savannah Valley Authority, SC
Present Storage (a-f): 92
Future Storage (a-f): 0
Present Investment ($000): 27.4
Future Investment: ($000): 0
Conduit Cost ($000): 0
Date Agreement Approved: Oct 89
Type: Reallocation from hydropower

Contractor: Columbia County, GA
Present Storage (a-f): 1,056
Future Storage (a-f): 0
Present Investment ($000): 313.0
Future Investment ($000): 0
Conduit Cost ($000): 0
Date Agreement Approved: Nov 89
Type: Reallocation from hydropower and conservation

Contractor: City of Thompson And McDuffie County, GA
Present Storage (a-f): 1,056
Future Storage (a-f): 0
Present Investment ($000): 334.7
Future Investment ($000): 0
Conduit Cost ($000): 0
Date Agreement Approved: Aug 90
Type: Reallocation from hydropower

Savannah District (continued)

J. STROM THURMOND DAM AND LAKE (cont.)

Contractor: City of Lincolnton, GA
Present Storage (a-f): 83
Future Storage (a-f): 0
Present Investment ($000): 24.6
Future Investment ($000): 0
Conduit Cost ($000): 0
Date Agreement Approved: Apr 90
Type: Reallocation from hydropower

JACKSONVILLE DISTRICT

☆CERRILLOS DAM AND RESERVOIR
CWIS No. 74996-01
Cerrillos River
Ponce Municipio, Puerto Rico

Contractor: Common. of PR
Present Storage (a-f): 25,200.
Future Storage (a-f): 0.
Present Investment ($000): 98,670.
Future Investment ($000): 0.
Conduit Cost ($000): 0.
Date Contract Approved: Mar 82
Type:

MOBILE DISTRICT

☆ ALLATOONA LAKE
CWIS No. 00220
Etowah River
Bartow County, Georgia

Contractor: Cobb Co.-Marietta Wtr. Auth.
Present Storage (a-f): 13,140.
Future Storage (a-f): 0.
Present Investment ($000): 1,268.4
Future Investment ($000): 0.
Conduit Cost ($000): 0.
Date Contract Approved: Oct 63
Type:

Contractor: City of Cartersville
Present Storage (a-f): 1,996.
Future Storage (a-f): 0.
Present Investment ($000): 177.
Future Investment ($000): 0.
Conduit Cost ($000): 219.
Date Contract Approved: Dec 66
Type:

☆ OKATIBBEE LAKE
CWIS No. 13230
Okatibbee Creek
Lauderdale County, Mississippi

Contractor: Pat Harrison WW District
Present Storage (a-f): 13,100.
Future Storage (a-f): 0.
Present Investment ($000): 1,292.
Future Investment ($000): 0.
Conduit Cost ($000): 0.
Date Contract Approved: May 65
Type:

GREAT LAKES AND OHIO RIVER DIVISION

PITTSBURGH DISTRICT

☆**BERLIN LAKE**
CWIS No. 01400
Mahoning River
Portage and Mahoning Counties, Ohio

Contractor: Mahoning Val. San. Dist.
Present Storage (a-f): 19,400.
Future Storage (a-f): 0.
Present Investment ($1000): 1,365.0
Future Investment ($1000): 0
Conduit Cost ($1000): 1.3
Date Contract Approved: Feb 50
Type:

☆**MICHAEL J. KIRWAN DAM AND RESERVOIR**
CWIS No. 19660
West Branch Mahoning River
Portage County, Ohio

Contractor: Trumbull County
Present Storage (a-f): 17,800.
Future Storage (a-f): 0.
Present Investment ($1000): 1,750.2
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Oct 61
Type:

Contractor: Mahoning County
Present Storage (a-f): 35,100.
Future Storage (a-f): 0.
Present Investment ($1000): 3,449.8
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Oct 61
Type:

☆**MOSQUITO CREEK LAKE**
CWIS No. 11870
Mosquito Creek
Trumbull County, Ohio

Contractor: City of Warren
Present Storage (a-f): 11,000.
Future Storage (a-f): 0.
Present Investment ($1000): 467.
Future Investment ($1000): 0.
Conduit Cost ($1000): 67.
Date Contract Approved: Feb 48
Type:

☆**STONEWALL JACKSON LAKE**
CWIS No. 17580
West Fork River
Lewis County, West Virginia

Not Under Contract
Present Storage (a-f): 0.
Future Storage (a-f): 2200.
Present Investment ($1000): 0.
Future Investment ($1000): 4,300.
Conduit Cost ($1000): 0.

HUNTINGTON DISTRICT

☆ALUM CREEK LAKE
CWIS No. 00280
Alum Creek
Delaware County, Ohio

Contractor: State of Ohio
Present Storage (a-f): 29,700.
Future Storage (a-f): 49,500.
Present Investment ($1000): 6,847.5
Future Investment ($1000): 11,412.6
Conduit Cost ($1000): 0.
Date Contract Approved: Jun 68
Type:

☆JOHN W. FLANNAGAN DAM AND RESERVOIR
CWIS No. 08550
Pound River
Dickenson County, Virginia

Contractor: John Flannagan Water Auth.
Present Storage (a-f): 356.
Future Storage (a-f): 1,769.
Present Investment ($1000): 57.1
Future Investment ($1000): 283.6
Conduit Cost ($1000): 0.0
Date Contract Approved: Oct 77
Type:

☆NORTH FORK OF POUND LAKE
CWIS No. 12710
North Fork of Pound River
Wise County, Virginia

Contractor: Town of Pound
Present Storage (a-f): 62.
Future Storage (a-f): 0.
Present Investment ($1000): 37.9
Future Investment ($1000): 0.0
Conduit Cost ($1000): 0.0
Date Contract Approved: Aug 68
Type:

☆PAINT CREEK LAKE
CWIS No. 13550
Paint Creek
Ross County, Ohio

Contractor: Highland County Water Co.
Present Storage (a-f): 721.
Future Storage (a-f): 0.
Present Investment ($1000): 189.7
Future Investment ($1000): 0.0
Conduit Cost ($1000): 0.0
Date Contract Approved: Jun 86
Type:

☆TOM JENKINS DAM
CWIS No. 18300
Hocking River
Athens County, Ohio

Contractor: State of Ohio
Present Storage (a-f): 5,690.
Future Storage (a-f): 0.
Present Investment ($1000): 785.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Feb 48
Type:

LOUISVILLE DISTRICT

☆BARREN RIVER LAKE
CWIS No. 00970
Barren River
Allen and Barren Counties, Kentucky

Contractor: Glasgow
Present Storage (a-f): 681.
Future Storage (a-f): 0.
Present Investment ($1000): 22.3
Future Investment ($1000): 0.0
Conduit Cost ($1000): 0.0
Date Contract Approved: Nov 65
Type: Reallocation of Permanent Pool

☆BROOKVILLE LAKE
CWIS No. 02060
East Fork Whitewater River
Franklin and Union Counties, Indiana

Contractor: State of Indiana
Present Storage (a-f): 89,300.
Future Storage (a-f): 0.
Present Investment ($1000): 7,541.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Aug 65
Type:

☆CAESAR CREEK LAKE
CWIS No. 02350
Caesar Creek
Warren, Clinton and Greene Counties, Ohio

Contractor: State of Ohio
Present Storage (a-f): 39,100.
Future Storage (a-f): 0.
Present Investment ($1000): 5,742.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: May 90
Type:

☆GREEN RIVER LAKE
CWIS No. 06960
Green River
Taylor and Adair Counties, Kentucky

Contractor: Campbellsville
Present Storage (a-f): 3,460.
Future Storage (a-f): 0.
Present Investment ($1000): 92.1
Future Investment ($1000): 0.0
Conduit Cost ($1000): 0.0
Date Contract Approved: Apr 69
Type:

☆MONROE LAKE
CWIS No. 11770
Salt Creek
Monroe, Brown and Jackson Counties, Indiana

Contractor: State of Indiana
Present Storage (a-f): 160,000.
Future Storage (a-f): 0.
Present Investment ($1000): 8,015.
Future Investment ($1000): 0.0
Conduit Cost ($1000): 0.0
Date Contract Approved: Mar 61
Type:

☆PATOKA LAKE
CWIS No. 13730
Patoka River
Dubois, Orange and Crawford Counties, Indiana

Contractor: State of Indiana
Present Storage (a-f): 129,800.
Future Storage (a-f): 0.
Present Investment ($1000): 14,023.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Nov 70
Type:

Louisville District (continued)

☆**ROUGH RIVER LAKE**
CWIS No. 15610
Rough River
Breckinridge, Grayson & Hardin Counties, KY

Contractor: Leitchfield
Present Storage (a-f): 120.
Future Storage (a-f): 0.
Present Investment ($1000): 3.6
Future Investment ($1000): 0.0
Conduit Cost ($1000): 0.0
Date Contract Approved: Aug 66
Type: Reallocation of Conservation storage

Contractor: Hardinsburg
Present Storage (a-f): 150.
Future Storage (a-f): 0.
Present Investment ($1000): 17.8
Future Investment ($1000): 0.0
Conduit Cost ($1000): 0.0
Date Contract Approved: Mar 79
Type: Reallocation of Conservation storage

☆**WILLIAM H. HARSHA LAKE**
CWIS No. 05180
East Fork, Little Miami River
Clermont County, Ohio

Contractor: State of Ohio
Present Storage (a-f): 35,500.
Future Storage (a-f): 0.
Present Investment ($1000): 3,987.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: May 70
Type:

MISSISSIPPI VALLEY DIVISION

ROCK ISLAND DISTICT

☆**SAYLORVILLE LAKE**
CWIS No. 16510
Des Moines River
Polk, Dallas, Boone Counties, Iowa

Contractor: State of Iowa

Present Storage (a-f):	14,900.	
Future Storage (a-f):	0.	
Present Investment ($1000):		4,811.6
Future Investment ($1000):		0.0
Conduit Cost ($1000):		0.0

Date Contract Approved: Aug 82
Type: Reallocation of Flood Control storage

ST. LOUIS DISTRICT

☆**CARLYLE LAKE**
CWIS No. 02700
Kaskaskia River
Clinton County, Illinois

Contractor: State of Illinois

Present Storage (a-f):	33,000.	
Future Storage (a-f):	0.	
Present Investment ($1000):		3,635.
Future Investment ($1000):		0.
Conduit Cost ($1000):		0.

Date Contract Approved: Jun 58
Type:

☆**CLARENCE CANNON DAM - MARK TWAIN LAKE**
CWIS No. 02560
Salt River
Ralls County, Missouri

Not Under Contract

Present Storage (a-f):	*0.*	
Future Storage (a-f):	*20,000.*	
Present Investment ($1000):		*0.*
Future Investment ($1000):		*13,000*
Conduit Cost ($1000):		*0.*

☆**LAKE SHELBYVILLE**

CWIS No. 16691
Kaskaskia River
Shelby County, Illinois

Contractor: State of Illinois

Present Storage (a-f):	25,000.	
Future Storage (a-f):	0.	
Present Investment ($1000):		4,310.
Future Investment ($1000):		0.
Conduit Cost ($1000):		0.

Date Contract Approved: Jun 62
Type:

☆**REND LAKE**

CWIS No. 15190
Big Muddy River
Franklin County, Illinois

Contractor: State of Illinois

Present Storage (a-f):	109,000.	
Future Storage (a-f):	0.	
Present Investment ($1000):		10,000.
Future Investment ($1000):		0.
Conduit Cost ($1000):		0.

Date Contract Approved: May 65
Type:

VICKSBURG DISTRICT

☆**DEGRAY LAKE**
CWIS No. 36011
Caddo River
Clark and Hot Springs Counties, Arkansas

Not Under Contract
Present Storage (a-f): 0.
Future Storage (a-f): 167,750.
Present Investment ($1000): 0.
Future Investment ($1000): 5,904.
Conduit Cost ($1000): 0.

NORTHWESTERN DIVISION

SEATTLE DISTRICT

☆**WYNOOCHEE LAKE**
CWIS No. 67327
Wynoochee River
Grays Harbor County, Washington

Contractor: City of Aberdeen

Present Storage (a-f):	26,400.	
Future Storage (a-f):	18,200.	
Present Investment ($1000):		11,281.
Future Investment ($1000):		7,772.
Conduit Cost ($1000):		0.

Date Contract Approved: Oct 67
Type:

PORTLAND DISTRICT

☆**LOST CREEK LAKE**
CWIS No. 10090
Rogue River
Jackson County, Oregon

Contractor: City of Phoenix

Present Storage (a-f):	400.	
Future Storage (a-f):	0.	
Present Investment ($1000):		269.7
Future Investment ($1000):		0.
Conduit Cost ($1000):		0.

Date Contract Approved: Jun 82
Type:

Not Under Contract

Present Storage (a-f):	*0.*	
Future Storage (a-f):	*9,600.*	
Present Investment ($1000):		*0.0*
Future Investment ($1000):		*5,730.3*
Conduit Cost ($1000):		*0.0*

OMAHA DISTIRCT

☆**BOWMAN-HALEY DAM AND LAKE**
CWIS No. 01970
North Fork of Grand River
Bowman County, North Dakota

Contractor: Bowman County Wtr Mgmt Dist

Present Storage (a-f):	15,500.	
Future Storage (a-f):	0.	
Present Investment ($1000):		825.
Future Investment ($1000):		0.
Conduit Cost ($1000):		0.

Date Contract Approved: Dec 82
Type:

☆**GARRISON DAM AND LAKE**
CWIS No. 06400
Missouri River
Bismarch, North Dakota

Contractor: Basin Electric Power Cooperative

Pesent Storage (a-f)	21,000	
Future Storage (a-f)	0	
Present Investment ($1000):		630 per year
Future Investment ($1000):		0
Conduit ($1000):		0

Date Contract Approved: Oct. 88
Type:

KANSAS CITY DISTRICT

☆**CLINTON LAKE**
CWIS No. 03480
Wakarusa River
Douglas County, Kansas

Contractor: State of Kansas

Present Storage (a-f):	53,520.	
Future Storage (a-f):	35,680.	
Present Investment ($1000):		3,873.4
Future Investment ($1000):		2,582.3
Conduit Cost ($1000):		312.4

Date Contract Approved: Oct 78
Type:

☆**HILLSDALE LAKE**
CWIS No. 07540
Big Bull Creek
Miami County, Kansas

Contractor: State of Kansas

Present Storage (a-f):	7,500.	
Future Storage (a-f):	45,500.	
Present Investment ($1000):		3,314.2
Future Investment ($1000):		20,107.5
Conduit Cost ($1000):		0.0

Date Contract Approved: Apr 74
Type:

☆**LONG BRANCH LAKE**
CWIS No. 10030
Little Chariton River
Macon County, Missouri

Contractor: City of Macon

Present Storage (a-f):	4,400.	
Future Storage (a-f):	13,800.	
Present Investment ($1000):		1,118.3
Future Investment ($1000):		3,507.2
Conduit Cost ($1000):		0.

Date Contract Approved: Sep 72
Type:

Not Under Contract

Present Storage (a-f):	*0.*	
Future Storage (a-f):	*6,200.*	
Present Investment ($1000):		*0.*
Future Investment ($1000):		*1,575.7*
Conduit Cost ($1000):		*0.*

☆**MILFORD LAKE**
CWIS No. 11140
Republican River
Geary County, Kansas

Contractor: State of Kansas

Present Storage (a-f):	46,650.	
Future Storage (a-f):	253,350.	
Present Investment ($1000):		2,028.6
Future Investment ($1000):		1,1017.0
Conduit Cost ($1000):		0.0

Date Contract Approved: Sep 76
Type:

☆**PERRY LAKE**
CWIS No. 13920
Delaware River
Jefferson County, Kansas

Contractor: State of Kansas

Present Storage (a-f):	0.	
Future Storage (a-f):	150,000.	
Present Investment ($1000):		0.0
Future Investment ($1000):		9,208.3
Conduit Cost ($1000):		0.0

Date Contract Approved: Oct 77
Type:

☆**POMONA LAKE**
CWIS No. 14280
One Hundred Ten Mile Creek
Osage County, Kansas

Contractor: RWD #3

Present Storage (a-f):	230.	
Future Storage (a-f):	0.	
Present Investment ($1000):		13.4
Future Investment ($1000):		0.0
Conduit Cost ($1000):		0.0

Date Contract Approved: Sep 64
Type:

Contractor: RWD #9

Present Storage (a-f):	500.	
Future Storage (a-f):	0.	
Present Investment ($1000):		37.5
Future Investment ($1000):		0.0
Conduit Cost ($1000):		0.0

Date Contract Approved: May 74
Type:

Kansas City District (continued)

POMONA LAKE (continued)

Contractor: RWD #3
Present Storage (a-f): 270.
Future Storage (a-f): 0.
Present Investment ($1000): 20.1
Future Investment ($1000): 0.0
Conduit Cost ($1000): 0.0
Date Contract Approved: Jan 80
Type:

☆RATHBUN LAKE
CWIS No. 14880
Chariton River
Appanoose County, Iowa

Contractor: Rathbun RWD
Present Storage (a-f): 3,340.
Future Storage (a-f): 0.
Present Investment ($1000): 331.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Nov 86
Type: Reallocation of Conservation storage

☆SMITHVILLE LAKE
CWIS No.16980
Little Platte River
Clay and Clinton Counties, Missouri

Contractor: City of Plattsburg
Present Storage (a-f): 2,650.
Future Storage (a-f): 8,850.
Present Investment ($1000): 734.8
Future Investment ($1000): 2,458.
Conduit Cost ($1000): 0.
Date Contract Approved: Nov 72
Type:

Contractor: City of Smithville
Present Storage (a-f): 2,000.
Future Storage (a-f): 6,000.
Present Investment ($1000): 555.0
Future Investment ($1000): 1,665.1
Conduit Cost ($1000): 53.0
Date Contract Approved: Nov 72
Type:

Not Under Contract
Present Storage (a-f): 0.
Future Storage (a-f): 75,700.
Present Investment ($1000): 0.
Future Investment ($1000): 21,000.
Conduit Cost ($1000): 2,331.

SOUTHWESTERN DIVISION

LITTLE ROCK DISTRICT

☆ BEAVER LAKE
CWIS No. 01230
White River
Carroll County, Arkansas

Contractor: Beaver W.D. No. 1
Present Storage (a-f): 31,000.
Future Storage (a-f): 77,000.
Present Investment ($1000): 1,431.7
Future Investment ($1000): 3,477.1
Conduit Cost ($1000): 0.
Date Contract Approved: Jun 60
Type:

Contractor: Carroll-Boone Wtr. Dist.
Present Storage (a-f): 9,000.
Future Storage (a-f): 0.
Present Investment ($1000): 42.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Apr 77
Type: Reallocation

Contractor: Madison County Water District
Present Storage (a-f): 4,093.
Future Stroage (a-f): 0.
Present Investment ($1000): 783
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Contract Approved: Jun 92, Rev. Apr 96
Type: Reallocation of FC to WS

☆BLUE MOUNTAIN LAKE
CWIS No. 01800
Petit Jean River
Yell County, Arkansas

Contractor: City of Danville
Present Storage (a-f): 1,550.
Future Storage (a-f): 0.
Present Investment ($1000): 417.2
Future Investment ($1000): 0
Condit Cost ($1000): 0
Date Agreement Approved: Dec 94
Type: Reallocation of FC to WS

☆ BULL SHOALS

CWIS No. 00820
White River
Marion County, Arkansas

Contractor: Marion County Water District
Present Storage (a-f): 880.
Future Storage (a-f): 0.
Present Investment ($1000): 85
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Contract Approved: Apr. 88
Type: Reallocation of Hydro to WS

☆ DEQUEEN LAKE
CWIS No. 04620
Rolling Fork River
Sevier County, Arkansas

Contractor: Tri-Lakes Water District
Present Storage (a-f): 610.
Future Storage (a-f): 0.
Present Investment ($1000): 249.5
Future Investment ($1000): 0
Conduit Cost ($1000): 6.6
Date Agreement Approved: Feb 95
Type:

Not Under Contract
Present Storage (a-f): 0.
Future Storage (a-f): 17,275.
Present Investment ($1000): 0.
Future Investment ($1000): 4,942.4
Conduit Cost ($1000): 186.9

Little Rock District (continued)

☆ **DIERKS LAKE**
CWIS No. 04770
Saline River
Howard and Sevier Counties, Arkansas

Contractor: Tri-Lake Water Dist.
Present Storage (a-f): 190.
Future Storage (a-f): 9,910.
Present Investment ($1000): 40.6
Future Investment ($1000): 2,110.1
Conduit Cost ($1000): 181.7
Date Contract Approved: Feb 77
Type:

☆ **GILLHAM LAKE**
CWIS No. 06550
Cossatot River
Howard County, Arkansas

Contractor: Tri-Lakes Wtr Dist
Present Storage (a-f): 323.
Future Storage (a-f): 20,277.
Present Investment ($1000): 167.2
Future Investment ($1000): 5,251.0
Conduit Cost ($1000): 79.0
Date Contract Approved: Dec. 80, additional storage Feb.95
Type:

☆ **GREERS FERRY LAKE**
CWIS No. 07070
Little Red River
Cleburne County, Arkansas

Contractor: City of Clinton
Present Storage (a-f): 900.
Future Storage (a-f): 0.
Present Investment ($1000): 81.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Nov 70
Type: Reallocation

Contractor: Community Water System
Present Storage (a-f): 225.
Future Storage (a-f): 0.
Present Investment ($1000): 20.3
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Apr 71
Type: Reallocation

Contractor: Community Water System
Present Storage (a-f): 3,776.
Future Storage (a-f): 0.
Present Investment ($1000): 457.8
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Contract Approved: Feb 95
Type: Reallocation from FC to WS

☆ **MILLWOOD LAKE**
CWIS No. 11240
Little River
Hempstead and Little River Counties, Arkansas

Contractor: Southwest AR Wtr Dist
Present Storage (a-f): 44,544.
Future Storage (a-f): 105,456.
Present Investment ($1000): 4,318.7
Future Investment ($1000): 10,089.8
Conduit Cost ($1000): 110.5
Date Contract Approved: Nov. 80
Type:

☆ **NIMROD LAKE**
CWIS No. 12620
Fourche LaFave River
Perry County, Arkansas

Contractor: City of Plainview
Present Storage (a-f): 33.
Future Storage (a-f): 0.
Present Investment ($1000): 1.2
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Dec 73
Type: Reallocation

Little Rock District (continued)

NINROD LAKE (continued)

Contractor: City of Plainview
Present Storage (a-f): 110.
Future Storage (a-f): 0.
Present Investment ($1000): 22.0
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Contract Approved: Sep 94
Type: Reallocaiton of FC to WS

☆ **NORFORK LAKE**
CWIS No. 12830
North Fork River
Baxter County, Arkansas

Contractor: City of Mtn Home
Present Storage (a-f): 2,400.
Future Storage (a-f): 0.
Present Investment ($1000): 196.4
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Jan 68
Type:

FT. WORTH DISTRICT

☆ **AQUILLA LAKE**
CWIS No. 74786
Aquilla Creek
Hill County, Texas

Contractor: Brazos River Authority
Present Storage (a-f): 3,360.
Future Storage (a-f): 30,240.
Present Investment ($1000): 1,257.
Future Investment ($1000): 11,316.
Conduit Cost ($1000): 0.
Date Contract Approved: Jun 76
Type:

☆ **BARDWELL LAKE**
CWIS No. 00930
Waxahachie Creek
Ellis County, Texas

Contractor: Trinity River Auth.
Present Storage (a-f): 10,700.
Future Storage (a-f): 0.
Present Investment ($1000): 823.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Jun 63
Type:

Contractor: Trinity River Auth.
Present Storage (a-f): 21,400.
Future Storage (a-f): 10,700.
Present Investment ($1000): 1,645.
Future Investment ($1000): 823.
Conduit Cost ($1000): 0.
Date Contract Approved: Oct 69
Type:

☆ **BELTON LAKE**
CWIS No. 01330
Leon River
Bell County, Texas

Contractor: Fort Hood
Present Storage (a-f): 12,000.
Future Storage (a-f): 0.
Present Investment ($1000): 161.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Jun 54
Type:

Contractor: Brazos River Auth
Present Storage (a-f): 113,700.
Future Storage (a-f): 0.
Present Investment ($1000): 1,524.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Jan 58
Type:

Contractor: Brazos River Auth
Present Storage (a-f): 247,000.
Future Storage (a-f): 0.
Present Investment ($1000): 3,601.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Dec 60
Type:

☆ **BENBROOK LAKE**
CWIS No. 01350
Clear Fork of the Trinity River
Tarrant County, Texas

Contractor: City of Ft. Worth
Present Storage (a-f): 7,250.
Future Storage (a-f): 0.
Present Investment ($1000): 310.0
Future Investment ($1000): 0.
Conduit Cost ($1000): 36.
Date Contract Approved: Aug 69
Type:

Contractor: Benbrook W&S Auth
Present Storage (a-f): 7,250.
Future Storage (a-f): 0.
Present Investment ($1000): 310.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Feb 72
Type:

Ft. Worth District (continued)

BENBROOK LAKE (continued)

Contractor: Benbrook W&S Auth
Present Storage (a-f): 9,208.
Future Storage (a-f): 0.
Present Investment ($1000): 394.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Aug 79
Type:

Contractor: Tarrant County WaterControl And Improvement Distirct No. 1
Present Storage (a-f): 48,792.
Future Storage (a-f): 0.
Present Investment ($1000): 2,086
Future Invistment ($1000): 0
Conduit ($1000): 0
Date Agreement Approved: 21 June 91
Type: Interim Use of Surplus Water

☆ **CANYON LAKE**
CWIS No. 02590
Guadalupe River
Comal County, Texas

Contractor: Guadalupe-Blanco River Auth
Present Storage (a-f): 366,400.
Future Storage (a-f): 0.
Present Investment ($1000): 8,080.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Oct 57
Type:

☆ **COOPER LAKE**
CWIS No. 03820
South Sulphur River
Delta and Hopkins Counties, Texas

Contractor: Sulphur R. M.W.D.
Present Storage (a-f): 17,750.
Future Storage (a-f): 54,000.
Present Investment ($1000): 3,836.
Future Investment ($1000): 11,670.
Conduit Cost ($1000): 0.
Date Contract Approved: Jun 68
Type:

Contractor: City of Irving
Present Storage (a-f): 46,200.
Future Storage (a-f): 54,425.
Present Investment ($1000): 9,985.
Future Investment ($1000): 11,762.
Conduit Cost ($1000): 0.
Date Contract Approved: Jun 68
Type:

Contractor: N. TX Mun. Wtr. Dist
Present Storage (a-f): 0.
Future Storage (a-f): 100,625.
Present Investment ($1000): 0.
Future Investment ($1000): 21,747.
Conduit Cost ($1000): 0.
Date Contract Approved: Jun 68
Type:

☆ **FERRELL'S BRIDGE DAM - LAKE O' THE PINES**
CWIS No. 05850
Big Cypress Creek
Marion County, Texas

Contractor: N.E. Texas, MWD
Present Storage (a-f): 250,000.
Future Storage (a-f): 0.
Present Investment ($1000): 1,753.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Jul 55
Type:

☆ **GRANGER DAM AND LAKE**
CWIS No. 75357
San Gabriel River
Williamson County, Texas

Contractor: Brazos River Auth
Present Storage (a-f): 0.
Future Storage (a-f): 37,900.
Present Investment ($1000): 0.
Future Investment ($1000): 12,865.
Conduit Cost ($1000): 0.
Date Contract Approved: Apr 81
Type:

Ft. Worth District (continued)

☆ **GRAPEVINE LAKE**
CWIS No. 06760
Denton Creek
Tarrant and Denton Counties, Texas

Contractor: City of Grapevine
Present Storage (a-f): 1,250.
Future Storage (a-f): 0.
Present Investment ($1000): 23.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Sep 53
Type:

Contractor: Dalles Co. Park Cities
Present Storage (a-f): 50,000.
Future Storage (a-f): 0.
Present Investment ($1000): 607.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Mar 54
Type:

Contractor: City of Dallas
Present Storage (a-f): 85,000.
Future Storage (a-f): 0.
Present Investment ($1000): 1,433.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Mar 54
Type:

Contractor: City of Grapevine
Present Storage (a-f): 25,000.
Future Storage (a-f): 0.
Present Investment ($1000): 684.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Feb 81
Type:

☆ **HORDS CREEK LAKE**
CWIS No. 07710
Hords Creek
Coleman County, Texas

Contractor: Central Colorado River Auth
Present Storage (a-f): 5,780.
Future Storage (a-f): 0.
Present Investment ($1000): 100.
Future Investment ($1000): 0.
Conduit Cost ($1000): 5.
Date Contract Approved: Jun 48
Type:

☆ **JOE POOL LAKE**
CWIS No. 09420
Mountain Creek
Dallas County, Texas

Contractor: Trinity River Authority
Present Storage (a-f): 0.
Future Storage (a-f): 142,900.
Present Investment ($1000): 0.
Future Investment ($1000): 57,955.
Conduit Cost ($1000): 80.
Date Contract Approved: Jun 77
Type:

☆ **LAVON LAKE**
CWIS No. 09580
East Fork of the Trinity River
Collin County, Texas

Contractor: North Texas MWD
Present Storage (a-f): 100,000.
Future Storage (a-f): 0.
Present Investment ($1000): 1,256.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Jul 54
Type:

Contractor: North Texas MWD
Present Storage (a-f): 120,000.
Future Storage (a-f): 0.
Present Investment ($1000): 13,659.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Sep 67
Type:

Ft. Worth Distict (continued)

LAVON LAKE (continued)

Contractor: North Texas MWD
Present Storage (a-f): 160,000.
Future Storage (a-f): 0.
Present Investment ($1000): 21,381.3
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Dec 85
Type:

☆ **LEWISVILLE LAKE**
CWIS No. 09740
Elm Fork of the Trinty River
Denton County, Texas

Contractor: City of Dallas
Present Storage (a-f): 415,000.
Future Storage (a-f): 0.
Present Investment ($1000): 3,677.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Jul 53
Type:

Contractor: City of Denton
Present Storage (a-f): 21,000.
Future Storage (a-f): 0.
Present Investment ($1000): 250.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: May 54
Type:

☆ **NAVARRO MILLS LAKE**
CWIS No. 12260
Richland Creek
Navarro County, Texas

Contractor: Trinity River Auth
Present Storage (a-f): 53,200.
Future Storage (a-f): 0.
Present Investment ($1000): 2,176.
Future Investment ($1000): 0.
Conduit Cost ($1000): 28.
Date Contract Approved: Aug 59
Type:

☆ **NORTH SAN GABRIEL DAM**
GEORGETOWN LAKE
CWIS No. 75358
North Fork of the San Gabriel River
Williamson County, Texas

Contractor: Brazos River Auth.
Present Storage (a-f): 4,961.
Future Storage (a-f): 24,239.
Present Investment ($1000): 1,022.
Future Investment ($1000): 4,992.
Conduit Cost ($1000): 0.
Date Contract Approved: Apr 81
Type:

☆ **O. C. FISHER DAM AND LAKE**
CWIS No. 16090
North Concho River
Tom Green County, Texas

Contractor: Upper Colorado R. Auth.
Present Storage (a-f): 80,400.
Future Storage (a-f): 0.
Present Investment ($1000): 860.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Oct 48
Type:

☆ **PROCTOR LAKE**
CWIS No. 14580
Leon River
Comanche County, Texas

Contractor: Brazos River Auth
Present Storage (a-f): 31,400.
Future Storage (a-f): 0.
Present Investment ($1000): 1,314.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: May 60
Type:

Ft. Worth District (continued)

☆ **RAY ROBERTS LAKE**
CWIS No. 74787
Elm Fork of the Trinity River
Denton County, Texas

Contractor: City of Denton
Present Storage (a-f): 147,471.
Future Storage (a-f): 93,500.
Present Investment ($1000): 22,940.
Future Investment ($1000): 21,241.
Conduit Cost ($1000): 67.
Date Contract Approved: Sep 80
Type:

Contractor: City of Dallas
Present Storage (a-f): 419,709.
Future Storage (a-f): 266,100.
Present Investment ($1000): 65,422.
Future Investment ($1000): 60,324.
Conduit Cost ($1000): 191.
Date Contract Approved: Sep 80
Type:

☆ **SAM RAYBURN DAM AND RESERVOIR**
CWIS No. 16040
Angelina River
Jasper County, Texas

Contractor: City of Lufkin
Present Storage (a-f): 43,000.
Future Storage (a-f): 0.
Present Investment ($1000): 526.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: May 69
Type:

☆ **SOMERVILLE LAKE**
CWIS No. 17110
Yegua Creek
Burleson and Washington Counties, Texas

Contractor: Brazos River Auth
Present Storage (a-f): 143,900.
Future Storage (a-f): 0.
Present Investment ($1000): 7,197.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: May 62
Type:

☆ **STILLHOUSE HOLLOW LAKE**
CWIS No. 17530
Lampasas River
Bell County, Texas

Contractor: Brazos River Auth.
Present Storage (a-f): 204,900.
Future Storage (a-f): 0.
Present Investment ($1000): 6,983.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Apr 62
Type:

☆ **TOWN BLUFF DAM - B.A. STEINHAGEN LAKE**
CWIS No. 79053
Neches River
Tyler County, Texas

Contractor: Lower Neches Valley Auth
Present Storage (a-f): 94,200.
Future Storage (a-f): 0.
Present Investment ($1000): 2,000.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Jun 55
Type:

Ft. Worth District (continued)

☆ WACO LAKE
CWIS No. 19250
Bosque River
McLennan County, Texas

Contractor: City of Waco
Present Storage (a-f): 13,026.
Future Storage (a-f): 0.
Present Investment ($1000): 0.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Apr 58
Type:

Contractor: Brazos River Auth
Present Storage (a-f): 91,074.
Future Storage (a-f): 0.
Present Investment ($1000): 5,577.
Future Investment ($1000): 0.
Conduit Cost ($1000): 216.
Date Contract Approved: Apr 58
Type:

Contractor: Brazos River Auth.
Present Storage (a-f): 47,526.
Future Storage (a-f): 0.
Present Investment ($1000): 15,242.4
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Sep 84
Type: Reallocation of Flood Control storage

☆ WHITNEY LAKE
CWIS No. 19920
Brazos River
Bosque and Hill Counties, Texas

Contractor: Brazos River Auth
Present Storage (a-f): 50,000.
Future Storage (a-f): 0.
Present Investment ($1000): 1,181.4
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Nov 82
Type: Reallocation of ?

☆ WRIGHT PATMAN DAM AND LAKE
CWIS No. 18110
Sulphur River
Bowie and Cass Counties, Texas

Contractor: City of Texarkana
Present Storage (a-f): 91,263.
Future Storage (a-f): 0.
Present Investment ($1000): 1,788.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Feb 54
Type:

TULSA DISTRICT

☆ **ARCADIA LAKE**
CWIS No. 75012
Deep Fork River
Oklahoma County, Oklahoma

Contractor: Edmond Public Works Auth
Present Storage (a-f): 8,460.
Future Storage (a-f): 14,630.
Present Investment ($1000): 16,253.6
Future Investment ($1000): 27,790.0
Conduit Cost ($1000): 266.6
Date Contract Approved: Nov 79
Type:

☆ **BIRCH LAKE**
CWIS No. 01540
Birch Creek
Osage County, Oklahoma

Not Under Contract
Present Storage (a-f): 0.
Future Storage (a-f): 7,630.
Present Investment ($1000): 0.
Future Investment ($1000): 2,209.
Conduit Cost ($1000): 23.

☆ **BROKEN BOW LAKE**
CWIS No. 02040
Mountain Fork River
McCurtain County, Oklahoma

Contractor: Oklahoma Tourism & Recreation Department
Present Storage (a-f): 60.
Future Storage (a-f): 0.
Present Investment ($1000): 2.0
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Sep 88
Type:

Contractor: Broken Bow Public Works Authority
Present Storage (a-f): 4,241.
Future Storage (a-f): 4,054,
Present Investment ($1000): 161.3
Future Investment ($1000): 107.6
Conduit Cost ($1000): 6.2
Date Agreement Approved: Feb 90
Type:

Not Under Contract
Present Storage (a-f): 0.
Future Storage (a-f): 144,145.
Present Investment ($1000): 0.
Future Investment ($1000): 3,827.0
Conduit Cost ($1000): 108.1

☆ **CANTON LAKE**
CWIS No. 02570
North Canadian River
Blaine County, Oklahoma

Contractor: Oklahoma City
Present Storage (a-f): 90,000,
Future Storage (a-f): 0.
Present Investment ($1000): 2,806.9
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Nov 91

Tulsa District (continued)

☆ COPAN LAKE
CWIS No. 03890
Little Caney River
Washington County, Oklahoma

Contractor: Copan PWA
Present Storage (a-f): 250.
Future Storage (a-f): 4,750.
Present Investment ($1000): 268.7
Future Investment ($1000): 5,105.2
Conduit Cost ($1000): 0.
Date Contract Approved: Sep 81
Type:

Not Under Contract
Present Storage (a-f): 0.
Future Storage (a-f): 2,500.
Present Investment ($1000): 0.
Future Investment ($1000): 2,686.9
Conduit Cost ($1000): 24.7

☆ COUNCIL GROVE LAKE
CWIS No. 04100
Grand (Neosho) River
Morris County, Kansas

Contractor: Kansas W.R. Board
Present Storage (a-f): 24,400.
Future Storage (a-f): 0.
Present Investment ($1000): 1,400.
Future Investment ($1000): 0.
Conduit Cost ($1000): 62.
Date Contract Approved: Nov 76
Type:

☆ DENISON DAM - LAKE TEXOMA
CWIS No. 74945
Red River
Grayson County, Texas

Contractor: City of Denison
Present Storage (a-f): 21,300.
Future Storage (a-f): 0.
Present Investment ($1000): 370.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Sep 53

Contractor: Texas Power & Light
Present Storage (a-f): 16,400.
Future Storage (a-f): 0.
Present Investment ($1000): 286.4
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Aug 61
Type:

Contractor: Red R. Auth of Texas
Present Storage (a-f): 450.
Future Storage (a-f) : 0.
Present Investment ($1000): 9.1
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Nov 69
Type:

Contractor: Red R. Auth of Texas
Present Storage (a-f): 1,806.
Future Storage (a-f): 0.
Present Investment ($1000): 364.4
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Aug 83
Type: Reallocation of Hydropower storage

Contractor: North Texas MWD
Present Storage (a-f): 75,000.
Future Storage (a-f): 0.
Present Investment ($1000): 16,264.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Dec 85
Type: Reallocation of Hydropower storage

Contractor: Buncombe Creek View Additon
Present Storage (a-f): 1.
Future Storage (a-f): 0.
Present Investment ($1000): 0.3
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Apr 92
Type: Reallocation of Hyropower

Contractor: Greater Texoma Utility Authority
Present Storage (a-f): 5,500.
Future Storage (a-f): 0.
Present Investment ($1000): 1,266.1
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Sep 92
Type: Reallocation of Hydropower

Tulsa District (continued

☆ EL DORADO LAKE
CWIS No. 05350
Walnut River
Butler County, Kansas

Contractor: City of El Dorado
Present Storage (a-f): 51,459.
Future Storage (a-f): 91,341.
Present Investment ($1000): 13,206.3
Future Investment ($1000): 23,441.2
Conduit Cost ($1000): 838.2
Date Contract Approved: Jun 72
Type:

☆ ELK CITY LAKE
CWIS No. 05360
Elk River
Montgomery County, Kansas

Contractor: Kansas Water Res. Board
Present Storage (a-f): 24,300.
Future Storage (a-f): 0.
Present Investment ($1000): 2,076.
Future Investment ($1000): 0.
Conduit Cost ($1000): 71.
Date Contract Approved: Nov 76
Type:

☆ EUFAULA LAKE
CWIS No. 05650
Canadian River
Oklmulgee, McIntosh, Haskell and Pittsburg Counties, Oklahoma

Contractor: Haskell Co. Water Co.
Present Storage (a-f): 400.
Future Storage (a-f): 0.
Present Investment ($1000): 35.4
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Aug 68
Type:

Contractor: Pitts. Co. Water Auth
Present Storage (a-f): 850.
Future Storage (a-f): 0.
Present Investment ($1000): 75.3
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Aug 68
Type:

Contractor: Haskell Co. RWD NO. 1
Present Storage (a-f): 50.
Future Storage (a-f): 0.
Present Investment ($1000): 4.4
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Jan 69
Type:

Contractor: RWD No. 4 Pitts. Co.
Present Storage (a-f): 50.
Future Storage (a-f): 0.
Present Investment ($1000): 4.4
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Sep 69
Type:

Contractor: RWD No. 3, Moskogee Co
Present Storage (a-f): 100.
Future Storage (a-f): 0.
Present Investment ($1000): 8.9
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Sep 69
Type:

Contractor: Porum Public Works Auth
Present Storage (a-f): 125.
Future Storage (a-f): 0.
Present Investment ($1000): 11.1
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Sep 69
Type:

Contractor: Lakeside Water Co. Inc
Present Storage (a-f): 20.
Future Storage (a-f): 0.
Present Investment ($1000): 1.8
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Nov 71
Type:

Tulsa District (continued)

EUFAULA LAKE (continued)

Contractor: Sherwood Forrest Company
Present Storage (a-f): 60.
Future Storage (a-f): 0.
Present Investment ($1000): 5.3
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Nov 71
Type:

Contractor: RWD No. 3, Haskell Co.
Present Storage (a-f): 25.
Future Storage (a-f): 0.
Present Investment ($1000): 2.2
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Jul 74
Type:

Contractor: Krebs Util. Auth
Present Storage (a-f): 280.
Future Storage (a-f): 280.
Present Investment ($1000): 29.1
Future Investment ($1000): 29.1
Conduit Cost ($1000): 0.
Date Contract Approved: Oct 80
Type:

Contractor: Rural WGS Dist #8 McIntosh Co
Present Storage (a-f): 300.
Future Storage (a-f): 1,200.
Present Investment ($1000): 31.6
Future Investment ($1000): 106.1
Conduit Cost ($1000): 0.
Date Contract Approved: Mar 81
Type:

Contractor: Porum Public Works Auth
Present Storage (a-f): 280.
Future Storage (a-f): 120.
Present Investment ($1000): 30.1
Future Investment ($1000): 10.6
Conduit Cost ($1000): 0.
Date Contract Approved: Sep 81
Type:

Contractor: Pitts Co. Public Works Auth
Present Storage (a-f): 300.
Future Storage (a-f): 190.
Present Investment ($1000): 33.1
Future Investment ($1000): 25.8
Conduit Cost ($1000): 0.
Date Contract Approved: Dec 81
Type:

Contractor: Longtown, R.W.&S.D.#1
Present Storage (a-f): 1,000.
Future Storage (a-f): 0.
Present Investment ($1000): 80.8
Future Investment ($1000): 0
Conduit Cost ($1000): 0.4
Date Contract Approved: Apr 85
Type:

Contractor: Public Service Co. of OK
Present Storage (a-f): 0.
Future Storage (a-f): 100.
Present Investment ($1000): 0
Future Investment ($1000): 8.1
Conduit Cost ($1000): .04
Date Contract Approved: Dec 85
Type:

Contractor: McAlester Public Works Authority
Present Storage (a-f): 6,250.
Future Storage (a-f): 0.
Present Investment ($1000): 505.1
Future Investment ($1000): 0
Conduit Cost ($1000): 2.2
Date Agreement Signed: Oct. 87
Type:

Contractor: Bristow Point Property Owners Association
Present Storage (a-f): 15.
Future Storage (a-f): 0.
Present Investment ($1000): 1.2
Future Investment ($1000): 0
Conduit Cost ($1000): 0.01
Date Agreement Approved: Aug 89
Type:

Tulsa District (continued)

EUFAULA LAKE (continued)

Contractor: Warner Utilities Authority
Present Storage (a-f): 220.
Future Storage (a-f): 0.
Present Investment ($1000): 17.8
Future Investment ($1000): 0
Conduit Cost ($1000): 0.08
Date Agreement Approved: Sep 89
Type:

Contractor: Twin Rivers Estates, Inc,
Present Storage (a-f): 9.
Future Storage (a-f): 0.
Present Investment ($1000): 0.7
Future Investment ($1000): 0
Conduit Cost ($1000): 0.003
Date Agreement Approved: Mar 90
Type:

Contractor: Bridgeport Dunes Condominium Homeowners Assoc., Inc.
Present Storage (a-f): 5.
Future Storage (a-f) 0.
Present Investment ($1000): 0.4
Future Investment ($1000): 0
Conduit Cost ($1000): 0.002
Date Agreement Approved: Sep 90
Type:

Contractor: Pittsburg County RWD #14
Present Storage (a-f): 320.
Future Storage (a-f): 0.
Present Investment ($1000): 25.8
Future Investment ($1000): 0
Conduit Cost ($1000): 0.1
Date Agreement Approved: Mar 91
Type:

Contractor: Duchess Creed Mobile Home Park
Present Use Storage (a-f): 4.
Future Use Storage (a-f): 0.
Present Investment ($1000): 0.3
Future Investment ($1000): 0
Conduit Cost ($1000): 0.001
Date Agreement Approved: Apr 92
Type:

Not Under Contract
Present Storage (a-f): 0.
Future Storage (a-f): 42,492.
Present Investment ($1000): 0.
Future Investment ($1000): 3,433.7
Conduit Cost ($1000): 15.2

☆ **FORT SUPPLY LAKE**
CWIS No. 06040
Wolf Creek
Woodward County, Oklahoma

Contractor: OK Board of Public Affairs
Present Storage (a-f): 400.
Future Storage (a-f): 0.
Present Investment ($1000): 38.8
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Jun 64
Type:

☆ **HEYBURN LAKE**
CWIS No. 07500
Polecat Creek
Creek County, Oklahoma

Contractor: Creek Co. RWD #3
Present Storage (a-f): 300.
Future Storage (a-f): 0.
Present Investment ($1000): 13.4
Future Investment ($1000): 0.
Conduit Cost ($1000): 51.2
Date Contract Approved: Sep 64
Type:

Contractor: Creek Co. RWD #3
Present Storage (a-f): 600.
Future Storage (a-f): 0.
Present Investment ($1000): 34.4
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Mar 68
Type:

Tulsa District (continued)

HEYBURN LAKE (continued)

Contractor: Creek Co. RWD #3
Present Storage (a-f): 1,100.
Future Storage (a-f): 0.
Present Investment ($1000): 73.1
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Nov 78
Type:

☆ **HUGO LAKE**
CWIS No. 07830
Kiamichi River
Choctaw County, Oklahoma

Contractor: Hugo Municipal Auth
Present Storage (a-f): 1,640.
Future Storage (a-f): 18,880.
Present Investment ($1000: 94.
Future Investment ($1000): 1,082.
Conduit Cost ($1000): 30.
Date Contract Approved: Oct 74
Type:

Contractor: Antlers Pub. Works Auth
Present Storage (a-f): 490.
Future Storage (a-f): 430.
Present Investment ($1000): 28.
Future Investment ($1000): 25.
Conduit Cost ($1000): 0.
Date Contract Approved: Mar 75
Type:

Contractor: Western Farmers Elect. Coop.
Present Storage (a-f): 6,100.
Future Storage (a-f): 17,350.
Present Investment ($1000): 350.
Future Investment ($1000): 995.
Conduit Cost ($1000): 0.
Date Contract Approved: Apr 80
Type:

Contractor: RWD #3, Pushmataha County
Present Storage (a-f): 512.
Future Storage (a-f): 0.
Present Investment ($1000): 29.4
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Oct 94
Type:

Not Under Contract
Present Storage (a-f): 0.
Future Storage (a-f): 2,198.
Present Investment ($1000): 0.
Future Investment ($1000): 126
Conduit Cost ($1000): 0.

☆ **HULAH LAKE**
CWIS No. 07850
Caney River
Osage County, Oklahoma

Contractor: Bartlesville
Present Storage (a-f): 15,400.
Future Storage (a-f): 0.
Present Investment ($1000): 618.7
Future Investment ($1000): 0.
Conduit Cost ($1000): 5.3
Date Contract Approved: Jun 57
Type:

Contractor: Hulah Water Dist
Present Storage (a-f): 100.
Future Storage (a-f): 0.
Present Investment ($1000): 4.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Nov 70
Type:

Contractor: Bartlesville Mod
Present Storage (a-f): 2,200.
Future Storage (a-f): 0.
Present Investment ($1000): 88.3
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Nov 70
Type:

Tulsa District (continued)

HULA LAKE (continued)

Contractor: Bartlesville
Present Storage (a-f): 2,100.
Future Storage (a-f): 0.
Present Investment ($1000): 84.2
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Nov 82
Type:

☆ JOHN REDMOND DAM AND RESERVOIR
CWIS No. 08530
Grand (Neosho) River
Coffey County, Kansas

Contractor: Kansas Water Res. Bd.
Present Storage (a-f): 34,900.
Future Storage (a-f): 0.
Present Investment ($1000): 4,488.
Future Investment ($1000): 0.
Conduit Cost ($1000): 11.
Date Contract Approved: Oct 75
Type:

☆ KAW LAKE
CWIS No. 08790
Arkansas River
Blaine County, Oklahoma

Contractor: OK Gas & Electric
Present Storage (a-f): 9,150.
Future Storage (a-f): 30,200.
Present Investment ($1000): 2,053.
Future Investment ($1000): 6,775.
Conduit Cost ($1000): 0.
Date Contract Approved: Apr 80
Type:

Contractor: Kaw Reservoir Auth
Present Storage (a-f): 0.
Future Storage (a-f): 0.
Present Investment ($1000): 0.
Future Investment ($1000): 0.
Conduit Cost ($1000): 388.
Date Contract Approved: Mar 81
Type:

Contractor: Stillwater Util. Auth.
Present Storage (a-f): 6,662.
Future Storage (a-f): 44,788.
Present Investment ($1000): 1,530.4
Future Investment ($1000): 10,290.0
Conduit Cost ($1000): 0.
Date Contract Approved: Mar 81
Type:

Contractor: Otoe-Missouria Tribe
Present Storage (a-f): 183.
Future Storage (a-f): 0.
Present Investment ($1000): 42.1
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Aug. 93
Type:

Contractor: Kaw Tribe of Oklahoma
Present Storage (a-f): 6.
Future Storage (a-f): 0.
Present Investment ($1000): 0.2
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: July 93
Type: Interim Use Irrigation

Not Under Contract
Present Storage (a-f): 0.
Future Storage (a-f): 80,211.
Present Investment ($1000): 0.
Future Investment ($1000): 18,427.9
Conduit Cost ($1000): 0.

Tulsa District (continued)

☆ **KEYSTONE LAKE**
CWIS No. 08990
Arkansas River
Tulsa County, Oklahoma

Contractor: Public Service Co. of OK
Present Storage (a-f): 12,500.
Future Storage (a-f): 5,500.
Present Investment ($1000): 1,094.8
Future Investment ($1000): 481.7
Conduit Cost ($1000): 0.
Date Contract Approved: Apr 71
Type:

Not Under Contract
Present Storage (a-f): 0.
Future Storage (a-f): 1,999.
Present Investment ($1000): 0.
Future Investment ($1000): 175.2
Conduit Cost ($1000): 28.3

☆ **MARION LAKE**
CWIS No. 10650
Cottonwood River
Marion County, Kansas

Contractor: Kansas Water Res. Bd.
Present Storage (a-f): 38,300.
Future Storage (a-f): 0.
Present Investment ($1000): 1,566.
Future Investment ($1000): 0.
Conduit Cost ($1000): 10.
Date Contract Approved: Nov 76
Type:

☆ **OOLOGAH LAKE**
CWIS No. 13340
Verdigris River
Rogers County, Oklahoma

Contractor: City of Tulsa
Present Storage (a-f): 285,450.
Future Storage (a-f): 0.
Present Investment ($1000): 9,229.3
Future Investment ($1000): 0.
Conduit Cost ($1000): 391.5
Date Contract Approved:
Mar 58 (38,000 AF); Feb 85 (247,450 AF)
Type:

Contractor: Collinsville
Present Storage (a-f): 6,670.
Future Storage (a-f): 0.
Present Investment ($1000): 215.7
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved:
Aug 58 (500 AF); Jun 5 (6,170 AF)
Type:

Contractor: Public Service Co. of OK
Present Storage (a-f): 20,990.
Future Storage (a-f): 0.
Present Investment ($1000): 678.7
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved:
Aug 58 (5,000 AF);
May 85 (15,990 AF)
Type:

Contractor: RWD #1, Nowata Co.
Present Storage (a-f): 200.
Future Storage (a-f): 0.
Present Investment ($1000): 6.5
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved:
Sep 64 (100 AF);
Mar 85 (100 AF)
Type:

Contractor: RWD #4, Rogers Co.
Present Storage (a-f): 1,590.
Future Storage (a-f) : 0.
Present Investment ($1000): 51.4
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved:
Jan 66 (300 AF); Jul 85 (1,290 AF)
Type:

Contractor: RWD #3, Rogers Co.
Present Storage (a-f): 5,960.
Future Storage (a-f): 0.
Present Investment ($1000): 192.7
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved:
Jan 66 (300 AF); Feb 85 (5,660 AF)
Type:

Tulsa District (continued)

OOLOGAH LAKE (continued)

Contractor: Town of Chelsea
Present Storage (a-f): 670.
Future Storage (a-f): 860.
Present Investment ($1000): 21.7
Future Investment ($1000): 27.7
Conduit Cost ($1000): 0.
Date Contract Approved: Apr 82
Type:

Contractor: City of Claremore
Present Storage (a-f): 445.
Future Storage (a-f): 0.
Present Investment ($1000): 14.4
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Sep 88
Type:

Contractor: RWD #3, Washington County
Present Storage (a-f): 4,170.
Future Storage (a-f): 0.
Present Investment ($1000): 134.8
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Jul 92
Type:

Not Under Contract
Present Storage (a-f): 0.
Future Storage (a-f): 15,595.
Present Investment ($1000): 0.
Future Investment ($1000): 504.2
Conduit Cost ($1000): 0.

☆ **PAT MAYSE LAKE**
CWIS No. 13700
Sanders Creek
Lamar County, Texas

Contractor: Paris, TX
Present Storage (a-f): 43,800.
Future Storage (a-f): 65,800.
Present Investment ($1000): 1,284.
Future Investment ($1000): 1,926.
Conduit Cost ($1000): 0.
Date Contract Approved: Feb 65
Type:

Not Under Contract
Present Storage (a-f): 0.
Future Storage (a-f): 0.
Present Investment ($1000): 0.
Future Investment ($1000): 0.
Conduit Cost ($1000): 10.

☆ **PEARSON-SKUBITZ BIG HILL LAKE**
CWIS No. 01450
Big Hill Creek
Labette County, Kansas

Contractor: Kansas W.R. Board
Present Storage (a-f): 9,200.
Future Storage (a-f): 16,500.
Present Investment ($1000): 2,490.5
Future Investment ($1000): 4,465.3
Conduit Cost ($1000): 21.3
Date Contract Approved: Oct 73
Type:

Tulsa District (continued)

☆ **PINE CREEK LAKE**
CWIS No. 14030
Little River
McCurtain County, Oklahoma

Contractor: Weyerhaeuser
Present Storage (a-f): 17,640.
Future Storage (a-f): 11,160.
Present Investment ($1000): 1,663.
Future Investment ($1000): 1,052.
Conduit Cost ($1000): 0.
Date Contract Approved: Nov 70
Type:

Not Under Contract
Present Storage (a-f): 0.
Future Storage (a-f): 20,600.
Present Investment ($1000): 0.
Future Investment ($1000): 1,942.
Conduit Cost ($1000): 148.

☆ **SARDIS LAKE**
CWIS No. 74925
Jackfork Creek
Pushmataha County, Oklahoma

Contractor: OK Wtr. Conserv. Stora. Comm
Present Storage (a-f): 141,700.
Future Storage (a-f): 155,500.
Present Investment ($1000): 7,766.
Future Investment ($1000): 8,522.
Conduit Cost ($1000): 111.
Date Contract Approved: Apr 74
Type:

☆ **SKIATOOK LAKE**
CWIS No. 75378
Hominy Creek
Osage County, Oklahoma

Contractor: Osage County RWD #15
Present Storage (a-f): 0.
Future Storage (a-f): 0.
Present Investment ($1000): 0.
Future Investment ($1000): 0.
Conduit Cost ($1000): 704.0
Date Contract Approved: Dec 92
Type:

Contractor: Osage County RWD #15
Present Storage (a-f): 0.
Future Storage (a-f): 2,000.
Present Investment ($1000): 0.
Future Investment ($1000): 563.9
Conduit Cost ($1000): 0.
Date Contract Approved: Dec 92
Type:

Contractor: Sand Springs Municipal Authority
Present Storage (a-f): 6,740.
Future Storage (a-f): 0.
Present Investment ($1000): 1,900.2
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Mar 88
Type:

Contractor: Sapulpa Municipal Authority
Present Storage (a-f): 2,245.
Future Storage (a-f): 2,245.
Present Investment ($1000): 632.9
Future Investment ($1000): 632.9
Conduit Cost ($1000): 0
Date Agreement Approved: Mar 88
Type:

Contractor: Skiatook Public Works Authority
Present Storage (a-f): 2,018.
Future Storage (a-f): 0.
Present Investment ($1000): 568.9
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Mar 88
Type:

Not Under Contract
Present Storage (a-f): 0.
Future Storage (a-f): 47,652.
Present Investment ($1000): 0.
Future Investment ($1000): 13,434.9
Conduit Cost ($1000): 0.

Tulsa District (continued)

☆ **TENKILLER FERRY LAKE**
CWIS No. 18050
Illinois River
Cherokee and Sequoyah Counties, Oklahoma

Contractor: E. Central OK Water Auth
Present Storage (a-f): 300.
Future Storage (a-f): 0.
Present Investment ($1000): 6.1
Future Investment ($1000): 0.
Conduit Cost ($1000): 11.6
Date Contract Approved: Oct 64
Type:

Contractor: RWD #13, Cherokee County
Present Storage (a-f): 100.
Future Storage (a-f): 0.
Present Investment ($1000): 2.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Nov 67
Type:

Contractor: RWD #2, Cherokee County
Present Storage (a-f): 100.
Future Storage (a-f): 0.
Present Investment ($1000): 2.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Nov 67
Type:

Contractor: Sequoyah Co. Water Assoc.
Present Storage (a-f): 2,200.
Future Storage (a-f): 0.
Present Investment ($1000): 44.4
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Jul 70
Type:

Contractor: Sequoyah Fuels Corp.
Present Storage (a-f): 14,000.
Future Storage (a-f): 0.
Present Investment ($1000): 282.5
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Jul 70
Type:

Contractor: Summit Water Inc.
Present Storage (a-f): 140.
Future Storage (a-f): 0.
Present Investment ($1000): 2.8
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Sep 71
Type:

Contractor: Paradise Hills, Inc.
Present Storage (a-f): 220.
Future Storage (a-f): 0.
Present Investment ($1000): 4.4
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Oct 74
Type:

Contractor: Lake Tenkiller Assoc.
Present Storage (a-f): 200.
Future Storage (a-f): 0.
Present Investment ($1000): 4.3
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved:Mar 81
Type:

Contractor: Greenleaf Nursery Company
Present Storage (a-f): 2,120.
Future Storage (a-f): 0.
Present Investment ($1000): 27.1
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Jun 94
Type: Interim Use Irrigation

Contractor: Greenleaf Nursery Company
Present Storage (a-f): 300.
Future Storage (a-f): 0.
Present Investment ($1000): 4.4
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Jul 95
Type: Interim Use Irrigation

Contractor: Tenkiller Water Company
Present Storage (a-f): 38.
Future Storage (a-f): 0.
Present Investment ($1000): 4.1
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Nov 89
Type:

Tulsa District (continued)

TENKILLER FERRY LAKE (continued)

Contractor: Steep and Ross Land Company
Present Storage (a-f): 17.
Future Storage (a-f): 0.
Present Investment ($1000): 2.1
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Nov 89
Type:

Contractor: Mongold Water System
Present Storage (a-f): 5.
Future Storage (a-f): 0.
Present Investment ($1000): 1.1
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Jan 90
Type:

Contractor: Tenkiller - Aqua Park
Present Storage (a-f): 17.
Future Storage (a-f): 0.
Present Investment ($1000): 2.1
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Sep 90
Type:

Contractor: Gore Public Works Authority
Present Storage (a-f): 480.
Future Storage (a-f): 0.
Present Investment ($1000): 51.8
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Sep 90
Type:

Contractor: Tenkiller Water Company
Present Storage (a-f): 34.
Future Storage (a-f): 0.
Present Investment ($1000): 3.8
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Oct 91
Type:

Contractor: Pettit Bay Water Association
Present Storage (a-f): 5.
Future Storage (a-f): 0.
Present Investment ($1000): 0.6
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Nov 91
Type:

Contractor: Fin and Feather Resort
Present Storage (a-f): 12.
Future Storage (a-f): 0.
Present Investment ($1000): 1.5
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Jan 92
Type:

Contractor: Sixshooter Water System
Present Storage (a-f): 2.
Future Storage (a-f): 0.
Present Investment ($1000): 0.3
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Jan 92
Type:

Contractor: The Dutchmnan's Cabins
Present Storage (a-f): 6.
Future Storage (a-f): 0.
Present Investment ($1000): 0.7
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Apr 92
Type:

Contractor: Bill Richardson
Present Storage (a-f): 1.
Future Storage (a-f): 0.
Present Investment ($1000): 0.1
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Jul 92
Type:

Contractor: Indian Hills Estate Company
Present Storage (a-f): 3.
Future Storage (a-f): 0.
Present Investment ($1000); 0.4
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Feb 93
Type:

Tulsa District (continued)

TENKILLER FERRY LAKE (continued)

Contractor: Charles Willige
Present Storage (a-f): 2.
Future Storage (a-f): 0.
Present Investment ($1000): 0.3
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approval: Feb 93
Type:

Contractor: J.R. and M.L. Mosteller
Present Storage (a-f): 2.
Future Storage (a-f): 0.
Present Investment ($1000): 0.2
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Aug 93
Type:

Contractor: Tenkiller Water Company
Present Storage (a-f): 30.
Future Storage (a-f): 0.
Present Investment ($1000): 3.8
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: May 94
Type:

Contractor: Tenkiller Water Company, Inc. dba Woodhaven
Present Storage (a-f): 15.
Future Storage (a-f): 0.
Present Investment ($1000): 1.9
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Sep 94
Type:

Contractor: Burnt Cabin RWD, Inc.
Present Storage (a-f): 12.
Future Storage (a-f): 0.
Present Investment ($1000): 1.2
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Nov 94
Type:

Contractor: Sunny Heights Water System
Present Storage (a-f): 10.
Future Storage (a-f): 0.
Present Investment ($1000): 1.2
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: Apr 95
Type:

Contractor Development Company
Present Storage (a-f): 3.
Future Storage (a-f): 0.
Present Investment ($1000): 0.4
Future Investment ($1000): 0
Conduit Cost ($1000): 0
Date Agreement Approved: May 95
Type:

Not Under Contract
Present Storage (a-f): 0.
Future Storage (a-f): 5,016.
Present Investment ($1000): 0.
Future Investment ($1000): 647.5
Conduit Cost ($1000): 0.

☆ **TORONTO LAKE**
CWIS No. 18350
Verdigris River
Woodson County, Kansas

Contractor: City of Toronto
Present Storage (a-f): 265.
Future Storage (a-f): 0.
Present Investment ($1000): 21.4
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Mar 65
Type:

Contractor: City of Toronto
Present Storage (a-f): 135.
Future Storage (a-f): 0.
Present Investment ($1000): 11.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: May 82
Type:

Tulsa District (continued)

☆ WAURIKA LAKE
CWIS No. 19570
Beaver Creek
Jefferson County, Oklahoma

Contractor: Waurika Proj Mast Conser Dist
Present Storage (a-f): 41,800.
Future Storage (a-f): 0.
Present Investment ($1000): 2,802.2
Future Investment ($1000): 0.
Conduit Cost ($1000): 213.
Date Contract Approved: Sep 70
Type:

Not Under Contract
Present Storage (a-f): 0.
Future Storage (a-f): 109,600.
Present Investment ($1000): 0.
Future Investment ($1000): 8,042.
Conduit Cost ($1000): 0.

WAURIKA WATER CONVEYANCE FACILITIES
Contractor: Waurika Master Conservancy District
Eastern Segment
Cost ($1000): 9,725.2
Southern Segment
Cost ($1000): 447.9
Western Segment
Cost ($1000): 20,608.5
Date Agreement Approved: Jun 78

☆ WISTER LAKE
CWIS No. 20120
Poteau River
Leflore County, Oklahoma

Contractor: Heavener Util. Auth
Present Storage (a-f): 1,600.
Future Storage (a-f): 0.
Present Investment ($1000): 41.7
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: May 63
Type:

Contractor: Poteau Valley Imp. Auth
Present Storage (a-f): 4,800.
Future Storage (a-f): 0.
Present Investment ($1000): 125.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Sep 67
Type:

Contractor: A.E.S. Shady Point Inc.
Present Storage (a-f): 7,253.
Future Storage (a-f): 0.
Present Investment ($1000): 109.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: May 87
Type: Reallocation of Conservation Storage

Not Under Contract
Present Storage (a-f): 0.
Future Storage (a-f): 347.
Present Investment ($1000): 0.
Future Investment ($1000): 116.
Conduit Cost ($1000): 0.

SOUTH PACIFIC DIVISION

SACRAMENTO DISTSRICT

☆ **DRY CREEK (WARM SPRINGS) LAKE AND CHANNEL**
CWIS No. 04990
Dry Creek
Sonoma County, California

Contractor: Sonoma Co. Water Agency
Present Storage (a-f): 44,000.
Future Storage (a-f): 88,000.
Present Investment ($1000): 4,145.
Future Investment ($1000): 8,289.
Conduit Cost ($1000): 0.
Date Contract Approved: Jan 65
Type:

Contractor: Sonoma Co. Water Agency
Present Storage (a-f): 44,000.
Future Storage (a-f): 124,000.
Present Investment ($1000): 4,145.
Future Investment ($1000): 88,335.9
Conduit Cost ($1000): 0.
Date Contract Approved: Oct 82
Type:

ALBUQUERQUE DISTRICT

☆ **ABIQUIU DAM**
CWIS No. 00070
Rio Chama
Rio Arriba County, New Mexico

Contractor: City of Albuquerque
Present Storage (a-f): 170,900.
Future Storage (a-f): 0.
Present Investment ($1000): 0.
Future Investment ($1000): 0.
Conduit Cost ($1000): 0.
Date Contract Approved: Mar 86
Type:

DATABASE VII
AGRICULTURAL WATER SUPPLY

Database VII
Agricultural Water Supply
List of Projects

Northwestern Division

Portland District

- Applegate
- Blue River [1]
- Cottage Grove [1]
- Cougar [1]
- Detroit-Big Cliff [1]
- Dorena [1]
- Fall Creek [1]
- Fern Ridge [1]
- Green Peter-Foster [1]
- Hills Creek [1]
- John Day [2]
- Lookout Point [1]
- Lost Creek
- Willow Creek [3]

Seattle District

- Wynoochee

Walla Walla District

- Ice Harbor [4]
- Little Goose [4]
- Lower Granite [4]
- Lower Monumental [4]
- Lucky Peak [5]
- McNary [4]
- Ririe [6]

Omaha District

- Big Bend [7]
- Fort Peck [8]
- Fort Randall [7]
- Garrison [8]
- Gavins Point [7]
- Oahe [8]

Kansas City District

- Harlan County
- Kanopolis [9]
- Wilson

South Pacific Division

Sacramento District

- Black Butte
- Buchanan
- Coyote Valley
- Folsom [10]
- Hidden
- Isabella
- New Hogan
- New Melones [10]
- Pine Flat
- Success
- Terminus

Los Angeles

- Alamo [11]

Albuquerque District

- Conchas
- John Martin
- Santa Rosa
- Tat Momoliket
- Trinidad

Southwestern Division

Fort Worth District

- Belton

Tulsa District

- Waruika

See following page for footnotes.

Footnotes for page C-72:

[1] Specific irrigation storage of 1,640,000 AF has been filed for irrigation use by the USBR. Because of the projects being planned and operated as a system (Willamette Basin), none of the irrigation storage is either separable or project specific and costs are not allocated on a project bases.

[2] Irrigation is authorized as only an “incidental” purpose. No cost is allocated to the function nor storage reserved.

[3] All irrigation is for future development and no costs have been allocated to the irrigation purpose.

[4] Irrigation is authorized as an “incidental” purpose. No cost is allocated to the function nor storage reserved.

[5] Provides irrigation storage during low runoff years when storage in Anderson Ranch and Arrow-Rock (two USBR projects) would not be sufficient.

[6] Project turned over to the USBR. Joint storage is for flood control, irrigation and recreation.

[7] Accommodate water withdrawal by permit, irrigation use not allocated.

[8] Joint storage with flood control, navigation and hydroelectric power.

[9] Storage will be allocated from flood control when irrigation project is operable.

[10] Project operated and maintained by USBR upon completion of construction.

[11] Operated as part of USBR Colorado River water system.

Database VII
Agricultural Water Supply
Division and District Summaries [1]

Division/ District	Number of Projects	Total Project Cost ($000)	Total Federal Cost ($000)	Storage Reserved for Irrigation	
				Joint (1000 AF)	Specific (1000 AF)
Northwestern/	(31)	(3,581,937)	(1,164,318)	(50,348)	(NA)
Portland	14	1,232,452	528,319	2,020	NA
Seattle	1	24,980	5,260	15	0
Walla Walla	7	1,091,072	249,005	90	0
Omaha	6	1,153,870	313,726	47,998	NA
Kansas City	3	79,563	68,008	225	312
South Pacific/	(17)	(822,670)	(506,319)	(5,677)	(597)
Sacramento	11	677,890	378,139	5,187	0
Los Angeles	1	14,780	14,780	230	0
Albuquerque	5	130,000	113,400	260	597
Southwestern/	(2)	(85,500)	(42,100)	(0)	(63.8)
Fort Worth	1	18,400	16,300	0	45
Tulsa	1	67,100	25,800	0	18.8
Total	**50**	**4,490,107**	**1,712,737**	**56,025**	**NA**

Footnote:
[1] See following pages C-91 through C-95 for footnotes that are project specific.

Database VII
Agricultural Water Supply
- NORTHWESTERN DIVISION -

Portland District

Project Name	Total Project Cost ($000)	Total Federal Cost [1] ($000)	Storage Reserved for Irrigation			Percent of Project Cost Allocated to Irrigation (%)
			Joint (1000 AF)	Specific (1000 AF)	(%)	
Applegate	96,320	93,437	65.0	0	76	2.1
Blue River	31,324	NA	[2]	[2]	[2]	27
Cottage Grove	2,460	NA	[2]	[2]	[2]	30
Cougar	60,462	38,738	[2]	[2]	[2]	5.4
Detroit-Big Cliff	66,867	21,187	[2]	[2]	[2]	7.6
Dorena	14,305	NA	[2]	[2]	[2]	38
Fall Creek	21,055	NA	[2]	[2]	[2]	40
Fern Ridge	4,686	NA	[2]	[2]	[2]	43
Green Peter-Foster	90,157	34,142	[2]	[2]	[2]	6.9
Hills Creek	48,973	26,931	[2]	[2]	[2]	9.4
John Day [3]	511,000	112,075	0	0	0	0
Lookout Point	97,473	49,575	[2]	[2]	[2]	1.5
Lost Creek	148,546	113,410	315.0	0	70	1.5
Willow Creek [4]	38,824	38,824	0	0	0	0
Total	1,232,452	528,319	2,020 [5]	NA	NA	NA

Footnotes:
[1] Total cost less reimbursables.
[2] Specific irrigation storage of 1,640,000 AF has been filed for irrigation use by the USBR. Because of the projects being planned and operated as a system (Willamette Basin), none of the irrigation storage is either separable or project specific and costs are not allocated on a project bases.
[3] Irrigation is authorized as only an “incidental” purpose. No cost is allocated to the function nor storage reserved.
[4] All irrigation is for future development and no costs have been allocated to the irrigation purpose.
[5] Assumes 1,640,000 joint storage in Willamette Basin projects.

Database VII
Agricultural Water Supply
- NORTHWESTERN DIVISION (continued)

Seattle District

Project Name	Total Project Cost ($000)	Total Federal Cost [1] ($000)	Storage Reserved For Irrigation			Percent of Project Cost Allocated to Irrigation (%)
			Joint (1000 AF)	Specific (1000 AF)	(%)	
Wynoochee	24,980	5,260	14.9	0	25	2

Footnote:
[1] Total cost less reimbursables.

Walla Walla District

Project Name	Total Project Cost ($000)	Total Federal Cost [1] ($000)	Storage Reserved For Irrigation			Percent of Project Cost Allocated to Irrigation (%)
			Joint (1000 AF)	Specific (1000 AF)	(%)	
Ice Harbor [2]	38,259	1,809	0	0	0	0
Little Goose [2]	63,850	2,382	0	0	0	0
Lower Granite [2]	341,804	76,531	0	0	0	0
Lower Monumental [2]	256,618	51,744	0	0	0	0
Lucky Peak [3]	19,080	19,080	0	0	0	0
McNary [2]	333,231	64,996	0	0	0	0
Ririe [4]	38,230	32,463	90	NA	NA	15.1
Total	1,091,072	249,005	90	0	0	NA

Footnotes:
[1] Total cost less reimbursables.
[2] Irrigation is authorized as an “incidental” purpose. No cost is allocated to the function nor storage reserved.
[3] Provides irrigation storage during low runoff years when storage in Anderson Ranch and Arrow-Rock (two USBR projects) would not be sufficient.
[4] Project turned over to the USBR. Joint storage is for flood control, irrigation and recreation.

Database VII
Agricultural Water Supply
- NORTHWESTERN DIVISION (continued) -

Omaha District

Project Name	Total Project Cost ($000)	Total Federal Cost [1] ($000)	Storage Reserved for Irrigation			Percent of Project Cost Allocated to Irrigation (%)
			Joint (1000 AF)	Specific (1000 AF)	(%)	
Big Bend [2]	107,187	3,708	0	0	0	0
Fort Peck [3]	159,900	48,602	13,649	0	72	21.5
Fort Randall [2]	198,066	70,004	0	0	0	0
Garrison [3]	294,915	86,692	17,560	0	73	19.9
Gavins Point [2]	49,231	13,504	0	0	0	0
Oahe [3]	344,571	91,216	16,789	0	72	18.1
Total	1,153,870	313,726	47,998	0	NA	NA

Footnotes:
[1] Total cost less reimbursables.
[2] Accommodate water withdrawal by permit, irrigation use not allocated.
[3] Joint storage with flood control, navigation and hydroelectric power.

Kansas City District

Project Name	Total Project Cost ($000)	Total Federal Cost [1] ($000)	Storage Reserved for Irrigation			Percent of Project Cost Allocated to Irrigation (%)
			Joint (1000 AF)	Specific (1000 AF)	(%)	
Harlan County	46,971	35,416	0	150	18	24.6
Kanopolis [2]	12,577	12,577	0	162	37	NA
Wilson	20,015	20,015	225	0	29	0
Total	79,563	68,008	225	312	NA	NA

Footnotes:
[1] Total cost less reimbursables.
[2] Storage will be reallocated from flood control when irrigation project is operable.

Database VII
Agricultural Water Supply
- SOUTH PACIFIC DIVISION -

Sacramento District

Project Name	Total Project Cost ($000)	Total Federal Cost [1] ($000)	Storage Reserved for Irrigation			Percent of Project Cost Allocated to Irrigation (%)
			Joint (1000 AF)	Specific (1000 AF)	(%)	
Black Butte	14,500	8,714	150	0	100	39.9
Buchanan	25,258	16,140	140	0	100	36.1
Coyote Valley	17,550	9,600	70	0	57	NA
Folsom [2]	100,000	63,000	1,000	0	100	NA
Hidden	30,555	25,177	85	0	100	17.6
Isabella	22,000	17,424	570	0	100	20.8
New Hogan	15,906	10,148	310	0	100	36.2
New Melones [2]	380,000	174,100	164	0	68	26
Pine Flat	39,068	24,800	1,000	0	100	36.5
Success	13,993	12,664	80	0	100	9.5
Terminus	19,060	16,372	142	0	100	14.1
Total	677,890	378,139	5,187	0	NA	NA

Footnotes:
[1] Total cost less reimbursables.
[2] Project operated and maintained by USBR upon completion of construction.

Los Angeles District

Project Name	Total Project Cost ($000)	Total Federal [1] Cost ($000)	Storage Reserved for Irrigation			Percent of Project Cost Allocated to Irrigation (%)
			Joint (1000 AF)	Specific (1000 AF)	(%)	
Alamo [2]	14,780	14,780	230	0	22	NA

Footnotes:
[1] Total cost less reimbursables.
[2] Operated as part of USBR Colorado River water system.

Database VII
Agricultural Water Supply
- SOUTH PACIFIC DIVISION (continued) -

Albuquerque District

Project Name	Total Project Cost ($000)	Total Federal Cost [1] ($000)	Storage Reserved for Irrigation			Percent of Project Cost Allocated to Irrigation (%)
			Joint (1000 AF)	Specific (1000 AF)	(%)	
Conchas	15,800	15,800	260	0	57	49
John Martin	15,200	15,200	0	357	58	0
Santa Rosa	43,400	43,400	0	200	44.5	44.5
Tat Momoliket	10,600	NA	0	20	100	NA
Trinidad	45,000	39,000	0	20	17.5	17.5
Total	130,000	113,400	260	597	NA	NA

Footnote: [1] Total cost less reimbursables.

Database VII
Agricultural Water Supply
- SOUTHWESTERN DIVISION -

Fort Worth District

Project Name	Total Project Cost ($000)	Total Federal Cost [1] ($000)	Storage Allocated to Irrigation			Percent of Project Cost Allocated to Irrigation (%)
			Joint (1000 AF)	Specific (1000 AF)	(%)	
Belton	18,400	16,300	0	45	36	4.3

Footnote: [1] Total cost less reimbursables.

Tulsa District

Project Name	Total Project Cost ($000)	Total Federal Cost [1] ($000)	Storage Allocated to Irrigation			Percent of Project Cost Allocated to Irrigation (%)
			Joint (1000 AF)	Specific (1000 AF)	(%)	
Waruika	67,100	25,800	0	18.8	6.5	0.2

Footnote: [1] Total cost less reimbursables.

APPENDIX D

REALLOCATIONS

DECEMBER 1998

Table of Contents

SUMMARY OF REALLOCATIONS (1)

Dist.	Project/User	Date Signed	Storage Reallocated (acre-feet)	Reallocated Purpose
ORL	Barren River Lake, KY City of Glasgow, KY	Nov ‘65	681	Permanent Pool
ORL	Rough River Lake, KY City of Leitchfield, KY	Aug ‘66	120	Conservation
SWT	Norfolk Lake, AR City of Mountain Home, AR	Jan '68	2,400	
SWL	Greers Ferry Lake, AR City of Clinton	Nov '70	900	Flood Control
SWL	Greers Ferry Lake, AR Community Water System	Apr '71	225	Flood Control
SWL	Nimrod Lake, AR City of Plainview, AR	Dec '73	33	
SWL	Beaver Lake, AR Carroll-Boone Water District	Apr '77	9,000	Flood Control
ORL	Rough River Lake, KY City of Hardinsburg	Mar '79	150	Conservation
NCR	Saylorville Lake, IA Iowa Natural Resources Council	Aug '82	14,900	Flood Control
SWF	Whitney Lake, TX Brazos River Authority	Nov '82	50,000	
SWT	Denison Dam, Lake Texoma, OK & TX Red River Authority of Texas	Aug '83	1,806	Hydropower
SAW	J. H. Kerr Lake, VA & NC City of Virginia Beach, VA	Jan '84	10,200	Hydropower
SWF	Waco Lake, TX Brazos River Authority	Sep '84	47,526	Flood Control
SWT	Denison Dam, Lake Texoma, OK & TX North Texas Municipal Water District	Dec '85	75,000	Hydropower
NAB	Cowanesque Lake, PA Susquehanna River Basin Commission	Jun '86	24,335	Flood Control
MRK	Rathbun Lake, IA Rathbun Regional Water Commission	Nov '86	3,340	Conservation
SWT	Wister Lake, OK A.E.S. Shady Point, Inc.	May '87	7,253	Conservation

Dist.	Project/User	Date Signed	Storage Reallocated (acre-feet)	Reallocated Purpose
SWL	Bull Shoals, AR Marion County	Apr '88	880	Hydropower
SAW	John Kerr Dam and Reservoir, VA Commonwealth of Virginia	Jan '89	23	Hydropower
SAW	J. H. Kerr Lake, VA & NC State of Virginia	Mar '89	23	Hydropower
MRK	Rathbun Lake, IA Rathbun Regional Water Commission	May '89	3,340	Recreation
SAS	J. Strom Thurmond Lake, GA & SC Savannah Valley Authority	Oct '89	92	Hydropower
SAS	J. Strom Thurmond Lake, GA & SC Columbia County	Nov '89	1,056	Hydropower
SAS	Hartwell Dam and Lake, GA Franklin County, GA	Feb '90	127	Hydropower
SAS	J. Strom Thurmond Lake, GA & SC City of Lincolnton, GA	Apr '90	83	Hydropower
SAS	J. Strom Thurmond Lake, GA & SC City of Thompson and McDuffie Co., GA	Aug '90	1,056	Hydropower
SAS	Richard B. Russell Lake, GA & SC City of Elberton, GA	Sep '90	381	Hydropower
MRK	Tuttle Creek, KS State of Kansas under the Kansas MOU	May '91	27,500	Conservation
SAW	John H. Kerr Lake, VA & NC Mecklenburg Cogeneration Limited Partners	Jun '91	600	Hydropower
SWL	Beaver Lake, AR Madison County Water District	May '92	3,875	Flood Control
SWT	Denison Dam, Lake Texoma, OK & TX Buncombe Creed View Addition	Apr '92	1	Hydropower
SWT	Denison Dam, Lake Texoma, OK & TX Greater Texoma Utility Authority	Sep '92	5,500	Hydropower
SWL	Nimrod Lake, AR City of Plainview	Sept '94	110	Flood Control
MRK	Tuttle Creek, KS State of Kansas under the Kansas MOU	Sept '94	8,650	Conservation
SWL	Blue Mountain Lake, AR City of Danville	Dec '94	1,550	Flood Control
SWL	Greers Ferry Lake, AR Community Water System	Feb '95	3,776	Flood Control

Dist.	Project/User	Date Signed	Storage Reallocated (acre-feet)	Reallocated Purpose
MRK	Pomona Lake, KS State of Kansas under the Kansas MOU	"95	14,325	Water Quality
LMV	Lake Oauchita, AR North Garland Regional Water District	Mar '96	1,575	Flood Control
MRK	Pomona Lake, KS State of Kansas under the Kansas MOU	Mar '96	18,176	Water Quality
SWL	Beaver Lake, AR Madison County Water District	Mar '96	4,093	Flood Control
MRK	Tuttle Creek Lake, KS State of Kansas under the Kansas MOU	Jun '96	13,850	Conservation
SWT	John Redmon, KS State of Kansas under the Kansas MOU	Jun '96	10,000	Water Quality
SWT	Marion, KS State of Kansas under the Kansas MOU	Jun '96	12,500	Water Quality
SWT	Council Grove, KS State of Kansas under the Kansas MOU	Jun '96	8,000	Water Quality
SWT	Elk City, KS State of Kansas under the Kansas MOU	Jun '96	10,000	Water Quality
SWL	Beaver Lake, AR Benton/Washington Counties	Jul '96	8,113	Flood Control
MRK	Harry S. Truman, MO Henry County	Jun "97	504	Hydropower
LRL	Cave Run Lake, KY West Liberty	Oct '97	264	
SWT	Lake Texoma, Denison Dam, TX and OK Greater Texoma Utility Authority as Agent for the City of Sherman, TX	Oct '97	5,500	Hydropower
MVK	Enid Lake, MS LS Power Electric Generation Facility	??? '98	2,000	Conservation
Total Reallocations 50			415,392	

Footnote: (1) Partial list only. Records are not sufficient to provide a complete list.

SUGGESTED CONTENTS OF A REALLOCATION REPORT

Table of Contents

1. Purpose.
   a. Who is requesting the M&I water supply and the amount of storage involved.
   b. What is the authority for the reallocation; will it be discretionary or will it require Congressional approval?

2. Project Background.
   a. Project authorization, construction and operation history.
   b. Project location, purposes and outputs.
   c. Information on previous reallocations and water supply repayment agreements.
   d. Information on approved cost allocation.

3. Economic Analysis (Reallocation Feasibility).
   a. Water Supply Demand Analysis.
   b. Analysis of Water Supply Alternatives (Benefits).

4. Derivation of User Cost.
   a. Hydropower Benefits Foregone.
   b. Hydropower Revenues Foregone.
   c. Hydropower Replacement Cost.
   d. Flood Control Benefits Foregone.
   e. Updated Cost of Storage.
   f. Users Cost.

5. Test of Financial Feasibility.

6. Cost Account Adjustments.

7. Environmental Considerations.

8. Conclusions.

9. Recommendations.

10. Appendices.
    a. Appropriate NEPA Documents.
    b. Letters and views of other Federal and non-Federal interests.
    c. Reports prepared by others.

Report

1. Purpose.

a. Who is requesting the M&I water supply and the amount of storage involved. *(Describe the city or industry that is requesting the storage and indicate how the water usage is projected to grow over the planning period. State the amount of storage that is under consideration in this report for reallocation.)*

b. What is the authority for the reallocation; will it be discretionary or will it require Congressional approval. *(Indicate the approval level for the report and reason for selection of that level; e.g., "Approval of this reallocation study for 50,000 acre-feet of storage from the hydropower pool is within the discretion of the Commander, USACE, as it is 7.75 percent of total storage and the impacts of the reallocation will not seriously affect the existing project purposes nor will it cause major structural or operational changes.")*

2. Project Background.

a. Project authorization, construction and operation history. *(Cite authorizing Public Law, House and/or Senate Documents, and authorized project purposes. Tell when project construction started, when it was placed in operation and when the top of the multipurpose pool elevation was reached. Tell the date hydropower was placed in-service (if appropriate) and any other pertinent operating information. Describe the type of construction used, dam dimensions, information on the spillway, and characteristics of the reservoir area.)*

b. Project location, purposes and outputs. *(Tell location of the project with respect to cities and drainage basins and provide a location map. Describe purposes for which the project is currently operating. If different from those authorized (see above paragraph 2a), explain. Provide a pertinent data table (see **Table 1** for an example.))*

c. Information on previous reallocations and water supply repayment agreements. *(Provide storage amounts, type of purpose from which reallocated, approval authority and date of approval. Also any other pertinent information; e.g., "Southwest Power was provided compensation for lost revenues in the amount of ...".)*

d. Information on approved cost allocation. *(Provide pertinent information and date of approval, as appropriate.)*

Table 1
Project Data Table \1

Feature	Elevation (feet, msl)	Capacity (acre-feet)	Area (acres)	Equiv. Runoff \2
Top of Dam	911.3	---	---	---
Top of Flood Control Pool	892.0	1.674,000	38,300	27.0
Top of Multipurpose Pool	867.0	875,000	24,600	14.1
Bottom of Power Pool \3	830.0	220,000	11,100	3.6
Flood Control Storage	867.0-892.0	774,000	---	12.5
Power Storage	830.0-867.0	655,000	---	10.6
Sediment Storage \4	---	25,000	---	0.4

Footnotes:
\1 From the "Final Integrated Storage Reallocation Report and Environmental Assessment for Stockton Lake, Missouri," Kansas City District, August 1993.

\2 From 1,160 square miles of drainage area upstream from dam.

\3 Power generation is limited to elevations above 845.0 because of the weir constructed to improve the water quality of the hydropower releases.

\4 Sediment storage is initially distributed 1/3 to flood control pool and 2/3 to power pool.

3. Economic Analysis (Reallocation Feasibility).

a. Water Supply Demand Analysis. *(Describe in as much detail as necessary the average daily water demand during drought conditions and how those demands are expected to increase over the period of the study (normally 30-50 years). This demand analysis should already have been performed by the requesting entity and may be in the form of a consultant's report. If this is the case, summarize the report in the text of the reallocation report, and include the entire consultant's report as an appendix. If inter-basin transfer of water is expected, briefly describe amounts to be withdrawn and returned to each system. Major impacts of inter-basin transfer should be covered in the environmental section of the reallocation report.)*

b. Analysis of Water Supply Alternatives (Benefits). *(Briefly describe each of the alternatives investigated as alternative sources of water. Such sources could be "no action", wells, and/or a pipe line from another reservoir. This documents the users alternative to reallocation of storage in the Federal reservoir and is considered to be the "benefit" associated with reallocation. This "benefit" value (economic and environmental) should be higher than the economic and environmental cost associated with reallocation. These alternatives should be described in enough detail to establish a price for a similar quality and quantity of water that is being received from the Federal project. There may be a consultants report for this documentation, if so, summarize and include the report as an appendix to the reallocation* *report. This paragraph should also briefly mention the reallocations considered (but not the cost associated with them) and should consider more than one alternative; e.g., reallocation of flood control, hydropower, or sediment storage and /or raising the top of the flood control pool.)*

4. Derivation of User Cost. *(The users cost is considered to be the higher of benefits or revenues foregone, replacement cost, or the updated cost of storage. These items are developed in the following paragraphs. The examples provided in the following paragraphs are from the "Final Integrated Storage Reallocation Report and Environmental Assessment for Stockton Lake, Missouri", prepared by the Planning Division of the Kansas City District, August 1993.* If reallocation of hydropower storage is contemplated and economic questions arise, the Power Branch of the U.S. Army Corps of Engineers Northwestern Division (CENWD-ET-WP) should be contacted for assistance. An outline of the Division report, prepared for the Stockton Lake reallocation is provided as page D-17.

a. Hydropower Benefits Foregone. *(Hydropower benefits are based on the cost of the most likely alternative source of power. When power storage is reallocated to water supply, the power benefits foregone are equivalent to the cost of replacing the lost power with the most likely alternative source of power. The power benefits foregone can be divided into two components: the lost energy benefits and the lost capacity benefits. In the case of water supply withdrawals, there is usually a loss of energy benefits, which are based on the loss in generation (both at-site and downstream) as a result of water being withdrawn from the reservoir for water supply rather than passing through the hydro plants. In addition, there could be a loss of capacity benefits as a result of a loss in dependable capacity at the projects. Dependable capacity could be lost as a result of; (a) a loss in head due to lower post-withdrawal reservoir elevations, and/or (b) a reduction in the usability of the capacity due to inadequate energy to support the full capacity during low-flow periods.*

Example. The average annual hydropower benefits foregone are summarized in **Table 2**. The study is based on a maximum water supply withdrawal of 15 million gallons per day (MGD) during the period 1998 through 2015 and 30 MGD from 2016 through 2072. In addition, the user does not plan on constructing pumping capability for more than 15 MGD until the year 2016 because demand is not expected to exceed 15 MGD until after 2015.

Table 2
Hydropower Benefits Foregone

Capacity Value 1/	$46.35/kW/yr)
Loss In Dependable Capacity, 1998-2015	4,552 kW
Loss in Dependable Capacity, 2016-2072	9,103 kW
Total Present Value of Capacity Benefits	$2,300,000
Levelized Annual Loss in Capacity Benefits	$190,100
Average Energy Value 2/ 3/	25.6(mills/kWh)
Average Annual Energy Loss, 1998-2015	3,316,000(kWh)
Average Annual Energy Loss, 2016-2072	6,631,000(kWh)
Total Present Value of Energy Benefits	$1,039,000
Average Annual Loss in Energy Benefits	$85,900
Present Value of Benefits Foregone (1998-2072)	$3,339,000
Average Annual Benefits Foregone	$276,000

Footnotes:
1/ Capacity given in kilowatts (kW)
2/ Energy given in kilowatt hours (kWh)
3/ 1 mill = $0.001

b. Hydropower Revenues Foregone. *(Hydropower revenues foregone represent the value of the income lost to the regional power marketing agency as a result of the lost power. Revenues foregone are based on the power marketing agency's current rates.)*

Example. The average annual hydropower revenues foregone are summarized in **Table 3**. The values are based on a maximum water supply withdrawal of 15 MGD from 1998 through 2015 and 30 MGD from 2016 through 2072.

c. Hydropower Replacement Cost. *(The replacement cost of power as used for computing the cost of reallocated storage is an economic or National Economic Development (NED) cost. In the case of hydropower, the NED cost of replacement power is, by definition, identical to the power benefits foregone. In this example, this is the value for Average Annual Power Benefits Foregone as is shown in Table 4-3 as $276,000. An exception to this rule is where there are existing Federal contracts which obligate the Government to deliver a specified amount of power and/or energy. In such cases, replacement costs will be actual costs incurred to fulfill the Governments obligations during the duration of the contracts and revert to benefits foregone for the remaining period of analysis.)*

Table 3
Hydropower Revenues Foregone

Capacity Charge	$30.24/kWh/yr
Loss in Marketable Capacity 1998-2015	5,231 kW
Loss in Marketable Capacity 2016-2072	10,462 kW
Total Present Value of Marketable Capacity	$1,724,000
Annual Loss in Capacity	$142,500
Energy Charge	6.4 mils/kWh
Average Annual Energy Loss 1998-2015	2,054,000 kWh
Average Annual Energy Loss 2016-2072	4,109,000 kWh
Total Present Value of Energy Loss	$143,300
Average Annual Loss in Energy Revenues	$11,800
Present Value of Revenues Foregone	$1,867,000
Total Annual Revenues Foregone	$154,400

d. Flood Control Benefits Foregone. *(In reallocation of flood control storage, lost flood control benefits in the entire system must be investigated as well as any other impacts on reservoir operations; e.g., lost hydropower benefits and/or the impacts on recreation opportunities. In reallocating flood control storage, it must be remembered that flood control is normally the primary purpose of the project. Any significant reduction in flood control protection which in turn would require mitigation through replacement storage can be considered as being beyond the discretionary authority as defined by Congress in the 1958 Water Supply Act.)*

Example.

(1). Lost Flood Control Benefits. Limited information was available to determine the benefits foregone if water storage is reallocated from flood control to water supply. Primarily, available data from the Sac River basin were used for this study. Stage-damage data from the original project justification and a 1974 reevaluation report were analyzed for the Sac River. The decrease in flood damage reduction benefits that would occur along the Sac River as a result of a reallocation from flood control storage were expressed as a proportion of overall damages. This proportional reduction was then applied to the current estimated flood control benefits for Stockton Lake, which were updated for this analysis. Available data for the downstream rivers (Osage, Missouri, and Mississippi) were insufficient for producing a reliable estimate of impacts. Therefore, a range of benefits was developed. The upper limit assumed that the downstream rivers would receive the same proportional impact as the Sac River; i.e., that a pool raise causing a one percent reduction in flood control benefits on the Sac also would cause a one percent reduction on the other three rivers. The lower limit assumed that there would be no impact on Mississippi flood waters, but that the impact on the Osage and Missouri Rivers would remain the same. All annual benefits were adjusted to current price levels and the lower limit was established as 0.4 percent of the total annual benefits ($217,700) and the upper limit was established as 1.3 percent of total annual benefits ($665,200).

(2). Lost Hydropower Benefits. A two foot raise in the multipurpose pool would not entirely offset all hydropower benefit losses at Stockton and would not reduce the hydropower losses at the downstream hydropower projects (Harry S. Truman and Bagnell). These values were computed by the Northwestern Division based on information provided by Southwestern Power Administration. The computations are similar to those shown in Table 4-3, with the same capacity and energy values. The total hydropower benefit foregone from reallocation of 50,000 acre-feet of flood control storage was computed to be $2,309,811.

(3). Lost Recreation Benefits. No loss of recreation benefits would be anticipated as a result of an increase in the multipurpose pool even though impacts to recreation facilities and fish and wildlife habitat were identified and are explained in detail in the Environmental Effects paragraph. Most of the impacts would be eliminated by modifying recreation facilities and increased maintenance. These mitigation measures would be paid for by the water supply customer if storage is reallocated from the flood control pool.

(4). Other Costs. If the multipurpose pool was raised two feet, there would be associated costs. These costs are summarized in **Table 4**.

Table 4
Other Costs

Item	Costs Associated with Raising Lake Level 2 feet
Flowage easements	$120,000
Relocation of roads and bridges	$200,000
Historic properties survey and any appropriate mitigation measures	$278,000
Present worth of modifying recreation facilities	$234,700
Present worth of additional recreation O&M	$48,400
Total	$881,100

(5). Total Costs. The total cost associated with reallocation of flood control storage is summarized in **Table 5**.

Table 5
Total Cost with Reallocation from Flood Control Storage

Item	Cost
Lost flood control benefits	$ 217,000 to $ 665,200
Lost hydropower benefits	$2,309,811 to $2,309,811
Lost recreation benefits	$ 0
Other costs	$ 881,100
Total	$3,407,911 to $3,856,111

e. Updated Cost of Storage. *(The cost allocated to the user under this procedure updates the cost of the reservoir to present day price levels and then assigns a percentage of the costs based on the "Use of Facilities" cost allocation procedure. Costs are updated from "as built" costs to 1967 prices by use of the* Engineering News Record *(ENR) Construction Cost Index and then from 1967 to current prices by use of the Corps' Civil Works Construction Cost Index System (CWCCIS). Land values will be updated by the weighted average update of all other project features. Costs are to be indexed from the midpoint of the physical construction period to the beginning of the fiscal year in which the contract for the reallocated storage is approved. Construction will be considered as having been initiated at the start of the month when lands for the project were first acquired or on the date when the first construction contract was awarded whichever was earlier. Construction will be considered as having been completed at the end of the government fiscal year in which final deliberate impoundment of the reservoir pool was initiated.*

Use of Facilities Formula for Determining Updated Cost of Storage

$$\text{User cost} = (\text{Total Construction Cost } (-) \text{ Specific Costs}) \times \frac{\text{Storage Reallocated (AF)}}{\text{Total Usable Storage (AF)}}$$

In the above formula, "usable storage" does not include space set aside for sediment distribution or for hydropower head.)

Example. For this example, the "Reallocation Report and Environmental Assessment for Harry S. Truman Dam and Reservoir, Missouri" will be utilized. This report was prepared by the Kansas City District and is dated March 1994. This report is utilized because it is an older project that requires updating by both the ENR and the CWCCIS. This example, summarized in **Table 6**, updates the Pomme de Terre Lake Project.

Table 6
Updated Cost of Storage

Feature	As-built Joint-Use Costs	1967 ENR / 1959 ENR (Factor)	1967 Cost	FY '94 CWCCIS / FY '67 CWCCIS (Factor)	FY '95 Joint-Use Cost
Lands and Damages	$2,502,900	N/A	N/A	5.989 1/	$14,989,900
Relocations	$1,777,700	1078/811= 1.329	$2,362,600	449.40/100 = 4.494	$10,617,500
Reservoirs	$538,600	1.329	$715,800	486.39/100 = 4.864	$3,481,700
Dams	$8,807,200	1.329	$11,704,800	449.40/100 = 4.494	$52,601,400
Roads	$294,900	1.329	$391,900	465.83/100 = 4.658	$1,825,500
Buildings, Grounds & Utilities	$315,000	1.329	$418,600	424.61/100 = 4.246	$1,777,400
Permanent Operating Equipment	$101,900	1.329	$135,400	424.61/100 = 4.246	$574,900
Total Project Cost	$14,338,200	N/A	N/A	N/A	$85,868,300

Footnote: 1/ Derivation of Factor:
As-built Joint-Use Cost (-) Lands and Damages = $11,835,300.
FY '95 Cost (-) Lands and Damages = $70,878,400.
Ratio 70,878,400/11,835,300 = 5.989

The calculation for the updated cost of storage from Pomme de Terre Lake for 3,700 acre-feet of storage (out of a total usable storage of 637,000 acre-feet) is as follows:

$$\frac{\$85{,}868{,}300 \times 3{,}700 \text{ acre-feet}}{637{,}000 \text{ acre-feet}} = \$498{,}757$$

f. Users Cost. (*The cost to the user for the reallocated cost of storage is the higher of the preceding computed numbers. For this comparison, the updated cost of 50,000 acre-feet of storage in the Stockton Lake ($8,968,692) is utilized. This keeps the cost comparison consistent. This comparison is shown in* ***Table 7****.*

Table 7
Comparison of Alternatives to Obtain User Cost

Item	Cost
Lost Hydropower Benefits	$3,339,000
Lost Hydropower Revenues	$1,867,000
Replacement Cost of Hydropower	$3,339,000
Maximum Costs Associated with Lost Flood Control	$3,856,111
Updated Cost of Storage	$8,968,692

Based on this analysis, the updated cost of storage governs the cost of storage to the user. This is not unusual. While it can be costly and time consuming to compute the other costs, it is necessary.)

5. Test of Financial Feasibility. *(Compare the cost of the Federally reallocated storage to the most likely alternative determined in above paragraph 3b. The comparison should be based on the appropriate interest rate and repayment period and take into consideration all costs the user would incur to obtain comparable quantity and quality of water to the same location; i.e., consider treatment and transmission costs if significantly different.)*

Example. As a test of financial feasibility, the annual cost of the reallocated storage (determined in paragraph 4f), is compared to the annual cost of the most likely, least costly, alternative that would provide an equivalent quality and quantity of water which the local interests would undertake in absence of utilizing the Federal project. (This example is from the "Integrated Storage Reallocation Report and Environmental Assessment for Stockton Lake, Missouri", prepared by the Kansas City District, August 1993.) **Table 8** presents the cost of water supply storage space from Stockton Lake expressed as an annual charge using an 8.25 percent interest rate amortized over the remaining 77 year project life (100 year life from date first project purpose placed in operation, (factor 0.0826847), plus annual operation, maintenance, and major replacement cost (OM&R) costs for the storage. The table also presents the estimated annual cost for the most likely non-Federal alternative, Lake Webster West, a single purpose water supply lake located about 10 miles east of Springfield, Missouri. Lake Webster West would have an estimated dependable yield of 30 MGD with a 2% chance of shortage. The cost is expressed as an estimated annual charge using an 8.25 percent interest rate and a 77 year project life.

Table 8
Test of Financial Feasibility

Alternative	Capital Cost	Annual Capital Cost	Annual OM&R Cost	Total Cost
Stockton Lake, Multipurpose Pool				
Storage	$8,968,692	$741,600	$31,000	$772,600
Pipeline	$70,700,000	$5,845,800	$3,164,000	$9,009,800
	Total Annual Cost			$9,782,400
Lake Webster West	$87,600,000	$7,243,200	$2,600,000	$9,843,200

As depicted in the above table, reallocation from the multipurpose pool is financially feasible compared with the most likely non-Federal alternative.

6. Cost Account Adjustments. *(Where the reallocation adversely impacts Federal hydropower, a credit to the accounting records should be made based on the estimated loss of power outputs and the current rates charged by the Power Marketing Agency (PMA). Credit can also be made for costs incurred by the PMA for purchasing power to fulfill contracts for the duration of the contracts. Such credit should not be made until such actual costs are incurred and documented that they are directly attributable to the reallocation.)*

7. Environmental Considerations. *(Summarize in one or two paragraphs the environmental effects of each of the alternatives considered and, as appropriate, the need to comply with any other applicable Federal environmental laws or regulation, including the Clean Water Act Section 404(b)(1) Guidelines when activities involve a regulated discharge of dredged or fill material within waters of the United States. Note that the documentation required by the National Environmental Policy Act (NEPA) of 1969 should be included as an appendix.)*

8. Conclusions. *(Summarize in one to two pages the above findings and indicate the non-Federal sponsor's desire to pursue reallocation in the Federal project. Make appropriate reference to appendices (e.g. environmental assessment, letters from the non-Federal sponsor, other coordination activities, etc.)*

9. Recommendation. (Example) Based on the findings in this study and the Environmental Assessment, it is recommended that 5,000 acre feet of storage in the Burke Lake Dam and Reservoir project between elevations 300.0 and 350.5, feet M.S.L. be made available for reallocation from the conservation pool to municipal and industrial water supply. This would satisfy the needs of the city of Springfield, Virginia and the surrounding other small water suppliers in the region.

_____ ____

Date (name)
Rank, Corps of Engineers
District Engineer

10. Appendices. *(Appendices should include the following:*

a. The appropriate NEPA documentation (Environmental Assessment with a signed Finding Of No Significant Impact or an Environmental Impact Statement), required by Public Law 91-190, the National Environmental Policy Act of 1969 (83 Stat. 852, 42 U.S.C. 4121);

b. Letters and views of other Federal, state and/or local interests affected by the reallocation including the documentation of the "Opportunity for Public Review and Comment" required by Section 5 of Public Law 100-676, the Water Resources Development Act of 1988, (102 Stat. 4022, 33 U.S.C. 2312); and

c. Reports prepared by consultants and/or other Corps offices concerning various aspects of the reallocation effort.)

OUTLINE: VALUE OF HYDROPOWER LOSSES[1]

Chapter 1: INTRODUCTION
- a. Purpose and Scope
- b. Project Description
- c. Alternative Measures of Value
- d. Procedure
- e. Conduct of the Studies
- f. Pumping Requirements for Requested Water Supply
- g. Period of Analysis
- h. Interest Rate
- i. Price Level

Chapter 2: LOSS IN ENERGY BENEFITS
- a. Introduction
- b. Power Equation
- c. Average Annual Energy Loss
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Chapter 3: LOSS IN CAPACITY BENEFITS
- a. Introduction
- b. Basis of Dependable Capacity Loss
- c. Capacity Definitions
- d. SWPA Marketable Capacity Criteria
- e. Marketable Capacity Losses
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- h. Capacity Value
- i. Capacity Benefits Foregone

Chapter 4: REVENUES FOREGONE
- a. Introduction
- b. Energy Revenue Foregone
- c. Loss in Marketable Capacity
- d. Capacity Revenue Foregone

Chapter 5. CREDIT TO MARKETING AGENCY
- a. Introduction
- b. Remaining Period of Contract

[1] From the Water Supply Reallocation Report, Stockton Reservoir for the City of Springfield, Missouri. Prepared by the Power Branch, CENPD-PE-WP, North Pacific Division, Corps of Engineers. For the Kansas City District, Corps of Engineers, 3 August 1993.

c. SWPA Capacity Credit
d. SWPA Energy Credit

Chapter 6. SUMMARY OF BENEFITS
a. Power Benefits Foregone
b. Revenues Foregone
c. Replacement Cost of Power
d. Credit to Marketing Agency

APPENDIX E

WATER SUPPLY PLANNING MODELS

DECEMBER 1998

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WATER SUPPLY PLANNING MODELS

A. DEMAND FORECASTING MODELS

One model, **IWR-MAIN** is covered in this section. Additional information on demand forecasting modeling is contained in Chapter 6, Paragraph C and Chapter 8, Paragraph C.

1. IWR-MAIN Water Use Forecasting System (IWR-MAIN).

a. Available. Institute for Water Resources, U.S. Army Corps of Engineers, Casey Building, 7701 Telegraph Rd., Alexandria, VA 22310-3868, telephone (703) 428-8015. This software was developed with Planning and Management Consultants, Ltd., P.O. Box 1316, Carbondale, Illinois 62903.

b. Description. IWR-MAIN is a flexible software package for predicting future municipal and industrial water use. The forecasting system provides a variety of forecasting models, socioeconomic parameter generating procedures, and data management capabilities. A high level of disaggregation of water use categories is provided. Water requirements are estimated separately for residential, commercial/institutional, industrial, and public/unaccounted sectors. Within these major sectors, water use estimates are further disaggregated into individual categories such as metered and sewered residences, commercial establishments, and three-digit SIC manufacturing categories. Average daily water use, winter and summer daily use, and maximum-day summer use are forecasted as a function of explanatory variables which include: number of users; number, market value, and type of housing units; employment in commercial and manufacturing industries; water and wastewater fee rates; irrigated acreage; climatic conditions; and water conservation measures.

B. GROUNDWATER MODELS

Five models are covered in this section, **MODFLOW**, **PLASM**, **RANDOM WALK**, **MOC**, and **FEMWATER**.

1. Modular Three-Dimensional Finite-Difference Groundwater Flow Model (MODFLOW).

a. Available.

(1). Chief Hydrologist, Water Resources Division, U.S. Geological Survey, 409 National Center, Reston, Virginia 22092, telephone (703) 648-5215;

(2). International Groundwater Modeling Center Colorado, School of Mines Golden, Colorado 80401-1887, telephone (303)273-3103; and

(3). Scientific Software Group, P.O. Box 23041, Washington, D.C. 20026-3041, telephone (703)620-6793.

b. Description. MODFLOW simulates two-dimensional areal or cross-sectional, and quasi- or fully-three-dimensional, steady or transient, saturated flow in anisotropic, heterogeneous, layered aquifer systems. Layers may be simulated as confined, unconfined, or convertible between the two conditions. The model allows for analysis of external influences such as wells, areal recharge, drains, evapotranspiration, and streams. MODFLOW incorporates a block-centered finite-difference approach. The finite-difference equations are solved by either the strongly implicit procedure or the slice-successive over relaxation procedure.

2. Prickett-Lonnquist Aquifer Simulation Model (PLASM).

a. Available.

(1). Thomas A. Prickett & Associates, 6 GH Baker Drive, Urbana, Illinois 61801, telephone (217) 384-0615;

(2). International Groundwater Modeling Center Colorado School of Mines, Golden, Colorado 80401-1887 telephone (303) 273-3103; and

(3). Scientific Software Group, P.O. Box 23041, Washington, D.C. 20026-3041, telephone (703) 620-6793.

b. Description. PLASM simulates two-dimensional unsteady flow in heterogeneous anisotropic aquifers under water table, nonleaky, and leaky artesian conditions. The model allows representation of time varying pumpage from wells, natural or artificial recharge rates, the relationships of water exchange between surface waters and the groundwater reservoir, the process of groundwater evapotranspiration, and the mechanism of converting from artesian to water table conditions. PLASM incorporates an iterative alternating direction implicit finite difference solution of the equations of groundwater flow.

3. Random Walk Solute Transport Model (RANDOM WALK).

a. Available.

(1). Thomas A. Prickett & Associates, 6 GH Baker Drive, Urbana, Illinois 61801, telephone (217) 384-0615; and

(2). International Groundwater Modeling Center, Colorado School of Mines, Golden, Colorado 80401-1887, telephone (303) 273-3103.

b. Description. PLASM, described previously, is incorporated into the RANDOM WALK model to perform the flow computations. Thus, RANDOM WALK provides the same capabilities as PLASM for simulating nonsteady or steady, one- or two-dimensional flow. In addition, contaminant transport is simulated using discrete parcel random walk techniques. Solute transport is based on a particle in a cell technique for advective mechanisms, and a random walk technique for dispersion mechanisms. The effects of convection, dispersion, and chemical reactions are included. The solute transport model simulates continuous and slug contaminant source areas of various shapes, contaminant sinks such as wells and streams, vertically averaged salt-water fronts, and contaminant leakage from overlying source beds.

4. Method of Characteristics (MOC) Model of Two-Dimensional Solute Transport.

a. Available.

(1). Chief Hydrologist, Water Resources Division, U.S. Geological Survey, 409 National Center Reston, Virginia 22092, telephone (703) 648-5215;

(2). International Groundwater Modeling Center, Colorado School of Mines, Golden, Colorado 80401-1887, telephone (303) 273-3103; and

(3). Scientific Software Group, P.O. Box 23041, Washington, D.C. 20026-3041, telephone (703) 620-6793.

b. Description. MOC is a two-dimensional, transient, saturated condition, solute transport model. MOC allows modeling of heterogeneous and anisotropic (confined) aquifers. The model determines changes in contaminant concentrations caused by convective transport, hydrodynamic dispersion, mixing or dilution from recharge, and chemical reactions. The chemical reactions include first-order irreversible rate reaction (such as radioactive decay), reversible equilibrium-controlled sorption with linear, Freundlich, or Langmuir isotherms, and reversible equilibrium-controlled ion exchange for monovalent or divalent ions. The model assumes that fluid density variations, viscosity changes, and temperature gradients do not affect the velocity changes, and temperature gradients do not affect the velocity distribution. MOC solves the groundwater flow equation and the nonconservative solute-transport equation in a stepwise uncoupled fashion. The alternating direction implicit method or the strongly implicit procedure are optionally used to solve the finite difference approximation of the flow equation. The MOC model uses the method of characteristics (MOC) to solve the solute transport equation.

5. Finite Element Model of Density-Dependent Flow and Transport Through Saturated-Unsaturated Porous Media (FEMWATER).

a. Available.

(1). U.S. Army Groundwater Modeling Technical Support Center, Coastal and Hydraulics Laboratory, U.S. Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199, telephone (601) 634-2486 (for DoD, USEPA, and DOE users); and

(2). Engineer Computer Graphics Laboratory, Brighman Young University, Provo, Utah, telephone (801) 378-7569 (for all others).

b. Description. FEMWATER, developed by Dr. G.T. (George) Yeh, Penn State University, and WES, is the most versatile of a suite of models supported by the DoD Groundwater Modeling System (GMS). The GMS is a powerful pre- and post-processing graphical user interface which also supports the MODFLOW, MODPATH and MT3D (Modular Three-Dimensional Transport Model) computer models. MODPATH is a code that uses output from the USGS finite difference groundwater code MODFLOW. MODPATH tracks particles released in the flow field over time, thus showing the fate of each particle. FEMWATER allows analysis of pumping wells, injection wells, salinity intrusion, groundwater-surface water interaction and transport of conservative pollutant constituents. It is fully three-dimensional and the finite element architecture allows modeling of complex natural and manmade subsurface features. The GMS allows viewing of input and output graphically as slices in the vertical or horizontal plane, as well as animated time-dependent results. It also incorporates tools for analysis and interpretation of sub-surface data sets.

C. WATERSHED RUNOFF MODELS

Eight models are covered in this section; **HEC-1**, **TR-20**, **A&M Watershed Model**, **SSAR**, **SWMM**, **HSPF**, **SWRRB-WQ** and **CASC2D**.

1. Hydrologic Engineering Center HEC-1).

a. Available. Hydrologic Engineering Center, U.S. Army Corps of Engineers, 609 Second Street, Davis, California 95615 or by calling (530) 756-1104.

b. Description. HEC-1 models the watershed processes that convert rainfall and/or snowmelt to streamflow, which includes manipulating precipitation data, performing subwatershed precipitation-runoff computations, streamflow routing, and hydrograph combining. The model is designed for analyzing single precipitation events, rather than long-term continuous modeling. Precipitation volumes are converted to runoff volumes using one of several options. Runoff hydrographs are developed using either the unit hydrograph or kinematic wave approaches. The model also includes several optional modeling capabilities involving; parameter calibration, multiplan-multiflood analysis, dam safety analysis, economic flood damage analysis, and flood control system optimization.

2. Soil Conservation Service Technical Release No. 20 (TR-20).

a. Available.

(1). Engineering Division, Soil Conservation Service, U.S. Department of Agricultural, Washington, D.C. 20013-2890; and

(2). National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161, telephone (703) 487-4600.

b. Description. TR-20 is a single-event watershed model. A rainfall hyetograph is provided as input. The model computes the runoff hydrograph for each subwatershed, routes the hydrographs through reservoirs and stream reaches, and combines hydrographs. The Soil Conservation Service (SCS) rainfall-runoff relationship (curve number methods) and SCS curvilinear dimensions unit hydrograph are used to model the runoff response of a watershed to a rainfall event. Hydrographs are routed through stream reaches using the attenuation-kinematic routing method. Modified Puls routing is used for reservoirs.

3. A&M Watershed Model.

a. Available. Dr. Wesley P. James, Civil Engineering Department, Texas A&M University, College Station, Texas 77843, telephone (409) 845-4550.

b. Description. The A&M Watershed Model simulates a flood event caused by a rain storm. The model can be used to develop synthetic design storms, or historical gaged rainfall can be provided as input for generating hydrographs for planning and design studies. Alternatively, weather radar and/or gaged rainfall can be used for real-time streamflow forecasting. The model includes the following computational methods: SCS curve number and Green & Ampt loss rate options; two parameter gamma function unit hydrograph which can be adjusted by urbanization peaking factors; hydrologic and hydraulic stream routing options; hydrologic reservoir routing; and standard step method water surface profile computations. In addition to the basic rainfall-runoff and streamflow modeling, several optional capabilities are provided for design and analysis of storm sewers, culverts, detention basins, and sedimentation basins.

4. Streamflow Synthesis Reservoir Regulation (SSAR).

a. Available.

(1). Northwestern Division, U.S. Army Corps of Engineers, P.O. Box 2870, Portland, Oregon 97208-2870, telephone (503) 326-3758; and

(2). HOMS National Weather Service, NOAA, 1325 East-West Highway, Silver Spring, Maryland 20910.

b. Description. SSAR consists of three basic components; a watershed model for synthesizing runoff from rainfall and snowmelt, a streamflow routing model, and a reservoir regulation model. The model is a continuous watershed model designed for large river basins. Streamflows are synthesized from rainfall and snowmelt runoff. Rainfall data are provided as input. Snowmelt can be computed based on inputted precipitation depth, elevation, air and dew point temperatures, albedo, radiation, and wind speed. Snowmelt options include the temperature index method or the energy budget method. Application of the model begins with a subdivision of the river basin into hydrologically homogeneous subwatersheds. For each subwatershed, the model computes base flow, subsurface or interflow, and surface runoff. Each flow component is delayed according to different processes, and all are then combine to produce the total subwatershed outflow hydrograph.

5. Stormwater Management Model (SWMM).

a. Available. Center for Exposure Assessment Modeling, Environmental Research Laboratory, U.S. Environmental Protection Agency, 960 College Station Road, Athens, Georgia 30613-0801, telephone (706) 546-3549.

b. Description. SWMM is a comprehensive model for analysis of quantity and quality problems associated with urban runoff. Both single-event and continuous simulation may be performed for watersheds having storm sewers, combined sewers, and natural drainage. Flows, stages, and pollutant concentrations are predicted at pertinent locations in the system. The total SWMM package simulates the urban hydrologic and quality processes including rainfall, snowmelt, surface and subsurface runoff, flow through a drainage system including a sewer network, storage, and treatment. Options are provided for statistical analysis and presentation of the simulation results.

6. Hydrologic Simulation Program - Fortran (HSPF).

a. Available. Center for Exposures Assessment Modeling, Environmental Research Laboratory, U.S. Environmental Protection Agency, 960 College Station Road, Athens, Georgia 30613-0801, telephone (706) 546-3549.

b. Description. HSPF is a comprehensive package for simulation of watershed hydrology and water quality for both conventional and toxic organic pollutants. The model uses information such as: the time history of rainfall, temperature, and solar radiation; land surface characteristics such as land use patterns and soil properties; and land management practices to simulate the processes that occur in a watershed. Flow rates, sediment loads, and nutrient and pesticide concentrations are predicted for the watershed runoff. The model uses these results, along with input data characterizing the stream network and point source discharges, to simulate instream processes. Model output includes a time history of water quantity and quality at all pertinent locations in the watershed/stream system.

7. Simulator for Water Resources in Rural Basins - Water Quality (SWRRB-WQ.

a. Available. Grassland, Soil, and Water Research Laboratory, Agricultural Research Service, U.S. Department of Agriculture, 808 East Blackland Road, Temple, Texas 76502, telephone (817) 770-6500.

b. Description. SWRRB-WQ is designed to predict the effects of various types of land management practices on water and sediment yields and water quality in ungaged rural basins. The continuous precipitation-runoff model uses a daily time step. Many years of daily flows may be computed for specified precipitation data. Daily precipitation may be either inputted or developed by the model as Markov process using inputted probabilities. A large basin can be divided into up to ten subwatersheds. The major processes included in the model include surface runoff, percolation, return flow, evapotranspiration, transmission losses, pond and reservoir storage, sedimentation, nitrogen and phosphorus cycling and movement, pesticide fate and movement, and crop growth and management.

8. Cascading Planes, Two Dimensions (CASC2D).

a. Availability.

(1). Hydro-Science Division, Coastal and Hydraulics Laboratory, U.S. Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199, telephone (601) 634-4157 (for DoD and USEPA users); and

(2). Engineer Computer Graphics Laboratory, Brigham Young University, Provo, Utah, telephone (801) 378-7569 (for all others).

b. Description. CASC2D is a distributed physics-based computer model of rainfall-runoff process. The basin is represented as a regular grid of cells. Each cell contains assigned values for precipitation quantity, infiltration parameters, roughness, elevation, soil, and vegetation characteristics. Precipitation may be input as discrete gages or NEXRAD generated digital hourly precipitation files. It uses the Green-Ampt method for soil moisture accounting. NEXRAD is the acronym for the National Weather Service Weather Service Radar 88-Doppler, or WRS 88-D. This technology replaced the older WRS-57-C. These radars have the capability to quantify precipitation based on reflectivity algorithms. The precipitation quantities are captured as digital hourly precipitation files, which can be used by hydrologic models to compute runoff from the precipitation. Overland flow is computed using the diffusive wave approximation. Stream channels are represented in one dimension within the grid. Channel routing may be either by diffusive wave approximation or computed by solutions for the fully dynamic momentum equations. The CASC2D model is supported by the Watershed Modeling System (WMS). The WMS is a powerful pre- and post-processing graphical use interface. The WMS allows viewing of input and results graphically as static views or animated time-dependent results.

D. WATER DISTRIBUTION MODELS

Two models are covered in this section, **KYPIPE2** and **WADIS0**.

1. Kentucky Pipe2 (KYPIPE2.

a. Available.

(1). Mr. Don J. Wood or Mr. William C. Gilber, Civil Engineering Software Center, 212 Anderson Hall, University of Kentucky, Lexington, Kentucky 40506-0046, telephone (606) 257-3436 or (606) 257-4941; and

(2). Haestad Methods, Inc., 37 Brookside Road, Waterbury, Connecticut 06708, telephone (203) 755-1666 or (800) 727-6555.

b. Description. This comprehensive pipe network modeling system computes steady-state flows and pressures for specified demands. Optional capabilities are also provided for extended period simulations with storage tank levels varying over time. The model will compute flows for each pipe and the hydraulic grade and pressure at each node for a given set of water demands. Alternatively, capabilities are provided to determine a variety of design, operation, and calibration parameters, for specified pressure requirements. Simulations are based on iteratively solving the sets of continuity and energy equations using linearization schemes to handle nonlinear terms and a sparse matrix solution algorithm. Pipe head losses are estimated using either Hazen-Williams or Darcy-Weisbach equations.

2. Water Distribution Simulation and Optimization (WADISO) Model.

a. Available.

(1). Waterways Experiment Station, U.S. Army Corps of Engineers, 3909 Halls Ferry Road, Vicksburg, Mississippi, 39180-6199, telephone (601) 634-2581; and

(2). The model has also been published as a book and is available on diskettes from Lewis Publishers, Inc., 2000 Corporate Blvd. N.W., Boca Raton, Florida 33431, telephone (800) 272-7737.

b. Description. This model consists of three major modules or routines; simulation, optimization, and extended period simulation. The simulation routine calculates the flow and pressure distributions in a pipe network for specified demands. The optimization routine determines costs and some pressure distribution for a set of user specified pipe sizes and changes the sizes for selected pipes within user-specified limits until it finds the most economical arrangement that meets the pressure requirement. The extended period simulation module computes flow and pressure distributions in a pipe network, taking into consideration fluctuating storage tank water levels and varying water use patterns over time. All three routines allow for the presence of pumps, pressure-reducing valves, check valves within the water distribution system and multiple supply points. Pipe leak losses are estimated using the Hazen-Williams equation. There are no limits to the layout of a system except for the normal requirement of at least one constant head node such as a tank or reservoir. The optimization routine is intended for sizing of a limited number of pipes, not all the pipes in a large system.

E. STREAM HYDRAULICS MODELS

Six individual models plus one system of four models are covered in this section; **HEC-2**, **WSPRO**, **FLDWAY**, **UNET**, **FESWMS-2DH**, **HEC-6** and (the system) **TABS**.

1. Hydrologic Engineering Center HEC-2.

a. Available. Hydrologic Engineering Center, U.S. Army Corps of Engineers, 609 Second Street, Davis, California 95616, telephone (530) 756-1104.

b. Description. HEC-2 develops water surface profiles and related hydraulic data (depths, velocities, etc.) for steady gradually varied flow in natural and man-made channels. Both subcritical and supercritical flow regimes can be modeled. The computational procedure is based on the standard step method solution of the one-dimensional energy equation with frictional energy losses estimated with the Manning equation. Input data includes cross-sections describing channel and floodplain geometry and energy coefficients. The effects of various obstructions to flow such as bridges, culverts, weirs, and structures in the floodplain may be reflected in the model. HEC-2 provides optional capabilities for evaluating the effects of channel improvements and levees on water surface profiles. The program also includes options designed for application in flood plain management and flood insurance studies to evaluate floodway encroachments and to designate flood hazard zones. An option is provided for use in calibrating the Manning roughness coefficient. Other optional modeling capabilities involve bridge and culvert losses, stream tributaries, ice covered streams and split flows.

2. Water Surface Profiles (WSPRO).

a. Available.

(1). U.S. Geological Survey, Water Resources Division, 12201 Sunrise Valley Drive, Reston, Virginia 22092;

(2). Federal Highway Administration, Office of Research, Development, and Technology, 6300 Georgetown Pike, McLean, Virginia 22101-2296; and

(3). McTans Center for Microcomputers in Transporation, University of Florida, 512 Weil Hall, Gainesville, Florida 32611-2083, telephone (904) 392-0378.

b. Description. WSPRO develops water surface profiles and related hydraulic data (depths, velocities, etc.) for steady gradually varied flow in natural and man-made channels. Both subcritical and supercritical flow regimes can be modeled. The computational procedure is based on the standard step method solution of the one-dimensional energy equation with frictional energy losses estimated with the Manning equation. Input data includes cross-sections, describing channel and floodplain geometry, and energy loss coefficients. WSPRO was developed primarily to analyze the hydraulics of bridge waterways. The program provides capabilities for simulating flow through bridges and culverts, including multiple-opening structures, and flows over embankments.

3. Flood Wave (FLDWAY).

a. Available. Dr. D.L. Fread, Director, Hydrologic Research Laboratory, National Weather Service, National Oceanic and Atmospheric Administration, Silver Springs, Maryland 20910, telephone (301) 713-0006.

b. Description. This model combines the Operational Dynamic Wave Model (DWOPER) and the Dam-Break Flood Forecasting Model (DAMBRK) into a single model and provides additional hydraulic simulation methods with a more user-friendly model structure. These are one-dimensional dynamic routing models based on an implicit finite difference solution of the complete St. Venant equations. Discharges, velocities, depths, and water surface elevations are computed as a function of time and distance along the channel. Input data includes cross-sectional geometry of the river floodplain, energy loss coefficients, and inflow hydrographs. FLDWAY provides flexible capabilities for modeling unsteady flow in rivers with branching tributaries, irregular geometry, variable roughness parameters, lateral inflows, flow diversions, off-channel storage, local head losses such as bridge contractions and expansions, lock and dam operations, and wind effects. An automatic parameter calibration option is provided for determining values for roughness coefficients. Data management features facilitate use of the model in a day-to-day forecasting environment. The model is equally applicable to simulating unsteady flows in planning and design studies. Multiple dams located in series on the same stream can be simulated as well as single dams. An inflow hydrograph is routed through a reservoir using either hydrologic storage or dynamic routing.

4. One-Dimensional Unsteady Flow Through a Full Network of Open Channels (UNET).

a. Available. Hydrologic Engineering Center, U.S. Army Corps of Engineers, 609 Second Street, Davis, California 95616, telephone (530) 756-1104.

b. Description. UNET is a dynamic routing model based on a four-point implicit finite-difference solution of the St. Venant equations. Unsteady flow can be simulated for complex networks of open channels. Dendritic tributary configurations, split flow around islands, and closed loops, such as a canal connecting tributaries, can be included in the network being modeled. Various types of external and internal boundary conditions can be incorporated in the simulation including; flow and stage hydrographs, rating curves, gated and ungated spillways, pump stations, bridges, culverts, and levee systems. Channel geometry data can be inputted in HEC-2 cross-section format.

5. Finite Element Surface-Water Modeling System: Two-Dimensional Flow in a Horizontal Plane (FESWMS-2DH).

a. Available.

(1). U.S. geological Survey, Water Resources Division, 12201 Sunrise Valley Drive, Reston, Virginia 22092;

(2). Federal Highway Administration, Office of Research, Development, and Technology, 6300 Georgetown Pike, McLean, Virginia 22101-2296; and

(3). McTrans Center for Microcomputers in Transportation, University of Florida, 512 Weil Hall, Gainesville, Florida 32611-2083, telephone (904) 392-0378.

b. Description. FESWMS-2DH was developed to improve capabilities to model complex flow conditions at highway bridges. The generalized model is applicable to other two-dimensional steady or unsteady flow modeling problems as well. FESWMS-2DH is a modular set of programs which includes; DINMOD, the data input module; FLOMOD, the depth-averaging flow simulator module; and ANOMOD, the analysis of output module. The model is capable of simulating flow through single or multiple bridge opens as normal flow, pressure flow, weir flow, or culvert flow.

6. Scour and Deposition in Rivers and Reservoirs (HEC-6).

a. Available. Hydrologic Engineering Center, U.S. Army Corps of Engineers, 609 Second Street, Davis, California 95616, telephone (530) 756-1104.

b. Description. HEC-6 is a one-dimensional sediment transport model designed to develop water surface and sediment bed surface profiles by computing the interaction between sediment material in the streambed and the flowing water-sediment mixture. The model simulates the capability of a stream system to transport bed and suspended load, given the sediment yield from upstream sources. The total sediment load is computed for each cross-section along the trap efficiencies for clays, silts, and sands. The change in bed elevation, water surface elevation, and thalweg elevation are also computed for each cross-section. HEC-6 does not simulate bank erosion or lateral migration. The model is oriented toward analyzing long-term river and reservoir behavior rather than single short-term flood events. Flow computations are based on a standard step method solution of the steady-state one-dimensional energy equation. Several user-option alternative sediment transport functions are incorporated in the model.

7. TABS Modeling System.

a. Available.

(1). Waterways and Estuaries Division, Coastal and Hydraulics Laboratory, U.S. Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199, telephone (601) 634-3822 (for Corps users); and

(2). Engineer Computer Graphics Laboratory, Brigham Young University, Provo, Utah, telephone (801) 378-7569 (for all other users).

b. Description. The TABS suite of computer model programs includes RMA2, RMA4, RMA10 and SED2D. These codes are supported through the Surface Water Modeling System (SMS). The SMS is a powerful pre- and post-processing graphical user interface. RMA2 is a two-dimensional depth averaged finite element hydrodynamic computer mode. It computes water-surface elevations and horizontal velocity components for subcritical, free-surface flow in two-dimensional flow fields. RMA2 computes a finite element solution of the Reynolds form of the Navier-Stokes equations for turbulent flows. Friction is calculated with the Manning's or Chezy equation, and eddy viscosity coefficients are used to define turbulence characteristics. Both steady-state and dynamic problems can be analyzed. RMA4 is a finite element water quality transport numerical model in which depth concentration distribution is assumed to be uniform. Concentrations for up to six constituents, either conservative or non-conservative, can be computed within the computational domain. RMA10 is a three-dimensional derivative of RMA2 which allows for fully three-dimensional solutions to complex sub-critical flow fields. SED2D is a two-dimensional sediment transport computer code. It handles both cohesive and noncohesive sediment transport using the Ackers-White bed load function and advection diffusion equations for suspended material. The SMS allows viewing of input and output graphically.

F. RIVER AND RESERVOIR WATER QUALITY MODELS

Seven models are covered in this chapter; **QUAL2E**, **WASP**, **CE-QUAL-RIV1**, **CE-QUAL-R1**, **CE-QUAL-W2**, **HEC5-Q**, and **WQRRS**.

1. Enhanced Stream Water Quality Modes (QUAL2E).

a. Available. Center for Exposure Assessment Modeling, Environmental Research Laboratory, U.S. Environmental Protection Agency, 960 College Station Road, Athens, Georgia 30613-0801, telephone (706) 546-3549.

b. Description. QUAL2E is a steady-state one-dimensional model for simulating pollutant transport and transformation in well-mixed branching streams and lakes. Up to 15 user-selected water quality constituents in any combination can be simulated, including: dissolved oxygen, biochemical oxygen demand, temperature, algae as chlorophyll α, organic nitrogen as N, ammonia as N, nitrite as N, organic phosphorus as P, dissolved phosphorus as P, coliform bacteria, an arbitrary conservative constituent and three conservative constituents. A typical application of the model is to study the impacts of waste loads on stream water quality. The model can also be used to analyze the effects on water quality, primarily dissolved oxygen and temperature, caused by diurnal variations in meteorological data. Diurnal dissolved oxygen variations caused by algal growth and respiration can be examined.

2. Water Quality Analysis Simulation Program (WASP).

a. Available. Center for Exposure Assessment Modeling, Environmental Research Laboratory, U.S. Environmental Protection Agency, Athens, Georgia 30613, telephone (404) 546-3560.

b. Description. WASP is a compartment modeling framework for simulating contaminant fate and transport in rivers, reservoirs, estuaries, and coastal waters. WASP can be applied in one, two, or three dimensions. The WASP modeling system consists of two stand-alone computer programs, DYNHYD and WASP, that can be run in conjunction or separately. The unsteady flow hydrodynamic program DYNHYD simulates the movement of water, and the water quality program WASP simulates the movement and interaction of pollutants within the water. A variety of water quality problems can be analyzed with the selection of appropriate kinetic subroutines which may be either selected from a library or written by the user. WASP is a flexible framework for modeling hydrodynamics, conservative mass transport, eutrophication-dissolved oxygen kinetics, and toxic chemical-sediment dynamics.

3. Dynamic One-Dimensional Water Quality Model for Streams (CE-QUAL-RIV1).

a. Available. Water Quality and Contaminant Modeling Branch, Environmental Laboratory, Waterways Experiment Station, U.S. Army Corps of Engineers, 3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199, telephone (601) 634-3785.

b. Description. CE-QUAL-RIV1 is a one-dimensional (longitudinal) fully dynamic hydraulic flow and water quality simulation model intended for modeling highly unsteady streamflow conditions, such as that associated with peaking hydroelectric power tailwaters. The model also allows simulation of branched river systems with multiple control structures such as reregulation dams and navigation locks and dams. The model has two parts, hydrodynamics and water quality. Output from the hydrodynamic model is used to drive the water quality model. The hydrodynamics is based on an implicit numerical solution of the St. Venant equations. The water quality constituents which can be modeled include temperature, dissolved oxygen, carbonaceous biochemical oxygen demand, organic nitrogen, ammonia nitrogen, nitrate nitrogen, ortho-phosphate phosphorus, coliform bacteria, dissolved iron, and dissolved manganese. The effects of algae and macrophytes can also be included.

4. Numerical One-Dimensional Model of Reservoir Water Quality (CE-QUAL-R1).

a. Available. Water Quality and Contaminant Modeling Branch, Environmental Laboratory, U.S. Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199, telephone (601) 634-3785.

b. Description. CE-QUAL-R1 simulates the vertical distribution of thermal energy and chemical and biological materials in a reservoir through time. The model is used to study water quality problems and the effects of reservoir operations on water quality. A reservoir is conceptualized as a vertical sequence of horizontal layers with thermal energy and materials uniformly distributed in each layer. The distribution of inflows among the horizontal layers is based on density differences. Vertical transport of thermal energy and materials occurs through entrainment and turbulent diffusion. The interactions of numerous biological and chemical factors are reflected in the model. The model simulates the dynamics of 27 water quality variables, computing both in-pool and downstream release magnitudes. Eleven other variables are included which represent materials in the sediments. Reservoir outflows may occur in the model according to a specified schedule of port releases. Alternatively, the model may select port releases based on user specification of total release and desired release temperatures. Water quality problems that can be addressed include: prediction and analysis of thermal stratification, anoxic conditions, algal blooms, and growth of algae and macrophytes; location of selective withdrawal ports required to meet a downstream temperature objective; analysis of the effects of storm events, upstream land use changes, or reservoir operational changes on in-pool and release water quality.

5. Two-Dimensional, Laterally Averaged Model of Hydrodynamics and Water Quality (CE-QUAL-W2).

a. Available. Water Quality and Contaminant Modeling Branch, Environmental Laboratory, Waterways Experiment Station, U.S. Army Corps of Engineers, 3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199, telephone (601) 634-3785.

b. Description. CE-QUAL-W2 was developed for reservoirs but can also be applied to rivers and estuaries. The two-dimensional model simulates the vertical and longitudinal distributions of thermal energy and selected biological and chemical materials in a water body through time. The model provides capabilities for assessing the impact of reservoir design and operations on the water quality variables. The model determines in-pool water volumes, surface elevations, densities, vertical and longitudinal velocities, temperatures, and constituent concentrations as well as downstream release concentrations. The water quality model simulates the dynamics of up to 20 constituents in addition to temperatures and circulation patterns. The model simulates the interaction of physical factors (such as flow and temperature), chemical factors (such as nutrients), and an algal assemblage. The constituents are arranged in four levels of optional modeling complexity, permitting flexibility in model application. The first level includes materials that are conservative and noninteractive. The second level includes the interactive dynamics of oxygen-phytoplankton-nutrients. The third level allows simulation of pH and carbonate species. The fourth level allows simulation of total iron.

6. Simulation of Flood Control and Conservation System (Water Quality Version (HEC-5Q).

a. Available. Hydrologic Engineering Center, U.S. Army Corps of Engineers, 609 Second Street, Davis, California 95616, telephone (530) 756-1104.

b. Description. The flows computed by the flow simulation sub-model for multiple reservoir and non-reservoir control points are input to the water quality sub-model. The water quality simulation module computes the vertical distribution of temperature and other constituents in the reservoirs and the water quality in the associated downstream reaches. The model also determines the gate openings for reservoir selective withdrawal structures to meet user-specified water quality objectives at downstream control points. If the downstream quality objectives cannot be satisfied by selective withdrawal, the model will determine if the objectives can be satisfied by an increase in flow amounts. The water quality simulation can be used in three alternative modes: calibration, annual simulation, and long-term simulation. Two alternative groups of water quality constituents can be simulated. The first option includes: water temperature, up to three conservative constituents, up to three non-conservative constituents, and dissolved oxygen. The other option includes water temperature, total dissolved solids, nitrate nitrogen, phosphate phosphorus, phytoplankton, carboneous BOD, ammonia nitrogen, and dissolved oxygen.

7. Water Quality for River-Reservoir System (WQRRS).

a. Available. Hydrologic Engineering Center, U.S. Army Corps of Engineers, 609 Second Street, Davis, California 95616, telephone (530) 756-1104.

b. Description. The WQRRS package consists of the programs SHP, WQRRSQ, and WQRRSR which interface with each other. The Stream Hydraulics Package (SHP) and Stream Water Quality (WQRRSQ) programs simulate flow and quality conditions for stream networks which can include branching channels and islands. The Reservoir Water Quality (WQRRSR) program is a one-dimensional model used to evaluate the vertical stratification of physical, chemical, and biological parameters in a reservoir. The SHP provides a range of optional methods for computing discharges, velocities, and depths as a function of time and location in a stream system. The hydraulic computations can be performed optionally using input stage-discharge relationships, hydrologic routing, kinematic routing, steady flow equations, or the full unsteady flow St. Venant equations. The WQRRSR and WQRRSQ programs provide capabilities for analyzing up to 18 constituents, including chemical and physical constituents (dissolved oxygen, total dissolved solids), nutrients (phosphate, ammonia, nitrite, and nitrate), carbon budget (alkalinity, total carbon), biological constituents (two types of phytoplankton, benthic algae, zooplankton, benthic animals, three types of fish), organic constituents (detritus, organic sediment), and coliform bacteria.

G. RIVER\RESERVOIR SYSTEM OPERATION MODELS

Seven models are covered in this section; **HEC-5**, **IRIS**, **TAMUWRAP**, **MODSIM**, **HEC-PRM**, **RSS**, and **CALIDAD**. Additional information on Reservoir/River models is contained in Chapter 8, Paragraph E.

1. Simulation of Flood Control and Conservation (HEC-5).

a. Available. Hydrologic Engineering Center, U.S. Army Corps of Engineers, 609 Second Street, Davis, California 95616, telephone (530) 756-1104.

b. Description. HEC-5 simulates multiple-purpose multiple-reservoir systems on essentially any stream tributary configuration using a variable computational time interval. The model makes release decisions to empty flood control pools and to meet user-specified diversion, instream flow, and hydroelectric energy targets, based on computed reservoir storage levels and flows at downstream locations. Seasonal rule curves and buffer zones can be specified. Multiple-reservoir release decisions are based on balancing the percent depletion in user-specified storage zones. Several alternative hydrologic flood routing methods are available. Various optional analysis capabilities are provided, including computation of firm yields for diversions, instream flows, or hydroelectric energy, and computation of expected annual flood damages.

2. Interactive River System Simulation (IRIS).

a. Available. Daniel P. Loucks, Civil & Environmental Engineering, Hollister Hall, Cornell University, Ithaca, New York 14853-3501, telephone (607) 255-4896.

b. Description. IRIS simulates water supply storage and conveyance systems of any normal branching configuration for given operating rules and streamflow sequences, using a user-specified time step. The model also includes hydroelectric power and water quality features. The configuration of the system is specified by "drawing in" nodes (reservoirs, inflow sites, junctions, and other key locations) and interconnecting links (river reaches, canals, and pipelines). System operating rules include: (1) reservoir releases specified as a function of storage and season of the year; (2) allocation functions for multiple links from the same node; and (3) storage distribution targets for reservoirs operating as a group. Model output includes time series plots of flows, storage, energy generated, and water quality parameters at any node or link in the reservoir/river system and probability distribution displays of magnitude and duration of shortages or failure events.

3. Water Rights Analysis Package (TAMUWRAP).

a. Available.

(1). Dr. Ralph A. Wurbs, Civil Engineering Department, Texas A&M University, College Station, Texas 77843, telephone (409) 845-3079; and

(2). Texas Water Resources Institute, Texas A&M University System, College Station, Texas 77843, telephone (409) 845-1851.

b. Description. TAMUWRAP is designed for analyzing water management within a water rights permit system, with water demands being met on the basis of specified priorities. A user-specified set of water demands are met, as water availability allows, following specified operating rules, for inputted sequences of streamflows and evaporation rates. A monthly time step is used. The model provides the capability to simulate a stream/reservoir/use system involving essentially any stream tributary configuration. Interbasin transfers and closed loops, such as pipelines carrying water upstream or between tributaries, can be included in the system. Hydroelectric power can also be included. Water use requirements and reservoir operating rules are specified in various optional formats. Selected multiple reservoirs can be operated in combination based on balancing the percent depletion in specified storage zones. As currently dimensioned, the system can contain up to 2,000 water rights, and each right can include both reservoir storage and/or a water demand target. Simulation results include diversions, shortages, hydroelectric energy generated, streamflow depletions, unappropriated streamflows, reservoir storage and releases, reservoir evaporation, and reliability statistics. A recent salinity version of the model includes capabilities for inputting salt loads and specifying maximum allowable salt concentrations as part of the diversion requirements.

4. River Basin Network Simulation Model (MODSIM).

a. Available. Dr. John W. Labadie, Department of Civil Engineering, Colorado State University, Fort Collins, Colorado 80523, telephone (303) 491-8596.

b. Description. MODSIM is a generalized river basin network simulation model for hydrologic and water rights analysis of complex water management systems. Water is allocated based on user-specified priorities and operating rules. The user assigns relative priorities for meeting diversion, instream flow, and storage targets, as well as lower and upper bounds on flows and storage. The model computes values for all pertinent flows and storage. Hydroelectric power operations can be included in the simulation. MODSIM output includes various optional tabular and graphical presentations of reservoir balances, flows, demands satisfied from surface and ground water, demand shortages, and energy generated.

5. Hydrologic Engineering Center Prescriptive Reservoir Model (HEC-PRM).

a. Available. Hydrologic Engineering Center, U.S. Army Corps of Engineers, 609 Second Street, Davis, California 95616, telephone (530) 756-1104.

b. Description. HEC-PRM is a network flow programming model which incorporates an economic objective function. Operation of the reservoir/river system is driven by user-inputted convex cost based piecewise linear penalty functions. The user must be able to express costs associated with various system purposes as a function of reservoir storage, instream flows, or diversions. Noneconomic components can also be included in the basically economic objective function. Operating rules are also reflected in the upper and lower bounds specified on flows, releases, and storage. For given sequences of inputted stream inflows, the model computes the instream flows, diversions, and storage for each month of the simulation period which minimizes the objective function. The computations are performed for all months simultaneously. Improved network flow computational algorithms have been developed in conjunction with HEC-PRM.

6. River Simulation System (RSS).

a. Available. Dr. Jacquelyn F. Sullivan, Center for Advanced Decision Support for Water and Environmental Systems (CADSWES), University of Colorado, Campus Box 421, Boulder, Colorado 80309-0421, telephone (303) 492-3972.

b. Description. The interactive graphics based RSS runs on workstations using the Unix operating system. RSS combines interactive computer graphics and data base management with river/reservoir system simulation. The object oriented structure provides flexibility from both user and programmer perspectives.

The user develops a model of a particular river/reservoir system by combining selected objects. Preprogrammed instructions for handling data and performing computations are associated with each object. Input and output data are also defined by user-selected objects. The user defines reservoir system operating policies using English-like statements, following a specified format, which utilize preprogrammed functions. If sufficient flexibility is not provided for a particular application, by the available RSS objects and statement functions, a programmer can readily modify the code to change existing objects and functions or add new ones.

7. Object-Oriented River Basin Modeling Framework (CALIDAD).

a. Available. Water Management Section, D-5755, U.S. Bureau of Reclamation, Denver Federal Center, P.O. Box 25007, Denver, Colorado 80225, (303) 236-4215.

(2). Description. The interactive graphics based CALIDAD runs on workstations using the Unix operating system. CALIDAD simulates the movement of water through a reservoir/river basin system and determines the set of diversions and reservoir releases which best meets the institutional constraints and management objectives. Simulations are performed using a monthly computational time step. The user builds a model for a specific river basin application by using objects which represent features such as inflows, reservoirs, diversions, hydropower plants, and irrigation or municipal water demand sites. CALIDAD has a palette of available objects from which to choose. Additional objects can be programmed and added to the library as needed. Both computational algorithms and data requirements are associated with each object. The physical parameters of the river basin features, such as reservoir storage characteristics and monthly streamflows, may be entered as object data. Institutional constraints and management objectives, called rules in the model, are also considered as data and entered through a separate rules editor. CALIDAD handles the management and institutional constraints using a heuristic technique called tabu search to determine permissible diversion and reservoir releases.

H. WATER CONSERVATION MODELS

Two models are covered in this section, **IWR-MAIN 6.1** and **WaterPlan 1**. Additional information on water conservation modeling is contained in Chapter 7, Paragraph B.

1. IWR-MAIN, version 6.1.

a. Available. Institute for Water Resources (IWR), U.S. Army Corps of Engineers, Casey Building, 7701 Telegraph Rd., Alexandria, VA 22315-3868, telephone (703) 428-8015. Planning chiefs in each Corps office was sent a copy and a manual of this software. Corps offices can obtain additional copies of this software from IWR at no cost. This software was developed with Planning and Management Consultants, Ltd.(PMCL), P.O. Box 1316, Carbondale, IL 62903. Training on this software is available from PMCL. There is a tution requirement for this training.

b. Description. IWR-MAIN, described above under "Demand Forecasting Models", includes a conservation module that aids water planners in evaluating conservation alternatives. This module can only be run in conjunction with forecasting future water demand for the specified service area. The conservation savings module dissaggregates seasonal water demands into end uses that are tracked to determine long-term conservation water saving associated with the specified indoor and outdoor end uses. Passive, active and temporary or emergency water conservation savings are computed by comparing the forecasted future demand without conservation measures to an alternate forecast incorporating selected conservation options. Water savings result from improved efficiencies gained by replacing standard fixtures with conserving or ultra-conserving fixtures, changes in rates structures and mandatory water reductions during water emergencies.

2. WaterPlan™, version 1.

a. Available. State of California, Department of Water Resources, P.O. Box 942836, Sacramento, CA 94236-0001, telephone Ms. Bravver at (916) 327-1770.

b. Description. The WaterPlan™ software calculates costs and savings of water conservation measures specified in the software for residential, commercial and industrial customers and can also address potential water saving within the water supply system. Documentation available with the software provides key numeric factors and descriptions of each conservation measure. The numeric data includes information on water savings associated with the specific measure, portion of the customer base expected to participate, impact on previously implemented conservation measures and the cost associated with activating this conservation measure.

I. INTEGRATED WATER SUPPLY AND DEMAND

One model, WEAP is covered in this section. Additional information on integrated water supply and demand is contained in Chapter 6, Paragraph C and Chapter 8, Paragraph D.

1. Water Evaluation and Planning (WEAP) System.

a. Available. Boston Tellus Institute, Stockholm Environment Institute, 11 Arlington Street, Boston, Massachusetts 02116-3411, telephone (617) 266-5400.

b. Description. Over the last decade, an integrated approach to water development has emerged which places water supply projects in the context of demand-side issues, water quality and ecosystem preservation. The WEAP system can address issues such as sectoral demand analyses, water conservation, water rights and allocation priorities, stream flow simulations, reservoir operations, hydropower generation, pollution loading and project benefit-cost analyses. WEAP is applicable to municipal or agricultural areas, single subbasins or complex river systems. The primary system components are database management, forecasting, and policy analysis. WEAP's systematic framework maintains and compares the water supplies and demand for the specified geographic area during the defined time frame. Alternative water use scenarios and management strategies may be evaluated. Water supply and use data may be displayed in a variety of tables and graphs. Network diagrams are available to show the interconnected relationships between the components of the water demand-supply system. Disaggregated demand forecasts may be performed for municipal, industrial, agricultural, and other types of water use over a long-term planning horizon. Several optional forecasting methods are available. All surface and ground water supplies can be included in a simulation. Major multiple-purpose reservoirs as well as local water supply reservoirs may be modeled. Withdrawals for water treatment plants, discharges from wastewater treatment plants, return flows, groundwater pumpage, and transmission losses are included in the water accounting system. Supplies and demands are compared at a site specific level, such as a water treatment or wastewater treatment plant, or at an aggregate level such as a city or county.

Stream flow data can be entered for the historical period-of-record or a critical drought period or alternatively stream flows can be entered characterizing typical wet, dry, and normal years. The model uses a monthly time interval.

APPENDIX F

OUTLINES FOR WATER CONTROL DOCUMENTS

DECEMBER 1998

Table of Contents

STANDING INSTRUCTIONS TO PROJECT OPERATORS FOR WATER CONTROL

(Title Page)

STANDING INSTRUCTIONS TO THE PROJECT OPERATOR FOR WATER CONTROL

(STRUCTURE OR PROJECT NAME)

(Stream)
(River Basin)
(State)

Exhibit___[1]

to the

Water Control Plan (or Manual)

for

(Parent Project Name)

District

U. S. Army Corps of Engineers

(Date)

(Revised Date)

[1] Omit for Type II projects that are not in a water resource system.

PHOTOGRAPHS

Include sufficient photographs to document the structure/project.

TABLE OF CONTENTS

See following guide for narrative development of "Standing Instructions."

PERTINENT DATA

The pertinent data shown here should be limited to one or two pages. Additional information can be included as an exhibit.

GUIDE FOR NARRATIVE DEVELOPMENT OF STANDING INSTRUCTIONS

I - BACKGROUND AND RESPONSIBILITIES

1-01. General Information.

a. Cite compliance with EM 1110-2-3600 and ER 1110-2-240, and state that a copy of these Standing Instructions must be kept on hand at the project site at all times, and that any deviation from the Standing Instructions will require approval of the District Commander.

b. Identify authorized project purposes and all water control objectives.

c. Identify chain of command and the entity to which the project operation is responsible for water control actions.

d. State project location and brief description of water control structures.

e. Describe constraints on physical operation of the water control structure.

f. Include a statement as to whether O&M is by the Corps or by local interests, and a statement as to whether it is a local protection project. Reference the Code of Federal Regulations (CFR Title 33, Part 208.10) when it applies.

1-02. Role of Project Operator.

a. Normal Conditions (not dependent on day-to-day instruction). Applies to Type II and some Type III projects. Include the following statement. "The Project Operator is responsible for water control actions during normal hydrometeorological conditions (non-flood, non-drought) without daily instruction. However, the water control manager should be contacted any time conditions are such that consultation or additional instruction regarding water control procedures is needed."

OR

a. Normal Conditions (dependent on day-to-day instruction). Applies to some Type III and most Type IV projects. Include the following statement when appropriate. "The Project Operator will be instructed by water control managers on a daily basis for water control actions under normal conditions."

b. Emergency Conditions (flood or drought). The same as above, as appropriate, during flood events and other emergency conditions.

II - DATA COLLECTION AND REPORTING

2-01. Normal Conditions. Instructions for collecting water data under normal hydrometeorological conditions, and instructions for reporting the water data to the District office.

2-02. Emergency Conditions. The same as the above during flood events and other emergency conditions. Specify more intensive requirements when appropriate.

2-03. Regional Hydrometeorological Conditions. Include the following statement. "The Project Operator will be informed by the water control manager of regional hydrometeorological conditions that may/will impact the structure."

III - WATER CONTROL ACTION AND REPORTING

3-01. Normal Conditions. Specific step-by-step instructions for water control action under normal hydrometeorological conditions, taking into account any constraints on water control or physical operation, and specific step-by-step instructions for reporting the action and any unusual conditions to the water control manager.

3-02. Emergency Conditions. The same as the above during flood events and other emergency conditions.

3-03. Inquiries. Include the following statement. "All significant inquires received by the Project Operator from citizens, constituents or interested groups regarding water control procedures or actions must be referred directly to water control managers."

3-04. Water Control Problems. Include the following statement. "The water control manager must be contacted immediately by the most rapid means available, in the event that an operational malfunction, erosion, or other incident occurs that could impact project integrity in general or water control capability in particular."

3-05. Communication Outage. Specific step-by-step instructions for water control action, in the event a communication outage with the water control manager occurs during either normal or emergency conditions, considering constraints.

PLATES

1. Maps of the project area showing the water control structures, streams, levees, dikes, channels, water data stations and parameters measured, with a vicinity map insert depicting the drainage area above the project.

2. Schematic drawing of the project facilities, including a plan and profile of water control structures which show key water levels (headwater and tailwater), and other pertinent information.

3. Forms for collecting water data, reporting water data, and reporting water control actions.

4. Discharge rating curves, if appropriate, with key elevations identified and a rating table inserted on the graph.

5. Water control diagrams and release schedules, if appropriate, for normal and emergency conditions, and for communication outages.

6. List of points of contact in District and/or Division office.

7. Other supporting plates, if needed.

WATER CONTROL PLAN

(Title Page)

WATER CONTROL PLAN[2]

(STRUCTURE OR PROJECT NAME)

(Stream)
(River Basin)
(State)

Appendix __

To the

Master Water Control Manual

for

(Parent Project Name)

District

U.S. Army Corps of Engineers

(Date)

(Revised Date)

[2] This format is used for Type III projects when a water control manual is not prepared. Use the format of Chapter VII in ETL 1110-2-251 for Type III and IV projects when a water control manual is prepared.

PHOTOGRAPHS

In photographs sufficient to document all water control structures.

TABLE OF CONTENTS

See following guide for narrative development of a “Water Control Plan.”

PERTINENT DATA

The pertinent data shown here should be limited to one or two pages. Additional information can be included as an exhibit.

GUIDE FOR NARRATIVE DEVELOPMENT OF A WATER CONTROL PLAN

I - INTRODUCTION

State the requirement for the Water Control Plan (ref. ER 1110-2-240, ref. Part 208.10 of CFR, Title 33, when applicable, and state as Type III project). Include in concise summary form; project authorization, purpose, location, description, and completion date of the principal and related projects.

II - PROJECT FEATURES

Description in concise summary form of all water passageways (discharge facilities, inflow and outflow, channels, etc.), related water resource projects, and all public use facilities.

III - HYDROMETEOROLOGY AND WATER QUALITY.[3]

Provide in concise summary form the following information:

•Watershed description
•Climate
•Runoff

[3] Detailed presentation of these topics in the system master manual is preferred when one is prepared.

•Table showing average monthly precipitation in inches and average monthly runoff in both inches and cfs
•Water quality design conditions
•Water passageway characteristics
•Data collection stations and maintenance of instrumentation
•Data collection procedure and reporting (refer to exhibit on "Standing Instructions to the Project Operator")
•Method of preparing hydrologic forecasts if done in-house
•Source, access procedure and overall suitability of, forecasts if obtained from NWS

IV - WATER CONTROL PLAN

1. Provide in detailed form the following information:

•Overall summary of the water control plan, including;
 o Objectives
 o Major constraints
•Specific objectives
•Regulating procedures
•Beneficial effects of regulation for each water control objective

2. Address the following objectives as appropriate. The discussion should include examples of regulation and any constraints.

•Flood control (include regulation for design flood)
•Navigation
•Water supply
•Water quality
•Fish and wildlife
•Hydropower
•Recreation
•Any other water control objectives and incidental achievements

V - PROJECT MANAGEMENT[4]

Provide in detailed form the following information:

•Project owner

---

[4] Ibid.

•Role of the regulating office (water control managers, and summarize requirements for the Water Control Morning Report for the subject project)
•Role of the Project Operator (refer to exhibit on “Standing Instructions”)
•Communication between the District office and project operator
•Coordination with local, state and other Federal agencies (as required)
•Future changes to the project and the impact on water control

PLATES

1. Map and plan of project area with vicinity map insert.

2. Plan and profile of structure clearly showing all discharge facilities.

3. Data collection network map (designate auto-recording, auto-reporting and key control point(s)).

4. Water Control Diagram (guide curve), with release schedule and explanatory notes, when applicable.

5. Discharge rating curves with rating table insert (designate important related elevations).

6. Hydrograph examples of water control regulation (inflow and outflow), with hyetographs (for floods of record and the design flood).

7. Frequency and duration curves for headwater or pool and control point or tailwater (discharge and stage).

8. Other plates as required for the project at hand.

EXHIBITS

1. Detailed Pertinent Data.

2. Other Exhibits, as appropriate.

3. Memorandum of Understanding or other Agreement.

4. Standing Instructions to the Project Operator for Water Control.

WATER CONTROL MANUAL

(Title Page)

WATER CONTROL MANUAL[5]

(Project Name)

(Stream)

(River Basin)

(State)

District

U.S. Army Corps of Engineers

(Date)

(Revised Date)

[5] Required for all Type III and IV projects.

PHOTOGRAPH

Include a choice photograph of the dam and reservoir or a composite of photos on one page showing spillways, outlet works, energy dissipators, exit channels, power facilities, overflow embankments, fuse plugs, and other pertinent control structures. If additional photographs are desired, include on separate pages.

NOTICE TO USERS OF HIS MANUAL

Regulations specify that this Water control Manual be published in a hard copy binder with loose leaf form, and only those sections, or parts thereof, requiring changes will be revised and printed. Therefore, this copy should be preserved in good condition so that inserts can be made to keep the manual current. Changes to individual pages must carry the date of revision, which is the Division's approval date.

REGULATION ASSISTANCE PROCEDURES

In the event that unusual conditions arise during non-duty hours, communication can be achieved by contacting, in the order listed, one of the following personnel (provide a telephone listing).

TABLE OF CONTENTS

See following guide for narrative development of "Water Control Manual."

PERTINENT DATA

The pertinent data shown here should be limited to approximately one page. Additional information can be included as an exhibit. Restrict information in this section to the following: (specific guidance to be provided by Division).

1. Location (state, county, river, and river mile).

2. Drainage area above the damsite and the uncontrolled areas above any major control points downstream; 1 inch of runoff = ___ acre-feet.

3. Type, length, height, top width of dam, dikes, and tidal barriers; type and size of all discharge facilities; spillway, outlet works, water supply pipes, penstocks, and locks.

4. Real estate guide taking lines by fee and easement.

5. Pertinent elevations with corresponding reservoir areas, incremental and cumulative storage and discharge capacities of spillway and outlet works for maximum pool, top induced surcharge, top flood control pool, top conservation pool, top inactive pool, invert lowest intake, and streambed. Also

indicate the volumes of sediment reserve, dead storage, and the range of any seasonal joint use or commingled storage reservations, when applicable.

GUIDE FOR NARRATIVE DEVELOPMENT OF A WATER CONTROL MANUAL

I - INTRODUCTION

1-01. Authorization. Cite applicable OCE Directives regarding preparation of manual; ER 1110-2-240, ER 1110-2-241, Section 7 of 22 December 1944 Flood Control Act and, when applicable, by request of local interests to regulate project, and other.

1-02. Purpose and Scope. Brief discussion of purpose and scope of manual (use language in ER 1110-240). Refer to guidance in EM 1110-2-3600 on scope and content.

1-03. Related Manuals and Reports. Master manual and others in same system; list of prior reports pertinent to project such as design memorandums, master plans, and emergency plans.

1-04. Project Owner. Name of agency.

1-05. Operating Agency. Dam attended continuously or part-time (specify period of attendance); damtender living nearby, name, office phone, damtender also operating other structures (reregu-lation, diversion, other) by remote control/manually; a non-Corps project with physical operation and maintenance officially per-formed by Corps.

1-06. Regulating Agencies. Corps direct and indirect responsi-bility for various project purposes including hydrologic forecasts; cite authority of Corps (owner, Section 7 Regulation, through FERC, non-Corps project with regulation officially performed by Corps, other); phone and address of regulating office if non-Corps.

II - DESCRIPTION

2-01. Location. Stream, river mile, basin, state, county, nearby community.

2-02. Purpose. Concise paragraph stating (not explaining authorized purposes and incidental benefits).

a. Those assigned by Congress initially in the legislation authorizing the project construction.

b. Those subsequently assigned by Congress in law(s) specific to the project.

c. Those contained in or derived from general Congressional acts.

d. Incidental benefits - those which accrue to any purpose other than an authorized purpose incidental to the operation for the authorized purposes.

2-03. Physical Components. Structural in general, hydraulic in particular, operating machinery. Show subparagraphs for embankment, dikes, barriers, spillway, outlet works, hydro-electric power facilities, water supply facilities, etc. Discuss multilevel outlets for water quality control.

2-04. Related Control Facilities. Integrated components of subject project; e.g. reregulation, diversion, pumpback, local protection, or other structures.

2-05. Real Estate Acquisition. Fee and easement takings in reservoir area, downstream channels, etc. Show backwater curves (profiles), if appropriate.

2-06. Public Facilities. Number and type of public use sites: contour map showing location of sites, especially campsites, islands, and trailer parks upstream and downstream of damsite.

III - HISTORY OF PROJECT

3-01. Authorization. Cite Congressional legislation applicable to project formulation; i.e. Flood Control Act, House Document, Public Laws, etc. (See Project Document).

3-02. Planning and Design. Brief history of planning and design.

3-03. Construction. Significant dates such as start of construction, diversion, deliberate impoundment, filling of conservation pool, and start of hydropower generation (may be shown in a table).

3-04. Related Projects. Other projects (Corps and non-Corps) in same system that affect water control objectives.

3-05. Modifications to Regulations. Brief history of changes to the water control plan due to change in needs and conditions since project formulation, related studies.

3-06. Principal Regulation Problems. Associated with regulation since project completion; erosion, boils, severe leakage, embankment overtopping or failure, structural hydraulic malfunction, groundwater table, flooding, nondamaging channel capacity (examples), and encroachment. (Some of this information can probably be presented in tabular form). Plate showing area of encroachment or channel deterioration.

IV - WATERSHED CHARACTERISTICS

4-01. General Characteristics. Total and contributing drainage area; slope, shape, elevation range, vegetation, tributaries; possible damage centers caused by high pool/backwater.

4-02. Topography.

4-03. Geology and Soils.

4-04. Sediment. Discussion of erosion and sediment production in watershed.

4-05. Climate. General description of climate over the water-shed. Use tables to show extreme and average or 30-year normal values by month. Show watershed average or representative stations. Include paragraphs on temperature, precipitation, snow, evaporation and wind.

4-06. Storms and Floods. Types (thunderstorms, hurricanes, etc.), time of year, major floods of record, and damages (limit to a few major floods).

4-07. Runoff Characteristics. Runoff related to antecedent rain, initial loses, time of concentration, monthly and annual streamflow distribution at key points, graphical display of record, seasonal variations, low flow, high flow, and tabulation of monthly and annual inflow volume at project for period of record. If data is available on computer, then cite automation records and how to access.

4-08. Water Quality. Description of water quality characteristics of the watershed and effects on operation of the lake. Describe the effects of agricultural and industry in the basin on water quality of the lake.

4-09. Channel and Floodway Characteristics. Downstream shape, condition, capacity, improvements, stability, tributaries, encroachments, alignment, water surface profiles, also description of damage centers and key control points, time of water travel (show graphically on plate), overbank, dikes, levees, control structures, and discharge rating curves for key stations.

4-10. Upstream Structures. Drainage area and regulated by whom.

4-11. Downstream Structures. Drainage area and regulated by whom.

4-12. Economic Data. May be tabular with brief descriptions.

a. Population.

b. Agriculture.

c. Industry.

d. Flood Damages. Average annual damages incurred and prevented, stage-damage curves for downstream reaches which are affected by this project (reaches affected by several projects should be shown in master manual). Curves would show stage versus structural damage and stage versus acres flooded.

V - DATA COLLECTION AND COMMUNICATION NETWORKS

5-01. Hydrometeorological Stations.

a. Facilities. Show locations on map, include USGS or NWS station numbers, types of stations (reporting, staff gauge, telemark etc.), inflow, outflow, water level, precipitation, groundwater, evaporation, snowpack, designated key stations, automated/manual status, automatic data processing compatibility, general adequacy of hydrometeorologic information available on a real time basis, reliability, reference chapters regarding hydrologic forecasting, and management.

b. Reporting. Stations reporting directly to office, reporting criteria, method, how reports from other stations are obtained, measurements, summary of activities during normal day-to-day and flood emergencies, reference instructions to damtender in back of manual, hydrologic/meteorologic measurements, and reporting.

c. Maintenance. Arrangements, who to contact for repair, etc.

5-02. Water Quality Stations.

a. Facilities. Location, number, and type.

b. Reporting. Same type of information as in paragraph 5-01b.

c. Maintenance. Same type of information as in paragraph 5-01c.

5-03. Sediment Stations. (Same type of information as in paragraph 5-01 and 5-02.

5-04. Recording Hydrologic Data. Method of recording and storing data, length of time to maintain records, forms, records management, and data banks for automated data processing.

5-05. Communication Network. Physical description of main and secondary networks showing diagram of network standby facilities and reliability. General status, type, and adequacy of data transmission, emergency warning and remote control, time of interrogation, emergency standby, reliability, and other uses of network.

5-06. Communication With Project.

a. Regulation Office With Project Office. Direct or indirect mode normal day-to-day flood warning, emergency regulation, and all other purposes and releases.

b. Between Project Office and Others. List areas requiring flood warning, type of warning facilities, recreation areas, campsites, floodway/plain encroachment, remote control or reregulation, diversion, and related structures of another agency.

5-07. Project Reporting Instructions. Instructions for reporting hydrologic data, items affecting release of water, confirmation of change in releases as instructed, complaints, operating machinery failure, out-of-service times for maintenance.

5-08. Warnings. Description of responsibility for issuing various types of warnings. Procedures, phone numbers, locations, etc., should be shown in a tabulation. Include instructions for providing warnings of discharge changes.

VI - HYDROLOGIC FORECASTS

6-01. General. Streamflow, lake level, and water quality prediction of forecasting. Include role of Corps and role of other agencies.

6-02. Flood Conditions Forecasts.

a. Requirements. Time required to compute flow hydrograph, time increment of forecast ordinates, key hydrologic and control point stations, use of data in general interpretation of flood control diagrams, consideration of uncontrolled runoff toward target flow at control stations, and target storage levels in the lake.

b. Methods. Methods and procedures of hydrologic forecast-ing , upstream/downstream flow, unit hydrograph, Antecedent Precipitation Index, stage-discharge relations, nomographs, rainfall-runoff relations, computer applications, relationship with NWS regarding forecasting, and sample of computer application program and how to access.

6-03. Conservation Purpose Forecasts.

a. Requirements. Hourly/daily/weekly hydropower, mosquito control, fish spawning, special recreation events, water supply/quality needs, water temperature, dissolved oxygen, other needs.

b. Methods. Methods and procedures for nonflood streamflow synthesis, water release temperature or dissolved oxygen, use of hydrologic data, computer applications, repetitive period for predicting, and sample of computer application program and how to access.

6-04. Long-Range Forecasts.

a. Requirements. Long-range streamflow synthesis, joint use or seasonal flood control/conservation storage utilization and reservation, snowpack, runoff, irrigation release scheduling, pool level predictions for recreation ecological conditions, monthly/seasonal hydropower scheduling lake turnover, nesting grounds, fishing, water supply/quality needs, drought conditions regarding water rights, navigation interest, low flow, and other.

b. Methods. Procedures for both flood control and conservation, seasonal outlook/forecast, snowpack surveys, repetitive period for predicting, use of hydrologic data, reliability of predictions, consideration of uncontrolled runoff in target flow at control point, computer applications.

6-05. Drought Forecast. Same type of information required in paragraph 6-04, plus reference documents (descriptions, completion dates and physical locations).

VII - WATER CONTROL PLAN

7-01. General Objectives. Overall and in general terms how the water control plan meets purposes as stated in paragraph 2-02.

7-02. Constraints. Physical, legal, political, social, and major conflicts between purposes associated with this project. Reference master manual for the system.

7-03. Overall Plan For Water Control. In general terms, consideration and treatment of coordinated system regulation among purposes and with other projects; compatibility among purposes, examples of comprehensive regulation for flood control/conservation; storage yield limitations.

7-04. Standing Instructions to Damtender. Reference appropriate exhibit during normal conditions. During communication outage, unforeseen emergency events requiring deviations from prevailing regulation schedules, spillway/outlet works restrictions.

7-05. Flood Control. Include normal and emergency regulations. Detailed explanation of release scheduling procedures during flood emergency, computer applications role of Corps, relative emphasis upon controlling peak outflow or pool level and backwater, use of seasonal or joint use storage, regulation with respect to storage zones including surcharge, use of streamflow predictions, forecasting total flow downstream, reference exhibits, etc. Also list constraints, e.g. upstream/downstream encroachments, storage age limitations, inadequate warning facilities, nondamaging channel capacity, low-water crossing, weak channel banks, allowable rate of release change, physical discharge capability, integrated regulations with other project/purpose.

7-06. Recreation. Include special releases for whitewater boat racing, canoe racing and other. Also include constraints such as droughts, floods, long-term/frequent inundation, rapid pool rise, pool fluctuation for other project purposes, adverse water quality, planned seasonal fluctuations, high-velocity downstream, prolonged flood release, etc.

7-07. Water Quality. Provide short-and-long term release scheduling and storage in general to provide for water quality. List constraints, e.g. commingled storage, lack of allocated storage, water rights, droughts, floods, and outlet facilities.

7-08. Fish and Wildlife. Accomplishment of fish and wildlife objectives by reregulation for other purposes, fluctuation on pool level for spawning or waterflow, temperature control, cold water fishery, multilevel releasing, etc. Constraints include lack of allocated storage, other project purposes, floods, droughts, undesirable quality, single-level intake, and water rights.

7-09. Water Supply. Provide releases to stream or withdrawal from reservoir for municipal, industrial, and/or irrigation usage; reference contract(s), low flow requirements, fish and wildlife, water rights; short term release scheduling; long-rang release planning, storage utilization (seasonal commingled, joint use). Show storage accounting method for more than one use of conservation storage. Reference and discuss example regulation exhibit. Constraints include storage space and yield, water rights, and other project purposes.

7-10. Hydroelectric Power. (Both Federal and non-Federal) Installed capacity; run-of-river with/without pondage, peaking, load factor, plant factor; relation to system load, minimum requirements for generation; contracts for primary and secondary energy, restrictions during flood periods. Provide the role of the Corps and FERC license in short-and-term generation scheduling, use of synthesized streamflow, snowpack surveys, pumpack operation, coordination with reregulation structure, utilization of storage/pondage in general and seasonally. Include rule curves and energy in storage curve for both Federal and non-Federal projects, and signed agreements with non-Federal hydropower developers at Corps projects. Constraints include overload limitation, storage, inflow, flood releases, tailwater, ice jams, head limitation on pool, release fluctuation, absence of reregulation structure, coordination with down stream reregulation, conflict with navigation, pumpback rate, water quality regulation and other projects.

7-11. Navigation. Release scheduling, accomplishment in general, lock filling and emptying procedure, aids to navigation, reference and discuss example regulation exhibit, integration with other projects. Constraints include release fluctuation for other purposes, critical high/low flow rates, sediment, dredging, lock size, lock filling/emptying time, other project purposes, lack of storage allocation for navigation releases and integrated regulation with other projects.

7-12. Drought Contingency Plans. Descriptions, completion dates, and where plans are physically located (can be attached as an addendum to the manual or be a stand-alone document) if properly referenced in manual.

7-13. Flood Emergency Action Plans. Same type of information as provided in paragraph 7-12.

7-14. Other. Health and welfare, mosquito control, debris control, low flow, ice jams, special or emergency drawdown, upstream/downstream groundwater table, releasing to aid construction upstream/downstream, toxic and hazardous spills, other as appropriate.

7-15. Deviation From Normal Regulation. Describe approval and notification procedures required when deviations from the normal water control plan are necessary. The District Commander is occasionally requested to deviate from normal regulation of the lake. Prior approval for a deviation is required from the Division Engineer except as noted in paragraph 7-15a. Deviation requests usually fall into the following categories:

a. Emergencies. Examples of some emergencies that can be expected to occur at a project are; drowning and other accidents, failure of the operation facilities, chemical spills, treatment plant failures and other temporary pollution problems. Water control actions necessary to abate the problem are taken immediately unless such action would create equal or worse conditions. Districts must inform their divisions office as soon as practicable, Prepare written confirmation of the deviation and description of the cause and furnish it to the division water control manager. Divisions may develop forms to facilitate the reporting of emergency deviations.

b. Unplanned Minor Deviations. There are unplanned instances that create a temporary need for minor deviations from the normal regulation plan, although they are not considered emergencies. Construction accounts for the major portion of these incidents and typical examples include utility stream crossings, bridge work, and major construction contracts. Deviations are sometimes necessary to carry out maintenance and inspection of facilities. Requests for changes in release rates generally involve time periods ranging from a few hours to a few days. Each request is analyzed on its own merits. In evaluating the proposed deviation, consideration must be given to upstream watershed conditions, potential flood threat, condition of the lake, and alternative measures that can be taken. In the interest of maintaining good public relations, requests generally are complied with, providing there are no foreseen adverse effects on the overall regulation of the project (or projects) for the authorized purposes. Approval for these minor deviations normally will be obtained from the division office by telephone. Written confirmation explaining the deviation and its cause will be furnished to the division water control manager.

c. Planned Deviations. Each condition should be analyzed on its merits. Sufficient data on flood potential, lake and watershed conditions, possible alternative measures, benefits to be expected, and probable effects on other authorized and useful purposes, together with the district recommendation, will be presented by letter or telefacsimile to the division for review and approval.

7-16. Rate of Release Changes. Show the normal allowable rate of increase and decrease in releases.

VIII - EFFECT OF WATER CONTROL PLAN

8-01. General. Discuss the overall effects and benefits from the project.

8-02. Flood Control.

a. Spillway Design Flood. General description, routing, total volume, stored volume, peak inflow, duration, maximum discharge, and maximum pool (show plate).

b. Standard Project Flood (SPF). General description, routing, Standard Project Storm (SPS), total volume, stored volume, duration, maximum discharge, peak inflow, maximum pool percent flood storage, or quantity surcharge storage utilized (show plate).

c. Other Floods. General description, routing, total volume, stored volume, comparison with flood or record or SPF, peak inflow/outflow, maximum pool, and surcharge storage utilized.

8-03. Recreation. Discuss effects and benefits.

8-04. Water Quality. Discuss effects and benefits.

8-05. Fish and Wildlife. Discuss effects and benefits.

8-06. Water Supply. Discuss effects and benefits.

8-07. Hydroelectric Power. Discuss effects and benefits.

8-08. Navigation. Discuss effects and benefits.

8-09. Drought Contingency Plans. Discuss effects and benefits.

8-10. Flood Emergency Action Plans. Discuss effects and benefits.

8-11. Frequencies.

a. Peak Inflow Probability. Graph showing inflow probability.

b. Pool Elevation Duration land Frequency. Above and below top of conservation pool, i.e. include graph (plate) with curves based on top of conservation pool as datum. Show one curve for frequency and one for duration. Plot of pool elevation for period of record. Table of annual peak discharges could be included.

c. Key Control Points. Stage/discharge curves, and frequency/duration curves (show bank-full, damage zones).

8-12. Other Studies.

a. Examples of Regulation. Up-to-date studies to develop and test regulation plan, yield analysis, criteria, data utilized, interpretations, integrated system regulation, new projects, seasonal storage investigation, hydrologic forecasting techniques, model development and other.

b. Channel and Floodway Improvement. Flood plain management studies and reports, encroachment, increase/decrease in channel capacity and seasonal channel capacity. Reference and discuss sample regulation exhibit, integration with other projects, and other.

IX - WATER CONTROL MANAGEMENT

9-01. Responsibilities and Organization.

a. Corps of Engineers. Owner/operator/regulator or combination thereof. Specify whether regulatory responsibilities is direct (day-to-day) or indirect (interagency agreement, advisory capacity, or by request). Differentiate between regulatory responsibility for various project purposes when applicable. Describe the role of the Corps when responsibility is indirect for both regulation and hydrologic forecasts (advisory/assistant/consultant). Provide an organizational chart, brief explanation of operation and maintenance responsibility. Reference instructions to damtender in back of this manual and any interagency coordination activities (see paragraph 9-02 and also Communications, chapter V), and instructions about reporting to higher authority.

b. Other Federal Agencies. Explanation or responsibilities similar to paragraph 9-01a. For example, Bureau of Reclamation project but Corps indirectly/directly prescribes real-time flood control and/or navigation regulation, or Corps project, but Bureau indirectly/directly prescribes regulation for irrigation.

c. State and County Agencies. Furnish information similar to paragraph 9-01a and b, furnish standards for water quality, serve in participation capacity through coordinated activities (see paragraph 9-02).

d. Private Organization. Furnish information similar to paragraph 9-01a, b, and c. (See ER 1110-2-8156 for additional information.)

9-02. Interagency Coordination. Explanation of coordination with press, community leaders, and other Federal, State, or local agencies concerning water control plan, flood fighting, special events, etc.

a. Local Press and Corps Bulletins. Explanation of coordination with local press for releases of public interest regarding conservation and flood aspects, gate closure, navigation season, reservoir levels, and other. Publication of news release bulletins regarding status of reservoirs concerning navigation, public use, agricultural harvesting, and flood emergency. Must avoid any conflict with NWS responsibilities for public notification as delegated by Congress.

b. Nation Weather Service (NWS). Coordination in data collection and providing forecasts of streamflow, precipitation, runoff, etc., real-time and long-range forecasts, and exchange of data.

c. U.S. Geological Survey. Coordination in data collection, gauge maintenance, sampling programs, streamflow measurement, etc.

d. Power Marketing Agency. Release schedules for hydroelectric power generation, monthly meetings or power allocation, etc.

e. Other Federal, State, or Local Agencies. Bureau of Reclamation, Environmental Protection Agency, State, private, other contacts, routine or random. Owners of non-Corps projects which directly affect Corps regulation.

9-03. Interagency Agreements. Formulation or modification of interagency agreements such as Section 7 Regulations, power contracts, field working agreements, memorandums of understanding, and other (reference exhibit).

9-04. Commissions, River Authorities, Compacts, and Committees. Title and concise function of institutional group (officially established) who share interest in river basin water control activities; hydroelectric power marketing; seasonal outlook regarding water supply (municipal, industrial, irrigation); storage utilization in general; Federal/State/local participating agencies; and other.

9-05. Non-Federal Hydropower. Non-Federal hydropower facility at Corps project. Furnish information and explanation of responsibilities similar to that comprised in paragraph 9-01.a. Reference all agreement documents (i.e., MOU's, MOA's, etc.) that define the Corps responsibilities to real-time flood control regulation at the Corps project.

9-06. Reports. Monthly charts, short-term hydrologic reports, emergency regulation reports, graphical and tabular summaries. Flood situation reports, quarterly, seasonal, or annual reports, including hydrologic forecasts (also postflood reports). Suggest tabulation to show report, when required; form number; and regulation requiring report.

TABLES

Disperse tables one page or less in size throughout the text. Include all tabulations over one page in this section to facilitate narrative continuity withing the text. Include tables showing elevation versus area and elevation versus capacity in increments of one foot or less. These tables should cover elevation ranges from bottom of the lake to maximum pool.

EXHIBITS

Label the following items as exhibits instead of appendices, reserving the latter term to tie individual manuals with master manuals. The number of exhibits will vary from project to project. "Standing Instructions to Damtenders" should be the last exhibit.

1. Supplementary Pertinent Data. May be extensive, but should be limited to aspects pertinent to water control. Several pertinent items are worthy of inclusion in this portion of the manual as it provides a compact ready reference source and facilitates quick orientation of important aspects relative to water control. Pertinent data should be used to document many aspects related to water control that do not warrant narration to expedite compilation and to avoid unnecessary wordiness of the text. A few items which constitute brief tables in themselves may be more suitable dispersed within the text to accompany

related discussions. However, abbreviated repetition of many items in the text is acceptable, since this exhibit will provide an overview of the project. Suggest all pages of the exhibit be of a different color than the remainder of the manual.

2. Formal Agreements. Examples are:

- Water Supply Agreements
- Power License Agreements
- Memorandums of Understanding
- Field Working Agreement
- Section 7 Flood Control Regulations
- Letters from other agencies or minutes of requesting commissions acknowledging or concurring in important or unusual aspects of the water control plan, and
- Non-Federal hydropower MOU/MOA's

To conserve space it may be desirable to show only the portion of agreement pertinent to water control, e.g., omit payment schedules.

3. Standing Instructions to Damtenders. Instructions may pertain to part or all of the following aspects: conservation regulation, normal flood regulation, emergency regulation; instructions during loss of communication for flood and non-flood conditions; public flood warning; data collection and reporting of data and regulation (print in color or with a special border).

PLATES

As appropriate, considering utility (need, clarity, conciseness) and avoiding repetition, preferably in the order of treatment in the manual.

MASTER WATER CONTROL MANUAL

OUTLINE

TITLE PAGE

PHOTOGRAPHS OF PROJECTS

NOTICE TO USERS OF THIS MANUAL

REGULATION ASSISTANCE PROCEDURES

TABLE OF CONTENTS

I - INTRODUCTION

II - BASIN DESCRIPTION AND CHARACTERISTICS

III - GENERAL HISTORY OF BASIN

IV - DESCRIPTION OF PROJECTS

V - DATA COLLECTION AND COMMUNICATION NETWORKS

VI - SYSTEM HYDROLOGIC FORECASTS

VII - SYSTEM WATER CONTROL PLAN

VIII - EFFECT OF SYSTEM WATER CONTROL PLAN

IX - SYSTEM WATER CONTROL MANAGEMENT

PERTINENT DATA FOR BASIN

TEXT OF MANUAL

Note: This outline is intended for preparation of Master Water Control Manuals. The format and content as presented in Appendix F, Part 3, should be used as a guideline. The chapter titles above should always be used; however, additional chapters may be added as required. Discretion may be employed in the selection of topics and subtopics within the chapter headings as they relate to the basin/watershed.

APPENDIX G

DEFINITIONS AND CONVERSION FACTORS

DECEMBER 1998

Table of Contents

DEFINITIONS

Acre-Foot. A unit for measuring the volume of water. It is equal to the quantity of water required to cover 1.0 acre to a depth of 1.0 foot and is equal to 43,560 cubic feet. It is used in measuring volumes of water used or stored.

Amortization. The economic process of repaying or liquidating a debt or recovering the wealth invested in a project over a determined period of time.

Appropriation Water Right. The legal right to the use of a carefully designated amount of water regardless of land ownership or place of use. Allocations among users are made by temporal priority (the party who first beneficially used the water). This system is used predominately in the western United States.

Authorized Project. A project specifically authorized by Congress for construction, generally, through language in an authorization or appropriation act, or a project authorized pursuant to Section 201, of the 1965 Flood Control Act.

Base Flow. One of three components that comprise streamflow and is that component that is return flow from groundwater.

Conjunctive Use. The combined use of surface and groundwater sources of water so as to achieve a greater aggregate yield than if the two had been operated separately.

Construction Cost. The total expenditures to physically build the project including the cost of lands, relocations, engineering, design, administration, and supervision. This cost is sometimes referred to as the "first cost."

Cost Allocation. A systematic distribution of costs among the project purposes of a multipurpose project.

Cost Sharing. The division of cost among various entities which gain benefit including Federal, state, local, or private interests.

Design Flood. The probabilistic estimate of a flood whose magnitude will be equaled or exceeded with a given frequency (for example, 0.1, meaning that on average it will be exceeded 10 times in a 100-year interval).

Drought. A relative term which is generally associated with a sustained period of significantly lower soil moisture levels and water supply relative to the normal levels around which the local environment and society have stabilized.

Drought Contingency Plans. General guides that allow for dynamic management of projects, or systems of projects, to address drought needs.

Drought Management Plans. See definition for Drought Contingency Plans.

Drought Preparedness Study. Planning of management for drought, prepared cooperatively by Federal and non-Federal agencies.

Economic Life. The period determined by the estimated point in time at which the combined effect of physical depreciation, obsolescence, changing requirements for project services, and time and discount allowances will cause the cost of continuing the project to exceed the benefits to be expected from continuation. It may be equal to or greater than the amortization period and may be equal to, but is generally less than, the physical life.

Evaporation. The changing of the liquid molecule of water to vapor.

Financial Feasibility. Criterion of project acceptability, based upon the financial value of the returns to the sponsoring entity exceeding the financial value of the costs to the sponsoring entity.

Future Use Storage. This is storage space in a project that is not under a repayment agreement and/or is under a repayment agreement, but the payments have not yet started.

Groundwater. The water that occurs beneath the earth's surface.

Guide Curves. A drawing that represents a compilation of regulating criteria, guidelines, curves, and specifications that govern basically the storage and release functions of a water resource project (also called Water Control Diagrams).

Hydrograph. A graphic plot of streamflow over time.

Immediate Use Storage. This is storage space in a project that is under a repayment agreement and payments have been initiated.

Investment Cost. The construction cost plus interest during construction. In water supply agreements, this is the construction cost allocated to that portion of the water supply storage space plus interest during construction for those projects paid out over time, but does not include (if there is any) interest on the unpaid balance.

Joint Costs. Total project costs less the summation of separable costs.

Joint-use Costs. Total project costs less all specific costs.

Prior Appropriation Water Right. The legal right to use water is based on the doctrine of "first in time is first in right," regardless of location or ownership of adjacent land.

Regulation Schedule. A schedule for the operation of a reservoir or system of reservoirs to meet the management goal or objective of the water control plan.

Riparian Water Right. The legal right to use water on land that is adjacent (riparian) to a stream. The amount of water accompanying this right is the maximum that can be used by a riparian landowner without unreasonably impairing other riparian owners. This system is used predominately in the eastern United States.

Safe Yield. The maximum quantity of water which can be reliably available throughout the most severe drought of record, or some other specified criterion. The critical period is often taken as the lowest natural flow on record for the stream.

Seasonal Storage. The maximum allowable water that may be stored in the flood control pool, for other multipurpose use, on a seasonal basis.

Separable Costs. Costs incurred to add a purpose to a project. These costs are normally calculated as a step in project (plan) formulation in considering the economic feasibility of including a purpose in a joint project. The separable cost is the minimum amount which should be considered for allocation to a given purpose. The separable cost for any specified purpose is determined by subtracting from the cost of the multipurpose project the cost of the most economical alternative project to obtain the same benefits as for the other purposes with the specified purpose omitted.

Specific Costs. The costs of identifiable project features normally serving only one purpose, such as a powerhouse or switch yard. These costs are the total cost of identifiable project features for that purpose.

Specific Facilities. Identifiable project features normally serving only one purpose.

Standard Project Flood. The Standard Project Flood (SPF) is the discharge hydrograph resulting from the Standard Project Storm (SPS). The SPS is a hypothetical storm having the most severe flood-producing rainfall depth-area-duration relationship and areal distribution pattern that is considered reasonably characteristic of the region in which the drainage area is located.

Storage Space. The volume in a reservoir project between two different elevations. The normally unit of storage space is acre-feet. There may or may not be any water available within this space.

Water Control Diagrams. These contain the regulation criteria in the form of guide curves and regulation schedules for individual reservoirs. They are used as guides to define various amounts of storage space as primary and secondary flood control storage.

Water Control Plan. The regulation of a project to meet the water management goals of the stream. In many cases, this will be a multi project plan requiring the integration of several individual plans in order to meet the overall river basin management objectives. In such cases, a master water control manual is prepared to define system regulation.

Water Rights. A form of real property, protected by state and Federal laws. Depending on the legal system used in the locale, water rights may originate in ownership of riparian lands or be acquired by statutorily-recognized methods of appropriation.

Yield. The quantity of water which can be taken, continuously, for any particular economic use. For municipal and industrial water supply purposes, this is normally taken as the flow which can be guaranteed during the 50-year drought on a 98% dependability.

CONVERSION FACTORS

Length (Example: 1 meter = 39.370 inches)

Item	centimeter	meter	kilometer	inch	foot	mile
centimeter	1	0.01	10{-5}	0.39370	0.032808	6.2137 x 10{-6}
meter	100	1	0.001	39.370	3.2808	6.2137 x 10{-4}
kilometer	10{5}	1000	1	39,370	3280.8	0.62137
inch	2.54	0.0254	2.54 x 10{-5}	1	0.083333	1.5783 x 10{-5}
foot	30.48	0.3048	3.048 x 10{-4}	12	1	1.8939 x 10{-4}
mile	1.6093 x 10{5}	1609.3	1.6093	63,360	5280	1

Area (Example: 1 acre = 43,560 square feet)

Item	sqm	ha	sqft	ac	sqmi
square meter	1	10{-4}	10.764	2.4711 x 10{-4}	3.8610 x 10{-7}
hectare	10{4}	1	107,639	2.4711	0.0038610
square foot	0.092903	9.2903 x 10{-6}	1	2.2957 x 10{-5}	3.5870 x 10{-8}
acre	4046.9	0.40469	43,560	1	0.0015625
square mile	2.590 x 10{7}	259.00	2.7878 x 10{7}	640	1

Volume (Example: 1 cubic meter = 35.315 cubic feet)

Item	liter	cubic meter	hectare-meter	cubic foot	U.S. gallon	acre-foot
liter	1	0.001	10-{7}	0.035315	0.26417	8.1071 x 10{-7}
cubic meter	1000	1	10{-4}	35.315	264.17	8.1071 x 10{-4}
hectare-meter	10{7}	10{4}	1	353,147	2.6417 x 10{6}	8.1071
cubic foot	28.317	0.028317	2.8317 x 10{-6}	1	7.4805	2.2957 x 10{-5}
U.S. gallon	3.7854	0.0037854	3.7854 x 10{-7}	0.13368	1	3.0689 x 10{-6}
acre-foot	1.2335 x 10{6}	1233.5	0.12335	43,560	325,851	1

Other conversions:
1 milliliter = 1 cubic meter
1 U.S. gallon x 1.2 = 1 imperial gallon
1 cubic foot / second-day = 1.9835 acre-feet = 86,400 cubic feet
1 acre foot = 43, 560 cubic feet = 1,234 cubic meters = 325,829 gallons

Flow (volume/time) or Discharge (Example: 1 gallon / minute = 1.6130 acre-foot / year)

Item	liter / second	cubic meter / second	cubic feet / second	gallon / minute	million gallons / day	acre-foot / year
liter / sec	1	0.001	0.035315	15.850	0.022824	25.567
cubic meter / sec	1000	1	35.315	15,850	22.824	25,567
cubic feet / sec	28.317	0.028317	1	448.83	0.64632	723.97
gal / min	0.063090	6.3090 x 10{-5}	0.0022280	1	0.00144	1.6130
MGD	43.813	0.043813	1.5472	694.44	1	1120.1
acre-ft / yr	0.039113	3.9113 x 10{-5}	0.0013813	0.61996	8274 x 10{-4}	1

Equivalent Flow Rates
1 million acre feet per year = 1,381.3 cubic feet/sec = 39.1 cubic meters/sec = 829.7 million gals/day
1 cubic foot per second = 724 acre-feet/year = 0.028 cubic meters/sec = 0.65 million gallons/day
1 cubic meter per second = 25,546 acre feet/year = 35.3 cubic feet/sec = 22.8 million gallons/day
1 million gallons per day = 1,121 acre feet/ year = 1.547 cubic feet/sec = 0.0438 cubic meters/sec

Kinematic Viscosity (Example: 1 square foot / second = 929 square centimeters / second)

Item	square meter / second	square centimeter / sec	square foot / sec	centistoke
sqm / sec	1	10{4}	10.7	10{6}
sqcenm / sec (stoke)	10{-4}	1	0.00107	100
sqft / sec	0.0929	929	1	9.34 x 10{4}
centistoke	10{-6}	0.01	1.07 x 10{-5}	1

Pressure **(force/area)** (Example: 1 ft. H_2O = 0.433 psi)

Item	kPa	psi	ft H_2O	m H_2O	atm
kPa	1	0.145	0.334	0.102	0.00989
psi	6.89	1	2.31	0.704	0.0680
ft H_2O	2.99	0.433	1	0.305	0.0294
m H_2O	9.81	1.42	3.28	1	0.0965
atm	101	14.7	33.9	10.4	1

kPa = kilopascal ft-lb
1 kPa = 1 kN/sqm
kN/sqm = kilonewton per square meter
psi = pounds of force per square inch
ft H_2O = feet of water column which would exert the same pressure
m H_2O = meters of water column which would exert the same pressure
atm = atmospheres

To convert from feet or meters to similar units of another fluid divide by the specific gravity of that fluid (*e.g.*, to convert ft water to ft mercury divide by 13.6, the specific gravity of mercury.)

Power **(energy/time)** (Example: 1 horsepower = 0.746 kilowatts)

Item	joule / sec	pounds of force / sec	kilowatt	hp	British thermal unit / second
Joule / sec (watt)	1	0.738	0.001	0.00134	9.48 X 10{-4}
ft-lbf / sec	1.36	1	0.00136	0.00182	0.00128
kilowatt	1000	738	1	1.34	0.948
horsepower (hp)	746	550	0.746	1	0.707
Btu / sec	1055	778	1.05	1.41	1

<u>References for conversion tables:</u>

Maidment, David R. (1993), “Handbook of Hydrology,” Professor of Civil Engineering, University of Texas at Austin,McGraw Hill, Inc. (For tables on Kinematic Viscosity, Pressure, and Power).

Walski, Thomas M. (1984), “Analysis of Water Distribution Systems,” U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi, Van Nostrand Reinhold Company. (For tables on Length, Area, Volume, and Flow).

APPENDIX H

KEY WORD INDEX

DECEMBER 1998

INDEX

REPORT DOCUMENT PAGE
for
Water Supply Handbook

1.

2. December 1996, Revised December 1998

3. Final

4. Water Supply Handbook

5.

6. Theodore M. Hillyer and Germaine A. Hofbauer

7. USACE, Water Resources Support Center
Institute for Water Resources
Casey Building, 7701 Telegraph Road
Alexandria, VA 22315-3868

8. Revised IWR Report 96-PS-4

9. Headquarters, U.S. Army Corps of Engineers
Directorate of Civil Works
20 Massachusetts Avenue, NW
Washington, D.C. 20314-1000

10.

11. Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161 (703) 487-4650

12a. Approved for public release; distribution unlimited

12b.

13. The field of water resources covers a wide range of topics and subject matter. This handbook focuses on one of those, the issue of water supply planning and resource management. Subject matter centers on the U.S. Army Corps of Engineers projects and authorities, but is equally valid for use by others interested in this topic. After an introductory chapter, the handbook describes the authorities, policies and and procedures pertaining to storage of water supplies in new and existing Corps reservoir projects and provides several water supply databases. Since reallocation is becoming more of an issue, a separate chapter is devoted to this topic. A chapter is also provided which, in essence, is a self-contained pamphlet which can be reproduced

and provided to local sponsors who may desire to enter into water supply agreements. The handbook then focuses on how water supplies are managed through modeling, water conservation, forecasting, and water control systems. Eight appendices accompany the basic nine chapters of the report, including an appendix on definitions and conversion factors and one as an index of key words.

14. Authorities, conservation, databases, drought, forecasting, management, modeling, partnership, policies, procedures, reallocation, reservoirs, water control systems.

15. 412

16.

17. Unclassified

18. Unclassified

19. Unclassified

20. Unlimited