COMMONWEALTH OF PENNSYLVANIA
Milton J. Shapp, *Governor*

DEPARTMENT OF ENVIRONMENTAL RESOURCES
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RESOURCES MANAGEMENT
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THE STATE WATER PLAN

PLANNING PRINCIPLES

GOALS, OBJECTIVES, STANDARDS, CRITERIA WORK PROGRAM and METHODOLOGY

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Prepared by

OFFICE OF RESOURCES MANAGEMENT
BUREAU of RESOURCES PROGRAMMING
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The administration and direct supervision of the State Water Plan effort was under John E. McSparran, Assistant Chief, Division of Comprehensive Resources Programming, and this report was prepared under the general supervision of V. M. Beard, Director, Bureau of Resources Programming, and William N. Frazier, Chief, Division of Comprehensive Resources Programming.

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Mr. Alan J. Sommerville reviewed and commented on the final draft of the report.

Mr. William S. Hetrick, Jr., designed the cover and with Mr. Albert W. Fechter assisted in the publication of the report.

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INTRODUCTION

Water use in the Commonwealth of Pennsylvania has increased and become more diversified, new water uses have appeared, and water problems associated with water supply, recreation, flood control, and the disposal of wastes have become more pressing with time and the growth of our population and industry. Further, the interrelationship of water uses, as well as water problems and their solutions, has become quite complex, and new technology and expertise has been developed.

In recent years, the general public's interest and concern with respect to water and related land resources has greatly intensified, and consequently, activity has increased at all levels of government. Old laws have been amended and new, more stringent Federal and State legislation has been passed, instituting greater controls over the use and development of water resources.

The State Water Plan, then, is urgently needed as a management tool to guide the conservation, development, and administration of the Commonwealth's water and related land resources on a comprehensive and coordinated basis.

Only thus, will the Commonwealth be able to maintain her current prosperity, provide adequate flood control for her citizens, and assure the supplies of good water necessary to meet her future needs.

The Department of Environmental Resources was charged with the responsibility of developing the Plan, under authority transferred from the former Department of Forests and Waters, and specifically outlined in Act No. 275, December 3, 1970.

Close coordination with other Commonwealth agencies, having duties and responsibilities with respect to the State's water and related land resources, has been achieved through a Water Resources Coordinating Committee, composed of management-level representatives from the Departments of Agriculture, Commerce, Community Affairs, Environmental Resources, Transportation, and the Public Utility Commission, the Fish and Game Commissions, and the Office of State Planning and Development.

A. *PLANNING REPORTS*

The results of the investigations and studies conducted in connection with the State Water Plan effort will be published in 23 reports, of which 19 will be subbasin reports.[1] Each subbasin report will include recommended solutions to water problems, as well as recommendations designed to meet short and long-term water needs.

Other documents to be published, in addition to this report on "Planning Principles", include reports entitled "State Summary", "Pennsylvania Water Laws and Institutional Arrangements", and "Water Resources Data System (WARDS)".

The "State Summary" will present the principal findings of the investigations and studies and afford a statewide overview of the State Water Plan. It will also summarize the results of the 19 individual subbasin studies.

The report on "Pennsylvania Water Laws and Institutional Arrangements" will investigate and analyze the legal and institutional constraints of the law and suggest needed changes or modifications.

The "Water Resources Data System (WARDS)", will document the basic data inventoried and used in developing the State Water Plan. It will, however, be available only upon request.

This report, "Planning Principles", documents the authority for planning, goals and objectives, pertinent standards and criteria, the work program,

[1]Being a small drainage area, subbasin 14 is combined with subbasin 16, for report purposes.

and methodology used in developing the State Water Plan. It is applicable to each of the 19 subbasin reports listed above.

B. *RELATED PLANNING*

The State Water Plan effort is closely coordinated with several Statewide planning activities in progress. Among these, the most important are: the Comprehensive Water Quality Management Plan (COWAMP), the Statewide Comprehensive Outdoor Recreation Plan (SCORP), the Environmental Master Plan, and the Pennsylvania Economic Program for Balanced Growth (PEP).

The Comprehensive Water Quality Management Plan will result in a separate series of reports which will provide the detailed water quality and wastewater elements of the State Water Plan.

The purpose of the Statewide Comprehensive Outdoor Recreation Plan is to help ensure that the present and future outdoor recreation needs of all Pennsylvanians and visitors, regardless of age, income, or residence groupings, are served in the most orderly and efficient manner possible.

The Environmental Master Plan will provide a planning and management framework to attain the overall environmental goals of the Commonwealth. This planning program, which focuses on man's relationship to his natural environment, is directed to the study, development, and implementation of an environmental policy which will recognize environmental values and restraints, as well as compatibilities and conflicts between present and projected resource supply and demand.

The Pennsylvania Economic Program for Balanced Growth will provide a planning and management framework to attain the overall economic goals of the Commonwealth. The PEP is designated to accelerate the rate of economic growth in Pennsylvania for the remainder of the 70's and beyond.

All of these planning efforts are directed toward achieving common goals and objectives of the Commonwealth.

C. *IMPLEMENTATION*

The State Water Plan deals with the Commonwealth's waters—a renewable and reusable resource. It is a living document, continually subject to change. As such, its goals, objectives, standards, and criteria will be adjusted, as required, to accommodate social, economic, political, and technological changes.

The overriding determinants in the wise management of the State's water and related land resources are the maintenance of the well-being of the Commonwealth's citizens and the improvement of their quality of life. With these objectives in mind, management needs for conservation, development, preservation, and regulation of the State's water resources are determined and programs are developed, through the planning process.

Upon completion of this process, plan and program implementation is carried out under the policy requirements and guidelines established by the General Assembly to assure that the best interests of all of the Commonwealth's citizens are protected.

The successful implementation of any such plan, of course, requires the close cooperation and coordinated effort of many Federal, State, and local governmental agencies, and depends, in large measure, on public interest, cooperation, and participation in the planning and implementation processes.

Consequently, an informed public whose viewpoints are expressed in the early planning stages is an important element of the State Water Plan. Moreover, the prospects for successful implementation of the State Water Plan are much greater when decisions are jointly made between State and local officials.

PLANNING PRINCIPLES USED IN THE DEVELOPMENT OF THE STATE WATER PLAN

The quality of life in Pennsylvania is determined by actions affecting the mutual interdependence of economic, social, and environmental goals and objectives. These actions must achieve a dynamic harmony among the various aspects of economic, social, and environmental quality. Some trade-offs must occur because there are only limited usable resources to meet all demands.

Therefore, it is necessary that the Commonwealth develop a framework within which relationships may be identified and decisions can be made enhancing the social and economic well-being of her citizens, while protecting environmental life support capabilities and preserving natural, scenic, historic, and esthetic environmental values.

The totality of the interrelationship describing man and environment requires that goals and related decisions concerning economic, social, and environmental quality be viewed comprehensively, with the aim of improving the overall well-being of the Commonwealth's citizens.

Drafted by Goals Task Force

Adopted by the State Water Plan Subcommittee

The following "Statement of Commonwealth Environmental Goals" has been adopted by the Environmental Quality Board, which stated that these goals "will be used in the formulation of policies, programs, and guidelines for the Environmental Master Plan and in planning and pursuing environmental programs and other programs which have an environmental impact." The development and updating of the State Water Plan will be compatible with the Environmental Plan program to insure uniformity and integration of all Commonwealth environmental goals and objectives.

The Environmental Goals of the Commonwealth

The OVERALL ENVIRONMENTAL GOAL of the Commonwealth shall be—

To protect the natural processes and ecological relationships of man's life-support system, and;

To manage our activities to preserve natural, scenic, and esthetic values of the environment while meeting society's needs.

Environmental Goals for Natural Resource Quality

Pennsylvanians will work toward their OVERALL ENVIRONMENTAL GOAL through the development of policies and programs seeking to achieve the goals set forth below.

Air Quality—to restore and maintain the quality of the air for the protection of man's health, welfare, and property, and for the protection of ecological systems enhancing their scenic and esthetic quality.

Water Resources—to achieve water of high quality in adequate supply to meet society's present and future needs, while enhancing scenic and esthetic quality, and giving consideration to the natural distribution of surface and subsurface water to protect ecological systems.

Land Resources—to ensure that surface and subsurface uses are planned to be compatible with the resource capability and protect the general health and welfare of the people, and to protect the ecological systems;

and to protect and improve the productive capacity of the soils, fields, and woodlands, and to reclaim those land resources degraded by man or natural disasters;

and to protect those ecologically fragile and wild lands and preserve for posterity places having archeological, cultural, ecologic, educational, recreational, historic, or scenic value.

Esthetic Quality—to achieve a visual, scenic, and acoustic environment consistent with the protection of environmental values.

Flora and Fauna—to provide for the protection of ecosystems for flora and fauna, ensuring species health, diversity, and propagation consistent with the management of fish and wildlife resources.

Waste Resources—to recognize all wastes as potential resources and to manage those resources for the protection, preservation, and enhancement of public health and environmental quality.

Environmentally-Related Goals for Social and Economic Well-Being

The Environmental Master Planning process acknowledges that Pennsylvanians have environmental goals related to social and economic well-being as set forth below, and furthermore, that environmental planning should be seen as part of the overall State comprehensive planning effort. A function of the Environmental Master Plan will be to provide a framework for coordinating social and economic interests with the OVERALL ENVIRONMENTAL GOAL.

Economic Development—To develop a responsive economic system encouraging planned economic activity and offering opportunities to all citizens consistent with the Environmental Goals of the Commonwealth.

Population—To consider the finite capacity of the natural environment in matters of population growth and distribution.

Education—To provide for the education of the Commonwealth's citizens to increase public awareness of the relationship between man's activities and the values and constraints of the natural environment, and to develop an attitude and way of life reflecting a regard for nature and the needs and limits of the natural processes.

Transportation—To develop a transportation system for the safe and efficient movement of people and goods consistent with the Environmental Goals of the Commonwealth.

Health—To achieve an environment without health hazards and pollutants.

Energy—To so manage energy resources that there will be an adequate supply to meet society's needs, while protecting environmental quality.

Community Development—To provide effective social services and facilities, decent housing, employment opportunities, security, and community identity which are available to all citizens of the Commonwealth and are consistent with environmental quality.

Outdoor Recreation—To maintain recreational resources and facilities adequate for the needs of society and compatible with the resource capability.

Food and Fiber—To consider environmental quality in the production of food and fiber free of contamination and disease.

PURPOSE, PLANNING GOALS, AND OBJECTIVES OF THE STATE WATER PLAN

A. PURPOSE

The purpose of this planning effort is to develop a *flexible State Water Plan* for the *wise management* of the Commonwealth's water and related land resources to meet the present and future needs of the people of Pennsylvania, and to improve the *quality of life*. Accordingly, the Plan provides guidelines designed to:

1. Regulate the quantity and quality of available water to assure adequate supplies of good water to meet present and future needs, in consonance with protection of the environment, as well as the public health, safety, and welfare.
2. Develop and conserve water and related land resources to meet residential, municipal, industrial, agricultural, electric power, navigation, and recreational requirements, and to provide flood damage reduction and water necessary to meet water quality management requirements.
3. Preserve the natural and scenic beauty of areas adjacent to certain wild and scenic water areas and streams for the use and enjoyment of present and future generations.
4. Control and reduce the amount of (acid) mine drainage entering the streams of the Commonwealth from abandoned surface and subsurface mines.
5. Establish priorities which permit needs to be met in order of urgency.
6. Utilize the water and related land resources of the Commonwealth toward achievement of the State's social, economic, and environmental goals.

B. SPECIFIC GOALS AND OBJECTIVES

1. *Water Supply*

   Goal: Water supplies of adequate quantity and quality to meet short-range and long-range needs.

   Objectives:

   a. Develop water resources to assure adequate supplies during water shortages and droughts, as well as other possible emergencies.

   b. Identify feasible alternatives (e.g., surface water versus ground water, individual development versus regionalization, single-purpose development versus multiple-purpose development, etc.), taking into account physical, social, economic, and environmental factors, to make possible selection of practicable solutions.

c. Encourage reuse of water, and the development and use of new technology.

d. Stress conservation measures that help insure the future availability of water resources.

e. Suggest changes in water laws and institutional arrangements deemed necessary to assure the adequacy of present and future supplies and the equitable distribution thereof.

2. *Flood Damage Reduction*

Goal: Mitigation of existing flood damage problems, and minimization of future flood damages.

Objectives:

a. Establish a list of urgent flood control needs for the purpose of guiding flood control investments.

b. Identify feasible alternatives (e.g., upstream versus downstream control and/or structures, single-purpose versus multi-purpose, permanent solutions versus emergency solutions, structural measures versus non-structural measures, etc.), taking into account physical, social, economic and environmental factors, to make possible the selection of practicable solutions.

c. Promote sound flood plain management and assist in integrating flood plain management with local land-use management.

d. Advocate and apply a basinwide system approach to flood damage reduction measures.

e. Stress the interrelationship between traditional State-Federal flood control measures and urban storm drainage.

3. *Outdoor Recreation*

Goal: Adequate water and related land resources to meet present and future water-oriented and water-enhanced recreational needs.

Objectives:

a. View recreation as primarily an environmental, economic, social, and educational concern.

b. Determine the geographic priorities in order to maximize benefits for the greatest number of citizens.

c. Provide adequate fishing and boating opportunities by construction of impoundments, development of access areas, and by obtaining easement on, or purchase of, impoundments from private owners.

d. Maintain a balance between development and preservation of natural resources to assure that all types of outdoor water-related recreational opportunities are available for present and future generations.

e. Coordinate the activities and the responsibilities of Federal, State, local, and private entities.

f. Coordinate water-related outdoor recreation planning with overall land-use planning, of which it is an integral part.

4. *Water Quality Management*

Goal: Prevent pollution of the waters of the Commonwealth, and reclaim and restore to a clean, unpolluted condition all presently polluted waters, so that probable and planned water uses will be protected at all times.

Objectives:

a. Establish water quality standards designed to protect all probable users of the Commonwealth's waters.

b. Provide for development of water quality management programs which include both individual and regional waste collection and treatment systems designed to protect and conserve the Commonwealth's waters.

c. Identify and develop institutional arrangements for implementation of regional or basinwide water quality plans.

d. Develop financing methods and programs for the provision of adequate present and future water management facilities and devices.

e. Provide a basis for allocation of grant funds and for enforcement of pollution control laws.

f. Control pollution from non-point sources, such as sediment and agricultural wastes, and prevent pollution incidents by requiring adequate product and waste handling safeguards.

g. Develop and institute programs for control and abatement of (acid) mine drainage from abandoned mines.

5. *Environmental Management*

A primary goal of the State Water Plan is to improve the quality of life of the Commonwealth's citizens.

Accordingly, in the process of attempting to identify and meet the Commonwealth's water resources needs and problems, efforts are also directed toward carrying out this task in a manner designed to improve and protect the State's natural environment.

Emphasis is made in the planning process to abate and prevent water pollution; to protect natural and scenic beauty of water areas and streams, and to protect and enhance ecological systems.

Participation by environmental interests are encouraged in the local involvement program of the State Water Plan, and alternative solutions to the problems and needs are screened with due consideration to our environment.

STANDARDS AND CRITERIA

The following Standards and Criteria were employed to assess the relevance and/or sufficiency of plans or projects in the pursuit of desirable goals and objectives. Some are currently in use, while others were formulated for planning purposes by interdisciplinary task forces of the Commonwealth. All standards and criteria have been set with due consideration to their social, economic, and environmental implications. These standards and criteria provided a starting point for planning, and it is possible that further study will indicate that some modifications will be required.

A. WATER SUPPLY

1. *Public Water Supply*

a. All new surface water sources, as well as existing water supply sources used for recreational purposes, must be provided with filtration and disinfection facilities.

b. The quality of water supplies shall meet the requirements contained in the 1962 edition of "Drinking Water Standards," published by the U. S. Public Health Service (Appendix A-1), or its replacement.

c. Planning criteria for determination of the adequacy of water supply sources and low flow criteria shall be those described in Appendixes A-2 and A-3.

d. Permits are required for allocation of surface water from all sources, and for interbasin transfers of water.

2. *Industrial Water Supply*

Quantity and quality shall depend on individual requirements of using industry.

3. *Agricultural Water Supply*

a. The following criteria shall be used to estimate the livestock water requirement in gallons per day for 1968.

Milk Cow	*Other Cattle*	*Horses & Ponies*	*Hogs*	*Sheep*	*Poultry*
35	12	12	4	2	0.1

b. For optimum yield, 1-inch of water per week is required for crops.

4. *Interstate Interbasin Transfers of Water*

Issues involving interstate use of water or interbasin transfers having interstate implications will be settled through appropriate River Basin Commissions or other interstate bodies.

5. *Intrastate Interbasin Transfers of Water*

The following guidelines apply to intrastate interbasin transfers:

a. Water within the basin shall be developed to the fullest economic, environmental, and hydrologic extent before transfers will be considered.

b. Future water needs of the basin of origin shall be protected.

c. No transfers will be allowed without proper compensation to the basin of origin.

B. FLOOD DAMAGE REDUCTION

1. Urban storm drainage is a local responsibility.

2. Flood protection projects shall be designed to provide protection for flood of record or a 100-year frequency flood, whichever is

greater, unless changes become necessary, due to economic or environmental considerations.

3. Where structural measures are preferred, generally the benefits accrued should be greater than the cost of project.

4. Flood plain management standards and criteria are pending.

5. The criteria outlined in the Department of Environmental Resources' publication, entitled "Dams and Encroachments," must be met.

C. OUTDOOR RECREATION

1. Water-related or enhanced recreational activities considered in this study include fishing, boating (including water skiing), swimming, picnicking, and camping.

2. Participation rates, by activity, and the activity standards are derived from the "Outdoor Recreation Horizons" and the "Statewide Comprehensive Outdoor Recreation Plan," and are shown in Appendix A-4. The former outlines the public outdoor recreation responsibilities of the Department of Environmental Resources. The Pennsylvania Fish Commission's responsibilities with respect to fishing and boating are included in Appendix A-5.

3. In general, the size of State Park lakes should be 100 acres or greater and the drainage area no less than 15 square miles.

4. Criteria of the Fish Commission, relative to the basic statewide access area plan, are shown in Appendix A-6.

5. Wild and scenic rivers shall be defined as the streams or stream reaches, and adjacent lands that are in a natural or esthetically pleasing condition and have either outstanding scenic, recreation, geologic, fish and wildlife, historic, cultural, or other similar values. All streams or stream reaches must be substantially free-flowing and have water of high quality, or water that can be restored to that condition. The criteria for wild and scenic river classification are shown in Appendix A-7.

D. WATER QUALITY MANAGEMENT

1. Water quality criteria for Pennsylvania Streams (Chapter 93 of Rules and Regulations of the Department of Environmental Resources) are shown in Appendix A-8.

2. Waste treatment levels necessary to meet water quality criteria should be provided.

3. A minimum of secondary treatment is required for domestic sewage, and other biodegradable wastes, and its equivalence is required for industrial wastes, including mine discharges. In addition, the *Best Practicable Treatment* requirement, as established by the U. S. Environmental Protection Agency under P. L. 92-500, must be met.

4. Water quality which might affect other states will be managed in consultation with appropriate River Basin Commissions and affected states.

WORK PROGRAM

The scope of study and the coordination program are outlined as follows:

Scope of Work

A. BREADTH AND DEPTH

This is a program-oriented, statewide, multiobjective, comprehensive planning study. "Multiobjective" planning considers economic, social, and environmental objectives. "Comprehensive" means that studies are made of water and related land resources problems and needs, including those related to water supply (municipal, industrial, electric power, and agricultural), flood control, outdoor recreation, navigation, water quality control, as well as wild and scenic rivers.

The level of detail of this study is between that of a Level A study and a Level B study, as defined by the U. S. Water Resources Council, and consequently, all aspects of water resources are studied in sufficient depth to identify objectives, needs, changing demands, alternative solutions to water problems and their environmental impacts, and to define a plan of action.

Wherever other investigations have been conducted, maximum use of that information is made, in order to facilitate the study.

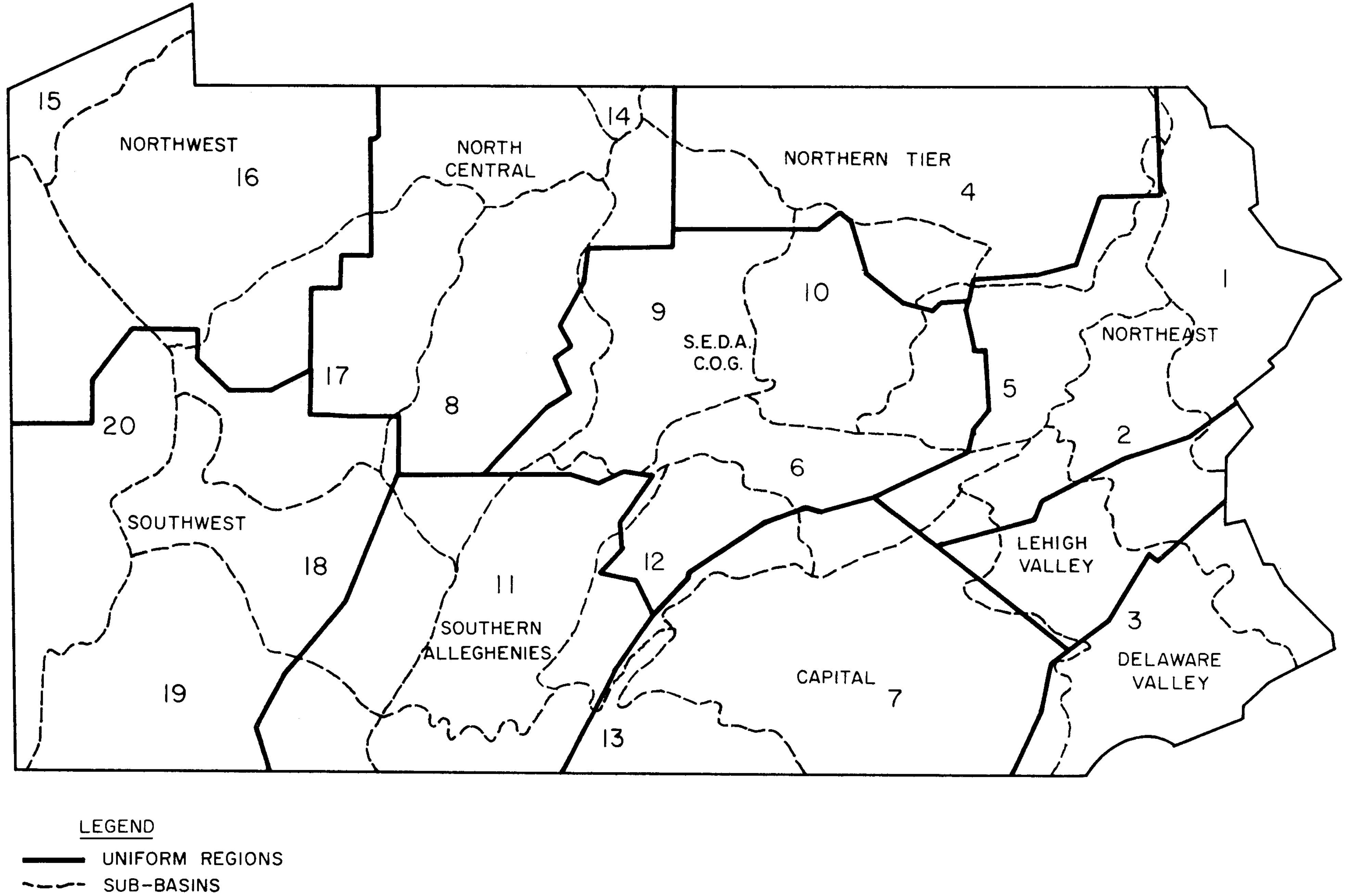


Figure 1 Sub-basins (20) and Uniform Regions (10)

Where several alternative solutions have been proposed for meeting identified water needs, sufficient investigation is made to preliminarily determine what appears to be the most desirable *solution concept* from the physical, economical, environmental, and social points of view.

Accordingly, the State Water Plan will serve as the basis and justification for further investigation of feasible alternatives prior to implementation.

The level of detail of the Comprehensive Water Quality Management Plan (COWAMP) will be between that of a Level B and a Level C study, as defined by the U. S. Water Resources Council. Where available data permits, solution concepts will be carried to a functional level so that specific projects, including institutional, financial, and management requirements may be identified. A more detailed description of COWAMP's scope is contained in the General Specifications for that study (1).[2]

B. HORIZONS

Needs, alternative solutions, and most desirable solution concepts will be developed for 1990, and the possible long-range (2020) problems and needs will be discussed. Planning periods coincide with the census years for better revaluation and updating.

C. PLANNING AREAS AND STUDY PRIORITIES

The planning units are the 20 subbasins designated in the original water resources investigations for the 1913 Water Resources Inventory Report, as shown in Figure 1. The Philadelphia and Pittsburgh areas were identified as having the primary need for study; therefore, studies for Subbasins 3 and 19 were begun in May, 1972 and May, 1973, respectively. The order of study was coordinated with the COWAMP studies, which were to begin in the most populated subbasins and then to proceed to the other subbasins within specific river basins.

The original schedule established the order of study by river basin in the following sequence:

(1) Delaware
(2) Ohio
(3) Susquehanna
(4) St. Lawrence
(5) Potomac

In 1973, it was necessary to revise the above schedule because of a major change in the order of studies being accomplished under the COWAMP program. The schedule was changed from the sequential order shown above to a simultaneous study of all areas in the state in order to coincide with the COWAMP program.

D. STAFF REQUIREMENTS

The basic staff responsible for developing and coordinating the State Water Plan is the Division of Comprehensive Resources Programming, Bureau of Resources Programming of the Department of Environmental Resources. In addition to the work done by the Division, assistance is provided by the staffs of other State agencies, as listed under "Coordination" and from the U. S. Department of Agriculture. The USDA is providing two full-time professionals and one typist, in addition to part-time assistance from other professionals within their organization.

The U. S. Army Corps of Engineers has authority under certain ongoing basin studies, the Northeastern United States Water Supply Study, the Metropolitan Urban Study Program, and the Water Resources Development Act, to offer technical assistance to State or local water resources study efforts. The Department is utilizing this assistance, where applicable, in the formulation of the State Water Plan.

A portion of the State Water Plan work has been done through the use of consulting engineering services for such activities as inventory and mapping. COWAMP, on the other hand, is being conducted by consultants under the State's supervision and assistance.

E. PLANNING PROCEDURES

Planning is an iterative process. Normally, it proceeds as follows:

1. The desired goals and objectives are established.
2. Standards and criteria for assessing the relevance and/or sufficiency of particular projects or plans in accomplishing the desired goals and objectives are set.
3. Planning techniques (methodologies) are employed to carry out the planning program, and work programs designed.

Figure 2, *Resources Management Cycle,* describes planning implementation and operation as being an iterative process with feedback loops which permit improvements to be made in the second round in light of the knowledge gained from the first.

In establishing planning goals and objectives, past and current policies of the Legislative and Executive branches were examined.

[2]Number in parenthesis indicates the reference number.

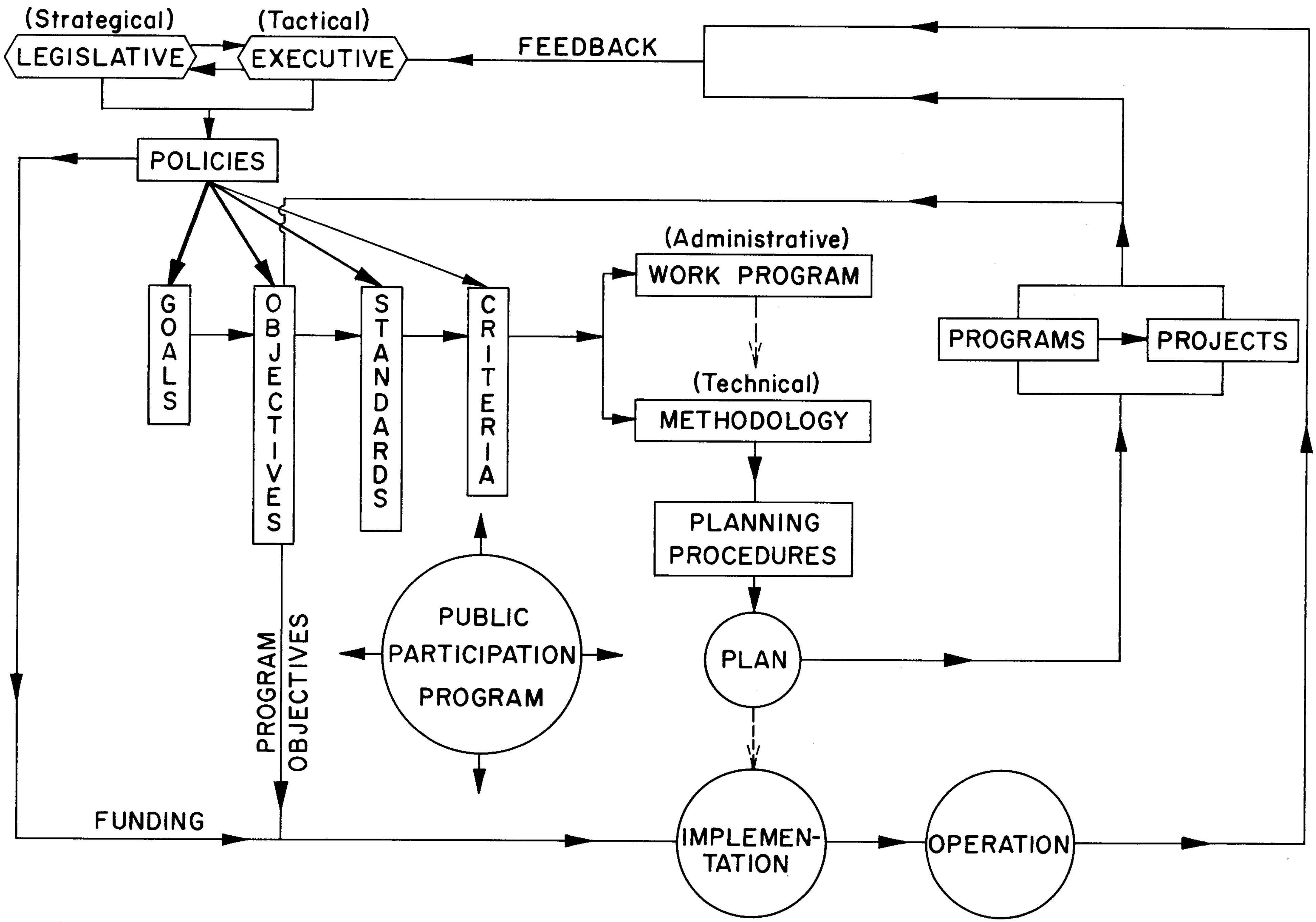


Figure 2 Resource Management Cycle

While goals provide specific directions or bearings by which the ideal condition is approached, *planning objectives* outline points to be emphasized toward meeting or attempting to meet the goal.

Standards and criteria are set to implement the goals and objectives.

In order to carry out the planning properly, a work program (a plan of study) and planning methodology must be developed. With these administrative and technical guides, a final plan evolves through the planning procedures. (See Figure 3 for details.)

Once adopted and funded, programs and/or projects contained in the plan become the State's *program objectives* which detail specific steps to be taken, now and in the future, in order to achieve the intended goals.

After implementation, operation of programs and projects will reveal the success and/or weaknesses of the plan. Experience gained from such operation will be helpful for subsequent planning.

Work elements and planning procedures are schematically shown on Figure 3.

Because of a tight timetable, manpower and budget limitations, and changes required to coordinate work in progress on the State Water Plan with that underway on the Comprehensive Water Quality Management Plan (COWAMP), it became necessary to schedule completion of the State Water Plan in two stages.

The purpose of Stage I is to *determine the problems associated with, as well as the needs and urgency* of all aspects of water supply, flood control, outdoor recreation, water quality control, and navigation by comparing the supply with the demand.

The purpose of Stage II is *to investigate resource opportunities, to study various alternatives* for satisfying needs or solving problems, and *to recommend the most desirable solution concept,* considering economic, social, and environmental aspects.

It is expected that Stage I will be completed statewide during 1975. A public participation program, further detailed under "Local Agencies," on page 13 of the following section, was included in the planning process, and local planning agencies are directly involved.

Following completion of Stage I, a local involvement or public participation program, coordinated with that of COWAMP and similar to those which were conducted in Subbasins 3 and 19 in 1972 and 1973, respectively, will be undertaken statewide, and Stage II will be completed.

The subbasin reports will be drafted as the planning progresses and will be finalized following completion of the above coordination effort.

F. REPORTS

Reports are being compiled for each subbasin. Each report is expected to include material on objectives, physical characteristics of the basin, demographic aspects, description of needs and problems for each aspect of water resources, discussion of resources opportunity and alternatives, and recommended solution concepts based on multi-objectives.

After all subbasin reports are completed, the results will be summarized and integrated to formulate an analysis of needs and recommended priorities of action, as seen from an overall statewide point of view.

In addition, as previously noted, the State Water Plan will include separate reports on "Pennsylvania Water Laws and Institutional Arrangements" and on the "Water Resources Data System (WARDS)."

Tentative outlines for a typical Subbasin Summary Report, and the WARDS report, are shown in Appendix B.

The Comprehensive Water Quality Management Plan will result in nine additional regional reports, and a statewide summary.

Coordination

A. FEDERAL AGENCIES AND RIVER BASIN COMMISSIONS

The following agencies are contacted for pertinent information, kept informed of progress, and requested to supply technical assistance, where feasible.

1. U. S. Army Corps of Engineers
2. U. S. Department of Agriculture
   a. Soil Conservation Service
   b. Economic Research Service
   c. Forest Service
3. U. S. Department of Commerce
   a. National Weather Service
4. Environmental Protection Agency
5. Title II River Basin Commissions
6. Federal Interstate Compact Commissions
   a. Delaware River Basin Commission
   b. Susquehanna River Basin Commission

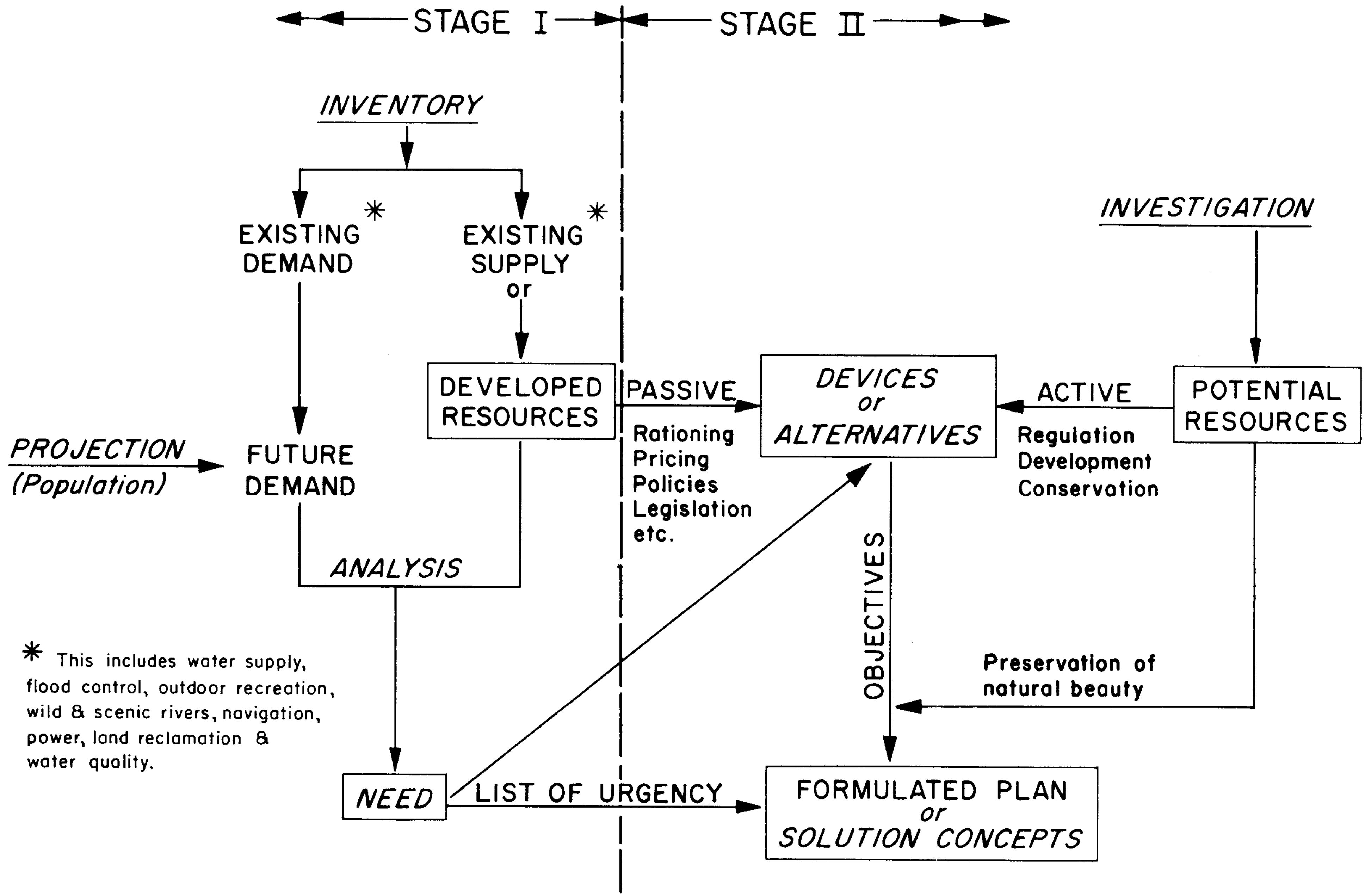


Figure 3 Planning Procedures

B. STATE AGENCIES

Lines of communications have already been established through the Water Resources Coordinating Committee and its State Water Plan Subcommittee. The Division of Comprehensive Resources Programming of the Bureau of Resources Programming is coordinating the work, but nearly all of the agencies represented on the Water Resources Coordinating Committee, as well as a number of other agencies, not so represented, are assisting with the work.

As mentioned previously, the State Water Plan is coordinated with and dovetailed into the Pennsylvania Economic Program and the State Environmental Master Plan.

When developed, the Comprehensive Water Quality Management Plan (COWAMP), required by the Federal Water Pollution Control Act Amendments of 1972 (P. L. 92-500) and the State Clean Streams Law, will serve as the water quality and wastewater management elements of the State Water Plan.

Responsibilities by other State agencies cooperating in this effort are as follows:

1. *Department of Agriculture*

   a. Determine and review present and future agricultural water demands.

2. *Department of Commerce*

   a. Assist in determining industrial water demands.

   b. Determine best locales for industrial placement for regional development.

3. *Department of Community Affairs*

   a. Assist in local coordination.

   b. Assist in identifying local water-related problems.

   c. Assist communities in establishing flood plain development controls.

   d. Assist in determining local, water-oriented recreation requirements.

4. *Department of Environmental Resources*
   Bureau of Resources Programming:
   Division of Comprehensive Resources Programming

   a. Coordinate overall effort.

   b. Participate in meetings with local, State, or Federal agencies.

   c. Determine water demands for municipal and industrial purposes.

   d. Determine water-related and water-enhanced recreational demands.

   e. Identify flood problems.

   f. Assist in projecting future agricultural demands.

   g. Determine water availability of existing sources of water supply and low-flow requirements.

   h. Assist in determining water needs for electric power generation.

   i. Propose feasible alternative solutions which fulfill the needs in a comprehensive multiobjective sense.

   j. Assist in determining the legal and institutional requirements of the Plan.

   k. Prepare the WARDS report, subbasin reports, and the State Summary Report.

   Division of Mine Area Restoration

   a. Identify mine drainage problems from abandoned mines, and recommend solutions and priorities for expenditure of State funds.

   b. Provide land reclamation plans for mine-scarred lands.

   c. Provide input of water quality data from abandoned mines.

   Division of Outdoor Recreation

   a. Determine statewide recreation needs.

   b. Identify potential wild, scenic, and recreational streams, and segments of streams, desirable for preservation.

   c. Evaluate and correlate State recreation needs with Federal and State project proposals.

   d. Determine those lands which should be acquired or managed to protect and enhance the State Forest and Park systems, and their natural resources.

   e. Assist in the determination of recreational need and use of State forest land.

   Division of Water Resources Projects

   a. Make field investigations of flood damage centers, examine alternative solutions for flood problems, and recommend appropriate action.

   Bureau of Forestry

   a. In cooperation with the U. S. Forest Service, describe current timber management, and recommend management methods by which water supply and erosion control needs can best be met.

b. Assist in the recreational and land management aspects of the Plan.

Bureau of Soil and Water Conservation

a. Determine the needed land conservation treatment and/or preservation.

Bureau of Water Quality Management

a. Develop water quality standards for surface and ground waters.

b. Develop the detailed water quality management element of the State Water Plan, through the Comprehensive Water Quality Management Plan (COWAMP) study program.

c. Assist in determining low-flow requirements.

d. Identify local surface and ground water problems.

e. Provide a general description of surface and ground water problems in each subbasin; also, determine possible solutions.

f. Evaluate ecological consequences of potential water resource projects, in cooperation with the Fish Commission.

Office of Enforcement and General Counsel

a. Survey water users, developers, and managers to identify legal and institutional problems related to the conservation, development, regulation, preservation, and use of the Commonwealth's water and related land resources.

b. Research laws and recommend the necessary legal and institutional changes required for the effective management of the Commonwealth's water and related land resources.

c. Prepare the "Pennsylvania Water Laws and Institutional Arrangements" report for the State Water Plan.

Bureau of Environmental Master Planning

a. Coordinate the State Water Plan with the State Environmental Master Plan.

Bureau of Topographic and Geologic Survey

a. Geologic inventory of all subbasins.

b. Evaluate ground water availability by geologic units using the Bureau's well records, published well records, and data from the Bureau of Water Quality Management.

c. Assist in cost estimates of ground water development.

5. *Department of Transportation*

   a. Assist with navigation aspects of Plan.

   b. Coordinate the State Water Plan with transportation plans.

6. *Historical and Museum Commission*

   a. Determine the historic and/or other sites that should be preserved.

7. *Office of State Planning and Development*

   a. Coordinate the State Water Plan with the Pennsylvania Economic Program and the State Comprehensive Outdoor Recreation Plan (SCORP.)

   b. Develop economic and demographic data for Plan.

   c. Assist in local coordination.

8. *Pennsylvania Fish Commission*

   a. Evaluate fishing potential at recreational sites.

   b. Assist in determining wild, scenic, and recreational streams, and stream reaches.

   c. Evaluate ecological consequences of possible construction at potential sites.

   d. Assist in navigational aspects of Plan.

   e. Determine streams which should be preserved for fishing.

   f. Determine water quality requirements for fish.

   g. Determine fish food organisms' requirements.

9. *Pennsylvania Game Commission*

   a. Evaluate ecological impacts on game environment of alternatives proposed in Plan.

   b. Assist with recreational and land management aspects of Plan.

   c. Evaluate wetlands as game habitat areas and recommend enhancement measures.

10. *Public Utility Commission*

    a. Assist with municipal water supply portion of Plan.

    b. Assist with electric power portion of Plan.

C. LOCAL AGENCIES

In order to have a workable Plan, local meetings and input are necessary. The purpose of such involvement is (a) to inform the local people of the State's water resources planning effort and (b) to bring local data, information, and opinion to the planning process, and (c) to gain the assistance of local plans and planning processes already developed to assure mutual understanding of water resources problems, needs, and solutions.

The State Water Plan effort has adopted the 10 uniform regions shown in Figure 1 as the basic organizational structure through which local involvement will be achieved.

In each of the 10 regions, a central regional agency is being sought to be designated as the lead or contact agency for assisting the State in gaining local input. In those regions where no single region-wide agency has been established, existing metropolitan (and if necessary, county) planning commissions will be requested to jointly peform this function. In all cases, metropolitan counties will be singled out for special consideration and contact by the regional agencies.

A suggested list of regional, metropolitan, and county agencies from which participation is being sought is as follows:

1. *Delaware Valley* (Uniform Region 1)

    a. Delaware Valley Regional Planning Commission.

2. *Lehigh Valley* (Uniform Region 2)

    a. Joint Planning Commission, Lehigh-Northampton Counties.

    b. Berks County Planning Commission.

3. *Northeast* (Uniform Region 3)

    a. Economic Development Council of Northeastern Pennsylvania.

    b. Lackawanna County Planning Commission.

    c. Luzerne County Planning Commission.

4. *Northern Tier* (Uniform Region 4)

    a. Northern Tier Regional Planning and Development Commission.

5. *SEDA-COG* (Uniform Region 5)

    a. Susquehanna Economic Development Association.

6. *Capital* (Uniform Region 6)

    a. Capital Regional Planning and Development Agency

    b. Lancaster County Planning Commission.

    c. Tri-County Regional Planning Commission.

    d. York County Planning Commission.

    e. Lebanon County Planning Commission.

    f. Adams County Planning Commission.

    g. Franklin County Planning Commission.

7. *Southern Alleghenies* (Uniform Region 7)

    a. Southern Alleghenies Planning and Development Commission.

    b. Blair County Planning Commission.

    c. Cambria County Planning Commission.

8. *North Central* (Uniform Region 8)

    a. North Central Pennsylvania Economic Development District.

9. *Northwest* (Uniform Region 9)

    a. Northwestern Pennsylvania Regional Planning and Development Commission.

    b. Erie County Metropolitan Planning Commission.

10. *Southwest* (Uniform Region 10)

    a. Southwestern Pennsylvania Regional Planning Commission.

    b. Southwestern Pennsylvania Economic Development District.

The following describes how the local involvement program operates.

1. The regional agencies are first "briefed" and their aid solicited. This briefing involves different agencies at different times, as the various subbasins are brought under study. Matters of both water planning and water quality management planning are discussed, and after the method of coordination is established, the contact agency(s) is given a detailed briefing by State personnel to assure a reasonable understanding of the objectives and workings of the State water and waste management planning efforts.

A comprehensive inventory document, the "Water Resources Data System" (WARDS) report, describes all the basic data inventoried and used in the State water planning process. The report lists every aspect of information relating to water resources from demographic and hydrological information to supply and demand data, including both computerized and non-computerized data.

A preliminary inventory report was prepared by the Bureau of Resources Programming in December, 1971, under the title "Water Management Information System (WAMIS)." The content of this report was limited to those items which were computerized and available to the Bureau at that time.

For "Comprehensive Water Quality Management Plan" (COWAMP) planning and program operation, a separate "WAMIS" is being developed by the Bureau of Water Quality Management.

In the future, "WARDS" will supersede the "WAMIS" report of the Bureau of Resources Programming and will be expanded to include the "WAMIS" of the Bureau of Water Quality Management.

The "WARDS" report is compatible with the Federal water data system only with respect to groundwater (wells) and water quality data. Groundwater information, available through the Bureau of Topographic and Geologic Survey, is compatible with the system of the U. S. Geologic Survey. Plans call for the water quality information compiled in "WAMIS" by the Bureau of Water Quality Management to be programmed into the Storage-Retrieval (STORET) system of the Federal Environmental Protection Agency.

In an effort to improve accessibility to water data throughout the nation, a National Water Data Exchange (NAWDEX) has been proposed for participating states.

B. POPULATION

In water resources planning, population data is one of the basic inputs for estimating water supply, recreation, electric power, and water quality control demands.

In order to coordinate water resources planning with planning in other State agencies, the same population projections must be used. The Office of State Planning and Development, through the "Pennsylvania Economic Program" and the "State Environmental Master Plan," has implicitly set the policy of population distribution throughout the State.

With the help of the National Planning Association, OSPD has completed population projections for each county in the State. These population projections are conceptually tied to economic and population trends.

The "Pennsylvania Economic Program" establishes targets for develoment which represent goals and objectives for achieving a desired balanced growth in the Commonwealth.

Population allocation models, developed by the Bureau of Resources Programming, are employed to distribute the projected county populations mentioned above, into watersheds.

Five different result sets may be printed as output or, if desired, any combination of result sets may be given.

Result sets one, three, and four are created by a model which distributes future population according to the percentage distribution of present populations. This model considers three different weighting factors, based on the presence of interstate highways near the individual political subdivisions where the populations are being distributed.

Result set two is the output of a second model, which distributes populations on the basis of densities and changes in densities in the political subdivision.

Result set five is obtained from a third model, which bases its distributions on past trends. This model uses, as additional input to the present census, the population figures from two previous projection intervals. Future populations are then distributed using a constrained parabolic relationship to account for past trends.

It is important to understand that each of these models has characteristics which render it more applicable in certain areas than others and more accurate for given projection intervals than others. Accordingly, a thorough understanding of the mathematics involved is necessary to effectively use the output.

The population allocation at minor civil division (MCD) level serves as a basis for local input. The MCD projection is adjusted by local agencies who participate in the local involvement meetings and are more familiar with their own situation. The MCD adjustments are made within the constraint that the total county population, projected by the Office of State Planning and Development, remains unaffected.

C. ANALYSIS

Analyses of supply and demand lead to assessment of *needs* and *urgency*. The standards and criteria, previously listed, are used to assess management needs and are applied in the analysis. The methods of analysis for water supply, flood damage reduction, outdoor recreation, and water quality management follow.

WATER SUPPLY ANALYSIS

Different techniques are applied to different water uses to determine the future needs. The unit-area of the study also varies. For example, the demand for public water supply is estimated for service areas of each public water supplier; for self-supplied industrial use by industrial plant; for power cooling by the individual plant; and for agricultural use by watershed. The demand-supply analysis methodology is discussed herein.

1. *Public Water Supply*

   Public water supply includes residential, commercial, and public-supplied industrial and agricultural uses. The 1970 and 1974 municipal water use inventories are the basic data used to determine the present supply-demand relationship. The estimate of needs or requirements proceeds as follows:

   a. The present peak demand, by water works, is determined from the inventory data. The peak demand is further adjusted according to the available treated water storage.

   b. The sources of supply, surface, or groundwater are listed from the inventory.

   c. The gross dependable yield for streams (with or without storage) and wells is estimated using the planning criteria for determination of the adequacy of water supply sources (Appendix A-2). Water Resources Bulletins No. 1 and No. 7, well inventory data, and various groundwater geology publications are also used for this purpose. The net dependable yield of surface water sources is obtained after the minimum downstream release requirement (Appendix A-3) is subtracted from the gross dependable yield.

   d. The adequacy of the present supply situation may then be determined by comparing (a) with (c).

   e. Future demand is determined by (1), projecting the future served population and (2), projecting the future per capita usage. The product of (1) and (2) is the future demand.

   The projection of future demands for each waterworks is then programmed for computer analysis (see Appendix C-1).

   Basically, the computer relies on two sources of information: water company and population data. From the water company data, the service area and the present average water use are obtained. The service area is expressed as the names of the municipalities served, and the percent of total municipal population served in each municipality. This permits the computer, by examining each waterworks file, to determine both served and unserved population in each municipality. For simplicity, it is assumed that the present unserved population will remain constant into the future. In many cases, this is a valid assumption, but, more importantly, it facilitates manual adjustments, where required.

   The computer divides the present average water use by the present population served to obtain the present gallons per capita per day (gpcd). This figure is then used in the following equation to project future gpcd's.

$$gpcd_{i,k} = gpcd_{i,k-1} + (a - gpcd_{i,k-1}) \times \frac{b}{c} \times gpcd_{i,1970} \quad \ldots (1)$$

   where a = regional maximum gpcd selected

   b = maximum allowed yearly percent increase of gpcd

   c = difference between regional maximum gpcd and regional minimum gpcd

   i = name of waterworks

   k = decade (i.e., 1980, 1990, etc.)

   In developing this equation, consideration was given to several other methods (See Appendix C-1), and the advantages of each have been incorporated. The figure obtained is then multiplied by the projected served population to determine demands for each municipality, and then summed to obtain the total future water use for the waterworks.

2. *Self-Supplied Domestic Uses*

   The self-supplied domestic users are the unserved population mentioned under public water supply.

   Self-supplied domestic water use can be calculated after the population served by each waterworks is determined. The per capita daily use is assumed to be 50 gallons at present and projected use is determined by application of Equation (1).

3. *Self-Supplied Industrial Uses*

   Methods for predicting future industrial water use are very limited. The most applicable methodology, to date, is that of Steward and Metzger (2), which takes into account future employment, as well as change of technology. This methodology was employed in the Northeastern United States Water Supply Study (NEWS). The equation is of the form:

$$F = \frac{(E) \times (O)}{(R) \times (T)} \ldots (2)$$

where F = the ratio of future to present industrial water needs.

(E) = the ratio of future to present employment in manufacturing industries.

(O) = the ratio of future to present output per employee.

(R) = the ratio of future to present recirculation.

(T) = the ratio of present to future gross water requirements per unit of production (including recirculation).

To determine the parameter values for E, O, R, and T, questionnaires were distributed to major water-using industries statewide (use greater than 100,000 gallons per day) and plant interviews were conducted. The results of these investigations provide the basic input to Equation (2), so that future water use of major industries can be determined.

Future withdrawals by small self-supplied industrial water users (those using less than 100,000 GPD of self-supplied water) are determined by first assuming that water use is proportional to the value added by the manufacturer. Linear projections were made on the value added by manufacturer for each two-digit Standard Industrial Classification (SIC) Group.

Figures for the value added by manufacturers were obtained from the Pennsylvania Department of Commerce M-4 Industrial Census Series. Values for the years 1959, 1964, 1965, 1967, 1968, 1969, 1970, 1971, and 1972 were used after adjustment to a common 1967 dollar value. This adjustment was made by using the wholesale price index, which was obtained from a statistical abstract of the United States.

These adjusted values added by manufacturers were then plotted against their corresponding years and a least squares analysis was performed to fit a line to the points. Least squares estimates of the values added by manufacturers were determined for the years 1970, 1980, 1990, 2000, 2010, and 2020.

Ratios of value added by manufacturer for the projection years to the base year 1970 were then calculated. These ratios, when multiplied by a particular industry's self-supplied water use in 1970, yield the projected water use for the corresponding year.

4. *Electric Power (Cooling, Self-Supplied)*

The water requirements for power cooling are the largest of all the water uses in Pennsylvania. For this reason, the cooling requirements and the sources of supply are investigated for each individual plant.

Although the cooling water requirement is derived from the amount of electric power produced, it is complicated by the fact that electric power can be generated from either hydro or thermal energy, and the thermal energy could be coal, fuel oil, gas, or atomic energy.

Also, cooling of condenser water may be by once-through cooling or by cooling towers having either mechanical or natural draft. Both the type of fuel or energy sources, and the type of cooling process affect the quantities of water required for cooling.

The current water withdrawals and consumptive use information are available from the data supplied by the Federal Power Commission and the Department of Environmental Resources 1969 inventory.

For the Delaware and Susquehanna River Basins, Master Siting Studies furnished by the industry to the respective River Basin Commissions, dated May, 1974, and March, 1974, are particularly useful. These reports give information on all existing plants, including plans for plant retirement, and information on new plants planned before 1988.

To complete the statewide assessment of power plants, the Department contracted with a consultant to gather and compile the same type information on all existing and planned power plants in the Ohio and Lake Erie Basins. This work was completed in June, 1974.

Both the Commissions' Master Siting Studies and the Department's information on the power plants in the Ohio and Lake Erie Basins will be updated more frequently than other water supply uses, because of the great impact of electric power cooling on water resources.

5. *Institutional Water Use (Self-Supplied)*

Institutions include schools, hospitals, prisons, fish hatcheries, and golf courses. Information for this type of water use for the Delaware River Basin is available from the Delaware River Basin Commission, while an inventory for the remaining portion of the State is virtually complete.

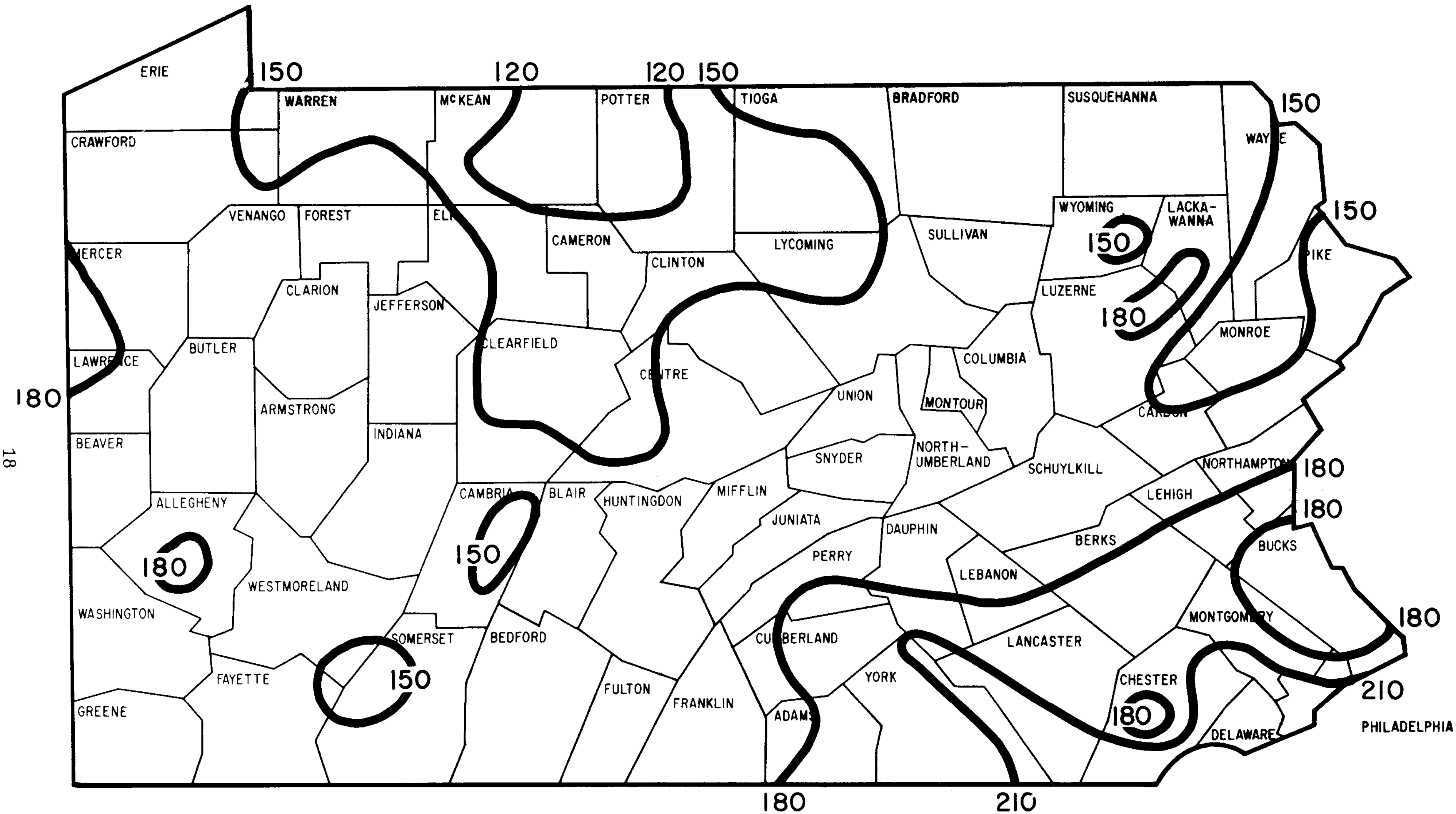


Figure 4 Days of Freeze Free Season (1968)

The future water use for schools, hospitals, and prisons is projected in a similar way to the self-supplied domestic use; and for golf courses, projections are made similar to those for irrigation water use, as described in the following section.

6. *Agricultural Water Use (Self-Supplied)*

Data concerning agriculture, such as acres of various types of cropland and number of livestock, are gathered annually by the Pennsylvania Crop Reporting Service. This office has also conducted special irrigation surveys, particularly during drought years, to augment the 5-year irrigation surveys conducted by the U. S. Department of Agriculture.

In 1969, the Department of Environmental Resources requested the Commonwealth's Department of Agriculture to disaggregate irrigation and livestock information, which was available on a county basis, to conform to the watersheds being used in the State Water Plan. It was also requested that they make projections of future water uses for irrigation and livestock.

To comply with this request, the Department of Agriculture formed committees of agricultural experts in each county which made projections of future irrigated crop acreages and livestock and then allocated those figures to the watersheds within the county. This information was processed through a Department of Agriculture computer program which determined the water requirements for each use in 1968 and 1980.

The following daily usage per head, in gallons, was suggested by W. J. Fluke, Director of the Pennsylvania Crop Reporting Service:

	1968	1980	2000
Milk Cow	35	40	50
Other Cattle	12	15	15
Horses and Ponies	12	12	15
Hogs	4	6	10
Sheep	2	3	5
Poultry	0.1	0.15	0.2

Using these per-head use figures, the Pennsylvania Department of Agriculture estimated the livestock water uses for 1980 by watersheds. The 1990 water uses were determined by extrapolating the number of livestock beyond 1980, and interpolating the per-head uses between 1980 and 2000.

Present (1968) and 1980 irrigation water uses were estimated by a method suggested by N. Henry Wooding, Extension Agricultural Engineer from Pennsylvania State University. Wooding indicated that 1 inch of water per week would be needed to obtain optimum crop yields, and that about 50% of this total could be provided by the natural rainfall, even in the driest years.

Based on these assumptions, the following method, applicable statewide, was developed for estimating irrigation water use during a drought which will occur on the average of once in 50 years:

a. From Figure 4, the freeze-free season in days may be obtained for the watershed of interest. This represents the growing season.

b. Convert the number of days into weeks and subtract 6 weeks from it. This is the effective growing season in which irrigation is needed.

c. Apply ½ inch per week of irrigation water to areas to be irrigated. The number of acres to be irrigated in 1990 was extrapolated from the acres estimated for 1968 and 1980, by the Department of Agriculture.

7. *Analyses of Consumptive Uses and Reuses*

The total diversions of withdrawals for various uses within each of the watersheds are determined for the present and projected for the future, as described above. However, the total watershed or basin withdrawal figure is not informative, since this does not indicate the intensity of the withdrawal or properly consider consumptive uses and reuses.

It should be noted that only a fraction of the withdrawn waters are actually consumed, the remainder returning to the stream for downstream uses.

The following list shows the approximate percentages of withdrawal amount that are consumptive uses:

Municipal	Industrial (non-power)	Power Cooling	Livestock	Irrigation
10%	Vary	Vary	75%	100%

Obviously, some water is used and reused many times before it finally flows into the sea, especially during low-flow periods. However, water quality degrades as the number of reuses increases. It should also be noted that the stream records at the gaging stations reflect the influence of the existing upstream storages, as well as the past and present consumptive uses.

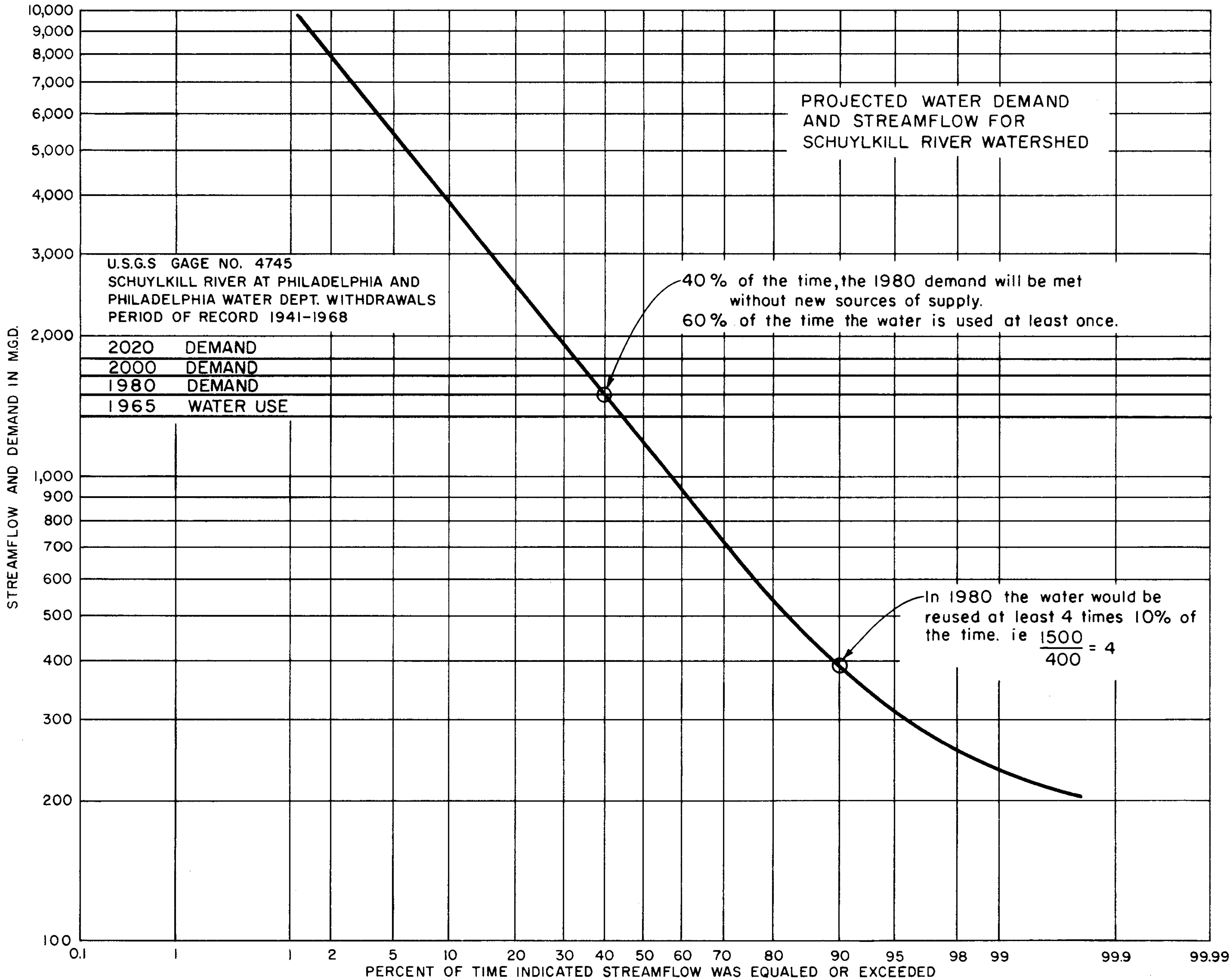


Figure 5 Reuse Study

In view of these facts, the water supply study proceeds as follows:

a. After the public water supply problems and needs are identified by waterworks, investigation of possible regionalization, taking into account any proposed plans, is made before other alternatives are explored.

b. Withdrawals of all kinds are summed for each of the watersheds (properly combined), and the withdrawal intensity which is the withdrawal per square mile of drainage area, is calculated for comparison.

c. Consumptive uses are calculated for each watershed. Future incremental consumptive use indicates the minimum incremental storage or new source required to compensate this loss.

d. Reuse studies are made along main stems and main tributaries, so that the critical problem areas can be located. Figure 5 illustrates this methodology. The number of reuses for a given percent of time may be calculated by dividing the *aggregated demand* above a certain point along the stream by the yield for the same percentile on the *duration curve* developed for that location.

FLOOD DAMAGE REDUCTION ANALYSIS

Floods are natural occurrences that cause damages and loss of life, primarily as a result of man's use of, and encroachment upon, the flood plains.

A number of factors have combined to make the Commonwealth particularly prone to the hazards of floods: her abundant rainfall; her geographic location with respect to the paths of major storms; her mountainous terrain, with narrow valleys and steep slopes; and the fact that her early settlers were attracted to, and built on, the flood plains adjacent to her rivers and streams.

In the latter instance, because rich farmlands were readily available in the river valleys, and the streams provided easy transportation, commerce and communications, as well as convenient water supply and waste disposal, much of the Commonwealth's growth has taken place in close proximity to her rivers and streams.

The need for regulating stream flow and man's activities on the flood plain was officially recognized by the Commonwealth in 1913, and later, in 1936.

The Act of June 25, 1913, as amended, authorized the State to regulate dams, other structures or obstructions as defined in the Act, in, along, across or projecting into all streams and bodies of water wholly or partly within, or partly forming the boundary of the Commonwealth.

The Act of August 7, 1936 and its amendments gave the former Water and Power Resources Board authority to construct flood control and recreational dams; to clean out, widen, alter, deepen or change the course, current, or channel of any river or stream for flood control purposes; install a flood forecasting and warning system; fill-up any canal or water course; construct and maintain levees, dikes, walls, revetments, dams, lakes or reservoirs necessary to prevent floods; and to control, preserve, and regulate the flow of streams and rivers. In spite of these past efforts to mitigate the flood damages, the average annual flood damage has been steadily increasing.

Pending flood plain management legislation is designed to minimize flood damages through land-use control. This legislation, however, will not solve most existing flood problems. Flood plain management alone will not protect communities, industries, and individual homes already in place on the flood plain. It will be necessary in these areas to minimize flood damages by combining land-use controls with proper structural measures. Because of budgetary limitations, a list identifying priority areas with the most urgent flood problems will be required.

A. NEED AND URGENCY

The potential maximum flood control need can be represented by the difference between total annual flood damage and total annual flood control benefit. With limited financial resources, these figures may be used to apportion the future investment.

To identify the urgency of need, both tangible and intangible factors must be considered. An explanation of the methodology utilized in developing the tangible factor is found in Appendix C-2. Intangible factors include the rate and type of development taking place in the watershed and historical loss of life as a result of floods.

1. *Tangible Factor (urgency index)*

The total annual flood damage and the total annual flood control benefit may be reduced to a per-square-mile basis designated as D and S respectively, for comparison. The difference, $D - S$ represents the potential maximum future investment per square mile. S/D indicates the degree of investment to date. Areas of high urgency may be identified with high $D - S$ or low S/D. To take into account both indicators, the product, $(D - S) \times (1 - S/D)$, is used as an urgency index. A high index reflects a high urgency.

2. *Intangible factors*

Another important element to be considered is the rate and type of the development taking place in the watershed. This indicates the potential growth and the potential damage. For rapidly growing watersheds, flood plain management and regulations are urgently needed to minimize future damages. The percentage of population change per year and the change in population per year per square mile between now and, say, 10 or 15 years from now may be used as a rate of development expected.

Loss of life is another element which should be considered in establishing a priority list based on urgency. However, there are a number of factors which make it difficult to consider equitably. For example, historical loss of life may have little or no bearing on the potential for loss of life in the future. One of the most difficult factors to estimate is the unpredictable behavior of humans. Historically, many lives would not have had to be lost, if people had not taken unnecessary chances or had heeded flood alerts.

The relative weights for the tangible factor and the intangible factors cannot be assigned. Therefore, the list will be established first according to the tangible factor then adjusted by considering intangible factors.

OUTDOOR RECREATION ANALYSIS

Recreation is a freely chosen set of activities or inactivities engaged in during leisure time. Outdoor recreation is simply recreation that is carried on outdoors.

The two main ingredients of outdoor recreation, beside participants, are the size of space and kinds of available resources. Resources for outdoor recreation include areas of land, bodies of water, forests, swamps and other natural and man-made features.

Water carries a great recreation potential. Water-based outdoor recreation in the form of water contact activities—swimming, skin diving, and water skiing; water non-contact activities—boating and fishing, and even pure viewing are continuously increasing in popularity. In addition, picnicking and camping are greatly enhanced by the proximity of a body of water.

Available statistical information shows that recreation participation has grown at a rate of 10% per year during the 30's, 40's, 50's and 60's, as indicated by the attendance figures of State parks, national forests, and the National Park System. The water-oriented recreation activities have grown at a much faster rate for the Tennessee Valley Authority system at reservoirs created by dams built by the Corps of Engineers.

A comparison with only 2% annual population growth during the same periods makes it evident that the per capita visitation rates rose markedly.

With the popularity of water-oriented recreational activities increasing, it is obvious that the need for this type of facility will be greatest near metropolitan areas where it is estimated that three-quarters of the people will live by the turn of the century. These people will have the greatest need for outdoor recreation, and their need will be the most difficult to satisfy since urban centers currently have the fewest recreation facilities (per capita) and the sharpest competition for use of the available land.

Fortunately, outdoor recreation is often compatible with other resource uses and, therefore, should be considered in many kinds of planning such as urban renewal, highway construction and water resource development. Indeed, multiple use of resources, including recreation, is usually compatible with other uses and contributes substantially to lowered cost of government services in the total system.

A major aim of the Statewide Comprehensive Outdoor Recreation Plan is the identification of critical areas of need, and the provision of recreation opportunities to satisfy these needs within the constraints of accessibility (e.g., one and one-half hour maximum driving time). An equally important goal is identification of natural and historic values that warrant protection by the State.

In many instances, resources that could be adopted to recreation uses are not being fully employed, and some areas now being used for recreation may not be used to capacity.

The State plan, then, considers all State land and waters having public recreation value and emphasizes multiple-use management and land capability planning.

The Pennsylvania *Statewide Comprehensive Outdoor Recreation Plan* (3) identifies the problems and needs in outdoor recreation in Pennsylvania. In addition, the significance of the proposed developments and the available financial resources were discussed in length.

However, because the State Water Plan addresses only water and related land resources, the outdoor recreation activities under study therein are limited to the same degree.

The methodology described in this section is the same as that in the *Outdoor Recreation Horizons* (4). The following describes the types of outdoor recreation activities considered, market areas, inflow-outflow relationships and identification of problems, needs and urgency:

A. RECREATION ACTIVITIES CONSIDERED

The Federal Outdoor Recreation Resources Review Commission (ORRRC) report (5) lists a total of nineteen outdoor recreation activities. More specialized in scope, the State Water Plan is concerned with only those activities that are water-oriented or water-enhanced.

Swimming, fishing, boating and water skiing are considered water-oriented, while picnicking, camping and pleasure driving are considered water-enhanced. Pleasure driving is not included at this time because of the difficulty in assessing its demand and supply. Water skiing was combined with boating since it is difficult to separate the facilities.

Therefore, *swimming, fishing, boating, picnicking* and *camping* are the activities investigated in this study.

B. MARKET AREA, INFLOW-OUTFLOW

The market area can be most completely determined by using gravitational models which take into account the attractiveness of a recreation area, as well as the distances from the area to surrounding population centers. Use of these models by the Office of State Planning and Development proved it to be very time-consuming. Accordingly, a simplified method is used in this study.

The simplified method requires tabulating, by county, the supply and demand data for each recreation activity. Areas of surplus and deficit can then be shown by comparing the supply with the demand.

Other things being equal, recreationists will move from the deficit areas toward the nearby surplus area. This response pattern defines the *present market*. The surplus area would be the *inflow* area and the deficit area would be the *outflow* area.

Since the inflow-outflow patterns will be modified by future facilities, the *future market* is a function of the future supply-demand relationship. It is assumed that inflow is equal to outflow at all State boundaries, except for the Philadelphia area. For this area, the *Outdoor Recreation Horizons* suggested a 40% discount on effective population because of its excessive outflow to the Atlantic shore.

C. DEMAND-SUPPLY ANALYSIS

Problems, needs and urgency may be identified through a demand-supply analysis. In the analysis, demand for recreation is derived basically from population and may be expressed as activity-days or facilities (units or acres) required. In order that supply can be compared with demand, facilities should be converted into the same unit as demand. The following is a discussion of recreational demand and supply, and the comparison of the two—resulting in "need."

1. *Demand*

Demand consists of participation in various activities by the general population, and *activity days* are an expression of the use of various recreation facilities.

a. *Recreation Participation*

Participation rate is the number of persons, expressed as percent of the population (excluding those 4 years of age or under), who engage in a specified recreation activity.

Since these participants may participate more than once during a recreation season, the average number of days per participant per season must be established to determine the total seasonal demand in activity-days.

The participation rate and the average participation frequency both of which reflect the satisfied demand are generally derived from questionnaire investigations or interviews.

(1) *Projections*

The Office of State Planning and Development in 1968 employed a consultant to estimate recreation participation rates and average number of days per participant per season, for a summer recreation period of 13 weeks (Memorial Day to Labor Day) for the years 1968, 1976, 1980, 1985 and 2000, for each of the 19 outdoor recreation activities listed in the ORRRC Report, and for each of the 13 regions previously used by the Office of State Planning and Development. These 13 regions were used for planning purposes prior to the adoption of the present 10 uniform regions.

In line with the Outdoor Recreation Resources Review Commission Report, the consultant concluded that participation rates and average number of days per participant per season would increase in the future for all the five activities under study due to expected higher personal real income, increased leisure time and higher mobility. It should be noted that the increase in leisure time will increase the participation rate and participation frequency (demand), and thereby increase the utilization of the developed facilities (supply) during current low use periods.

(2) *Adjustments*

The participation rates and average number of days per participant per season by age groups, Planning Regions, and activities are shown in Appendix A-4.

The criteria applicable to picnicking, camping, swimming and fishing are identical to those used in the *Statewide Comprehensive Outdoor Recreation Plan* (SCORP, June, 1971), and the *Outdoor Recreation Horizons.*

The boating participation rate and participation frequency have, however, been changed and are different from those used in the 1971 SCORP, and a new interpretation on fishing demand has been made.

The boating participation rate indicated in the SCORP is apparently not valid and has been adjusted drastically downward. When adjusted according to the total number of boats in the State and an assumed number of persons per boat, the statewide participation rate for 1968 was found to be about 5%. The participation frequency is assumed to be the same as fishing. The detailed methodology is shown in Appendix C-3.

The SCORP fishing participation rate and frequency developed by the consultant were adjusted so that they are consistent with the Fish Commission's estimates.

The 1969 usage (supply) estimate furnished by the Commission was about 9.9 million activity days per year in the State. This is very close to the demand estimate based on the 1968 participation rate; namely, 9.6 million days.

If the thirteen week summer season were used to determine fishing activity days the April trout season would not be included; therefore the activity days for fishing were estimated on the basis of a *calendar year* season.

b. *Activity Days*

The concept of "activity day" has come to be widely accepted as a means of expressing individual recreation participation. It can be defined as a measure of recreation-use by one person on one facility or area for the duration of one day, or for a part of a day. A recreationist who swims in the morning and picnics in the afternoon has participated in two activity days of recreation, i.e., one day picnicking and one day swimming.

c. *Seasonal Demand*

The above participation and activity days are frequently expressed in terms of the recreational demand over an entire season. Total seasonal demand (T.S.D.) in activity days for a given activity is determined using the following equation:

$$TSD = (\text{Population})_{\text{5 \& over}} \times (\text{Participation Rate})_{\text{5 \& over}} \times (\text{Average Number of Days per Participant per Season})_{\text{5 \& over}} \qquad \ldots\ldots\ldots\ldots (3)$$

The subscripts indicate age groups. It will be noted that the age group 1 to 4 years is completely discounted in the computation.

d. *Latent Demand*

The demand reflected in the above formula is as much a measure of supply as of demand. Hence, it does not necessarily indicate the full desire to participate when supply is adequate. The difference between this full-desire demand and the satisfied demand is called "latent demand."

Latent demand will not be included in the supply-demand analysis of this study. However, in the current update of the Pennsylvania SCORP, an attempt is being made to measure latent demand for future supply-demand comparisons.

2. *Supply*

a. *Nature of Supply*—Outdoor Recreation facilities are supplied by Federal, State and local governments, as well as by private profit and non-profit institureflect those of the Department of Environmental Resources and the Pennsylvania Fish Commission. These are shown in Appendix A-5.

Because the fishing and boating responsibilities in the ORH report included those of the Department of Environmental Resources, but not those of the Pennsylvania Fish Commission, the latter were added herein to reflect the true State's share.

In summary, supply responsibilities of a given recreation sector reflect: the existing pattern of sharing supply (among the sectors), and the nature of recreation which the sector can best provide (e.g., back packing in State Forest lands). Given a supply responsibility of an agency, the supply to be provided by the agency can be determined as follows:

(Picnicking) Supply to be provided (by that agency) = Total Demand (for picnicking) × % Responsibility (for picnicking for an agency)

This demand is then translated from activity days into units or acres of facility to be provided—using the activity standards described earlier. An example of this computational procedure can be found in Appendix C-4.

5. *Future Refinement on Methodology*

As part of the present Statewide Comprehensive Outdoor Recreation Plan (SCORP) updating effort, State agencies involved in outdoor recreation are working jointly toward improving the demand methodology, as well as the inventory of facilities. The refined methodology will be based on more reliable demand rates, more sophisticated age breakdown, income classes and social groups. The 1968 inventory data will be updated with respect to the refined demand methodology, and the recreation portion of the Sub-basin Summary reports will reflect these refinements.

WATER QUALITY MANAGEMENT ANALYSIS

Water of good quality is essential for almost every beneficial use, yet almost every use of water alters its quality and tends to cause some pollution. Wherever man exists, wastes from his activities inevitably find their way not only into the air and soil, but also into the streams.

The Department of Environmental Resources is concerned with the prevention and elimination of pollution in the Commonwealth's waters. The prevention, control, and abatement of water pollution is a complex problem, requiring a clear understanding of the physical, chemical and biological characteristics of the water and the engineering aspect of water pollution control.

The Pennsylvania General Assembly, with passage of the Commonwealth's Clean Streams Law, emphasized that clean, unpolluted streams are absolutely essential for attracting new industry, developing the tourist industry, and providing adequate outdoor recreation facilities. The objective of the law is then not only to prevent further pollution, but also to reclaim and restore every polluted stream to its natural state.

Accordingly, the prevention and elimination of water pollution is recognized as being directly related to the economic future of the Commonwealth.

Proper administration of the Clean Streams Law requires a comprehensive program of watershed management and control.

Water quality standards are utilized in the Commonwealth's quality management planning to implement State and Federal water quality laws and regulations.

In establishing water quality standards, the quality limit must be set so that the legislative intent of preventing pollution is carried out.

Pollution is defined in Pennsylvania's Clean Streams Law in relation to the effects on the beneficial uses of the water, as follows: " 'Pollution' shall be construed to mean contamination of any waters of the Commonwealth such as will create or is likely to create a nuisance or to render such waters harmful, detrimental or injurious to public health, safety or welfare, or to domestic, municipal, commercial, industrial, agricultural, recreational, or other legitimate uses, or to livestocks, wild animals, birds, fish or other aquatic life, including but not limited to such contamination by alteration of the physical, chemical or biological properties of such water, or change in temperature, taste, color and odor thereof, or the discharge of any liquid, gaseous, radioactive, solid or other substances to such waters . . ."

A. BENEFICIAL USES AND WATER QUALITY STANDARDS

Water quality standards have been established and adopted for the State's waters to implement both the Commonwealth's Clean Streams Law and the Federal Public Law 92-500, and as a basis for establishing water quality management goals. Water quality standards are enforceable and consist of water quality criteria and a plan of implementation. The adopted standards serve two purposes: for regulation and enforcement and as planning guides for wastewater management.

Water quality standards are established to protect both the current and potential future beneficial uses of the streams. The following are categories of water uses considered by the Department in establishing water quality standards.

2. The contact agency(s) arranges local involvement meetings, disseminates materials as the Plan is developed, and assures that the comments of the local people are conveyed to the Department of Environmental Resources. Local meetings are held as often as required, normally about once per month.

3. Key State Water Plan personnel participate in all local involvement meetings and any special meetings deemed necessary.

4. Compensation to the regional agencies for their conduct of the "local role" in the State Water Plan pertains to such matters as:

   a. The dissemination of State-prepared planning documents and materials to interested persons, agencies, and organizations. These materials may deal with some or all of the matters as listed below.

   b. The review and evaluation of the economic and demographic information to be used in the Plan.

   c. The review and evaluation of the social, economic, and environmental issues of their area.

   d. Pointing out existing water-related problems and needs in cooperation with State and local agencies.

   e. Assisting the State in identifying alternative solutions to water needs which are preferred, and participating in the selection of final recommendations.

   f. Assisting the State in creating a local understanding of the Plan through discussion meetings which involve State participation, as outlined in paragraph 3 above.

   g. Sharing data, estimates, and projections, based on a mutually agreed upon work program and level of effort.

   h. Synchronizing planning phases and activities, based on a previously agreed upon schedule of work.

   i. Assisting the State in articulating goals and objectives, including an initial review of broad statewide goals developed by DER, and the development of local goals and objectives.

   j. Assisting the State in dealing with issues relating to demand, supply, solution alternatives, priorities, projects, and participation in the policy decisions arising from these issues.

6. Due to the more specific nature of the Comprehensive Water Quality Management Plan (COWAMP), it is necessary to establish working committee structures in selected areas. This committee structure is being established within the concept of this proposal, as mutually agreed upon by DER and the participating regional agencies.

METHODOLOGY

The methodologies employed to perform the various elements contained in Planning Procedures (Figure 3) are described herein. These elements consist of Inventory, Population, Analysis, Investigation of Potential Resources, Alternative Solutions, and Formulation of Conceptual Plan.

The first major task is to identify the *Needs and Urgency* (Stage I), and the second is formulation of the *Conceptual Plan* (Stage II).

Needs are determined by comparing the existing supplies with existing and projected demands. An inventory is required to appraise existing demand and the existing supply (facilities or developed resources). The future demand, which is a function of many social-economic factors, is generally related to the projected population and its distribution.

Needs and Urgency (Stage I)

A. INVENTORY

Both statistics and maps are essential for inventories which include type, quantity, and location information. In discussing inventories, it is difficult to define the end of an inventory stage because their characteristics and extent vary from item to item. For example, a surface water availability inventory may be considered complete after all of the pertinent U. S. Geological Survey surface water records have been collected. However, these records alone have limited usage for planning purposes until considerable reduction and analyses have been completed. If an inventory was conducted using questionnaires, the inventory stage is considered completed whenever the information collected has been verified and recorded manually, or in the form of a computer printout. Facilities and water use inventories fall in this category.

tions. This supply of recreation facilities is expressed in various units (e.g., acres, tables).

To express supply in a manner which can be compared with demand, it is necessary to incorporate activity standards into supply.

b. *Activity standards* are expressed in the number of activity days for which each acre or unit of facility can be utilized per recreation season. The derivation of activity standards is based on the park planning guidelines of numerous agencies, particularly those of the Pennsylvania Department of Environmental Resources.

   Activity standards used for the calculation in this report are expressed as either (1) the number of activity days per developed acre (Area Standards), or (2) the number of activity days per unit (Unit Standards). The acreages or units required may be determined by dividing the total activity days by the area standard or the unit standard.

   These two standards were developed according to the following formulas:

   (1) *Area Standards*

   Number of activity days per developed acre per season = Number of units per acre × number of people per unit × turnover factor × number of recreation days per week × number of recreation weeks in a use season.

   (2) *Unit Standards*

   Number of activity days per unit per season = Number of activity days per acre per season ÷ Number of units/acre.

   The unit standard is based on experience and varies with the desired density. For instance, the number of campsites in a State Park campground may vary from about four (4) to ten (10) sites per acre.

c. *Turnover*—Since the same facility may be utilized more than once a day by different parties, a factor called "turnover" is properly considered in the demand methodology. "Turnover" is the number of times a given facility or site is used during a day. An example of turnover would be 1.5 (times per day) for picnic tables.

d. *Summary*—Supply = amount of facility × Activity Standard. Depending upon the use period for which the activity standard is defined, the supply may be expressed as a design daily supply or a design seasonal supply.

3. *Need and Urgency*

Comparison of supply and demand indicates whether there is an excess or shortage of recreation facilities in a given drainage basin. In case of a shortage, responsibility for meeting this shortage must be determined, as follows:

Need = Demand for an Activity − Supply for the Activity

In order to determine the recreation facility need of an area, demands generated from each of the population centers must be allocated into the area in question and its environs. The aggregated demand of the area can then be compared with its total supply to estimate the need. The demand allocation method must take into account the following constraints:

a. Mobility
b. Traveling time
c. Costs of providing facilities

The difference between the total demand allocated from demand centers and the supply of the area represents the need.

Where the need is high, but the resources opportunity is rather poor, the percentage distribution of facilities may be revised to correct the situation.

Adjustments for resources opportunity is particularly important in the Stage-II study (Figure 3). In order to identify the urgency of needs in water and related outdoor recreation, the balances (Demand-Supply) are summed for all five activities for each study area. The total deficit, therefore, may be used to establish priority.

4. *Supply Responsibilities*

Outdoor recreation facilities have been supplied by Federal, State, and local governments, as well as private profit and non-profit institutions. Prior to publication of "Outdoor Recreation Horizons," the supply responsibilities which each of these sectors should bear had never been defined.

The State responsibilities, shown in the publication for the five activities under study,

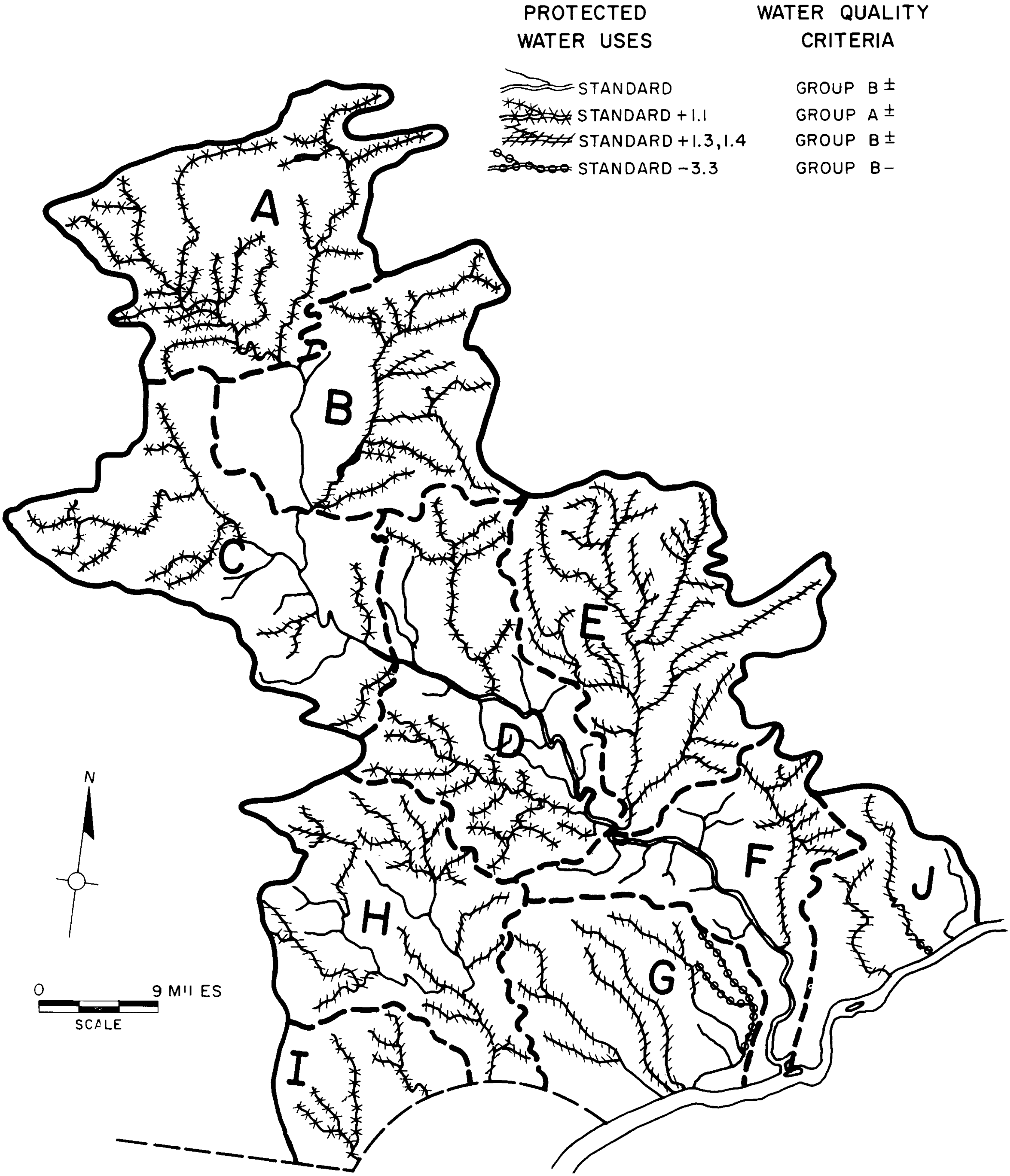


Figure 6 Designated Uses and Criteria

	Standard Water Use List
1. Aquatic Life	
1.1 Cold water fish	0
1.2 Warm water fish	X
1.3 Migratory fish	0
1.4 Trout stocking	0
2. Water Supply	
2.1 Domestic water supply	X
2.2 Industrial water supply	X
2.3 Livestock water supply	X
2.4 Wildlife water supply	X
2.5 Irrigation	X
3. Recreation	
3.1 Boating	0
3.2 Fishing	X
3.3 Water contact sports	X
3.4 Natural areas	X
3.5 Conservation areas	0
4. Others	
4.1 Power	X
4.2 Navigation	0
4.3 Treated waste assimilation	X

In establishing the water quality standards, State agencies involved in the water resources management, as well as the general public, were consulted to establish a list of beneficial uses of individual streams. This consultation took the form of staff meetings and public hearings.

After water use designations were determined for each water body or stream, appropriate specific criteria were developed to protect the designated uses.

As noted on the above tabulation, the categories of water uses designated by (X) marks are considered as standard (common) uses. The uses indicated (0) are specifically designated for individual waters. Group B criteria shown in Appendix A-8 generally apply to the standard uses.

When specific uses are added to the standard uses, or when uses are deleted from the standard uses, the specific criteria are changed accordingly.

Water quality criteria include both *general requirements* and *specific limits.* The general requirements provide guidance as to the substances that should not be present in the waters. Specific criteria define the limits of various chemical, physical and biological indicators that are essential for protecting the designated beneficial uses.

A generalized listing of the beneficial uses and the corresponding criteria can be found in Appendix A-8. Water quality criteria for the State's surface water are contained in Chapter 93 of the Rules and Regulations of the Department of Environmental Resources. As an example, Figure 6 shows the designated uses of streams and the corresponding criteria (generalized) in the Lower Delaware subbasin.

The implementation plan portion of the standards set forth the treatment requirements and effluent limits for each wastewater discharger. In the development of the implementation plan, individual watersheds are studied to determine the critical flows (normally the 7-day 10-year flow), waste loads and the physical and hydrological characteristics of the receiving stream.

Using these data as input, mathematical modeling of the stream is developed to determine the degree of treatment and effluent limits required to meet the stream quality criteria. A following section on "Water Quality Modeling" explains, in detail, the pertinent information needed in the development of the implementation plan.

In the past, the most common expression of effluent limits with respect to organic materials was described as percent of Biochemical Oxygen Demand (BOD) removal. However, this is not always an equitable requirement in that the discharger with higher raw waste strength is allowed to discharge a higher BOD concentration than the discharger with a lower raw waste strength.

Effluent limits for waste discharges are now being expressed in terms of poundage, concentration limits or both. These types of limits can be classified into *three* general levels of treatment processes:

1. Secondary Treatment:

   Reduction of pollutional properties of organic material (usually sewage and some industrial wastes) accomplished by settling the waste and subjecting it to a biological treatment process and disinfection. The organic component of the waste is reduced in the process by about 85%.

2. Tertiary Treatment:

   Tertiary treatment utilizes a single additional step applied only after conventional primary and secondary waste treatment, e.g., chemical treatment of a secondary effluent for removal of phosphorus. Organic constituents are normally reduced up to 95% in tertiary treatment and other constituents, such as phosphorus and ammonia are often reduced.

3. Advanced Waste Treatment:

   Advanced waste treatment refers to any method or process not now in common use, and is used after conventional treatment to remove refractory low level, difficult-to-remove substances. Organic removals are generally greater than 95% and other constituents, such as ammonia and nitrogen are

X–Standard (common) uses.

0–Specifically designated uses for individual waters.

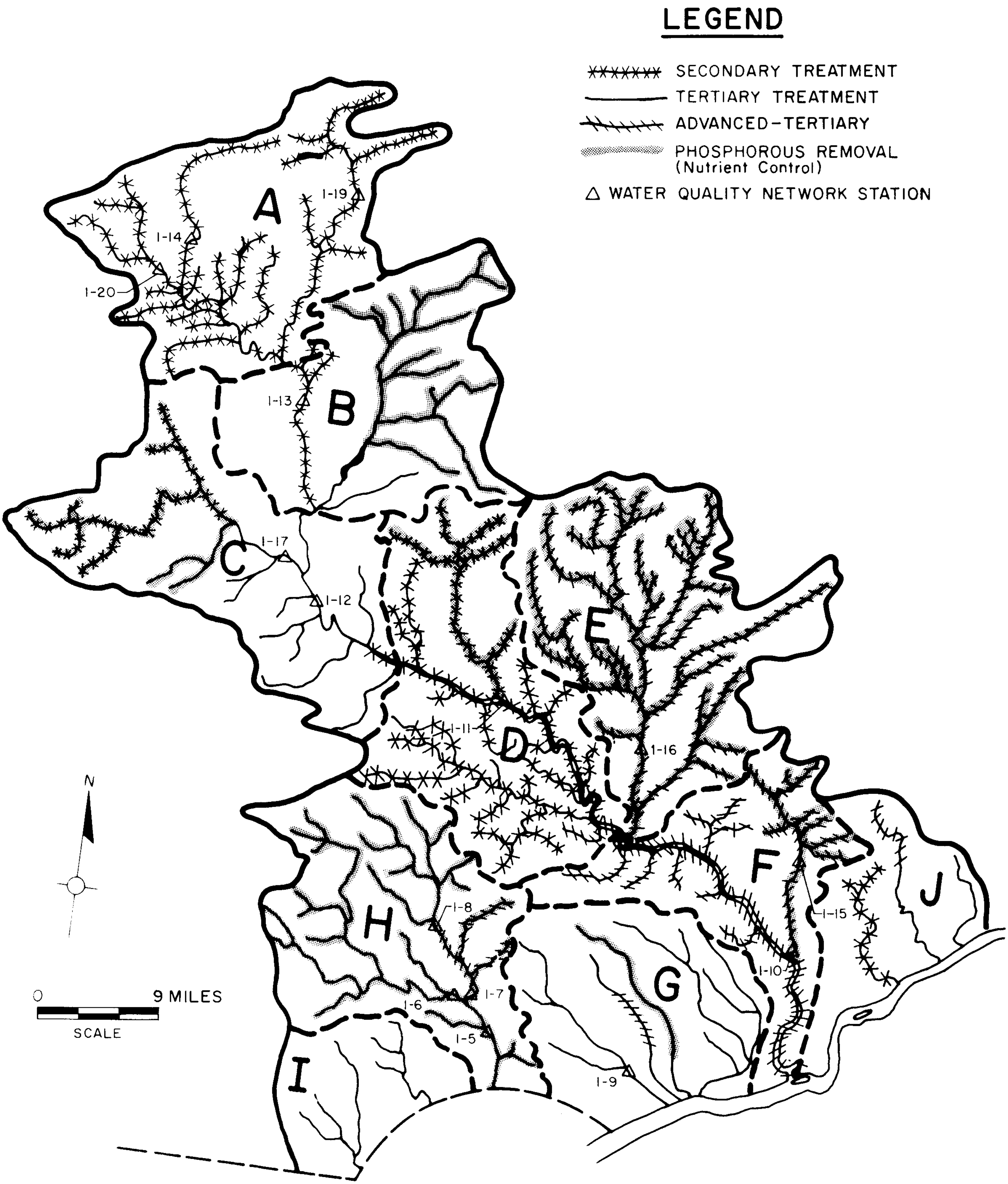


Figure 7 Required Treatment Level

removed to produce an effluent with very low levels of these indicators.

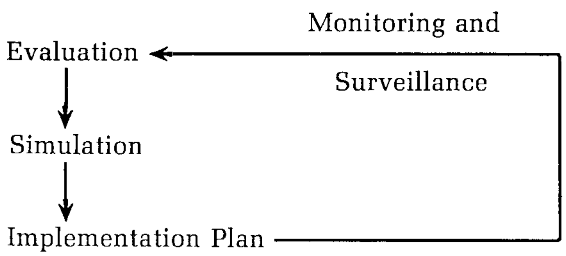
Using these three classifications, the required treatment levels can be shown on watershed maps, as exemplified by Figure 7. This map was developed based on the Department's Water Quality Standards, and implementation plans, and is subject to revision as water use and waste loads change in a watershed.

B. WATER QUALITY MODELING

Water quality modeling is undertaken to accomplish three basic purposes:

1. To simulate water quality conditions so that changes in water quality under variable conditions can be identified.
2. To evaluate water quality as an aid in interpreting the results of water quality monitoring and surveillance data.
3. To develop an implementation plan.

The three are interrelated in an overall water quality modeling effort as follows:



Water quality simulation is an important planning tool and is extensively used in plan development. It permits a projection of water quality conditions that would naturally occur at infrequent and unpredictable intervals, such as, during droughts.

Simulation also permits prediction of water quality conditions under "alternate futures," so that the impact of new or enlarged wastewater discharges, or of streamflow augmentation, can be analyzed. Evaluation of alternate futures is important in plan development.

Water quality evaluations are used to refine the simulation procedures and to identify special implementation needs. Application of this simulation technique is detailed in Appendix C-5.

In conjunction with the Comprehensive Water Quality Management Planning, a modeling package known as *Update and Documentation of Water Quality* Modeling (UDOM) is being developed.

The purpose of the UDOM project is to develop a computerized water quality modeling interface which includes systems design and the development and encoding of an initial data base. The package documents previous water quality modeling work, as described in Appendix C-5, and facilitates updating of these previous efforts. UDOM will be utilized to:

1. Further identify and refine the boundaries of water quality limiting zones and effluent limiting zones.
2. Determine waste load allocations in water quality limiting zones.
3. Help establish priorities related to water quality control matters. These priorities will relate to enforcement, as well as construction grants.
4. Provide a rapid and efficient tool for the evaluation of alternative waste discharge configurations.

Once the implementation plans are established, water quality control needs can be determined. Figure 8 is a schematic representation for the assessment of present and future water quality. The difference between the treatment requirement and the degree of treatment currently provided, determines the water quality management needs.

C. ADOPTION AND REVISION OF STANDARDS

The water quality criteria and implementation plans are documented as a report and distributed to industrial and municipal officials, legislators, and interested organizations and individuals prior to public hearing.

The hearing gives interested individuals, organizations, municipalities and industries an opportunity to express their views and desires concerning these criteria and implementation plans.

Based on the testimony presented at the hearing, and on written comments received, the Department of Environmental Resources reviews the report, makes necessary changes, and presents the final report to the Environmental Quality Board for adoption. Once adopted, the water quality criteria portion of the report becomes part of Chapter 93 of the Department's Rules and Regulations. Surveillance and monitoring programs insure compliance.

Water quality standards are reviewed periodically. The Federal Water Pollution Control Act Amendments of 1972 require that public hearings be held at least once every three years for the purpose of reviewing applicable water quality standards and, as appropriate, modifying and adopting standards.

It is also anticipated that the implementation plans would be modified as the result of the Comprehensive Water Quality Management Planning (COWAMP) program.

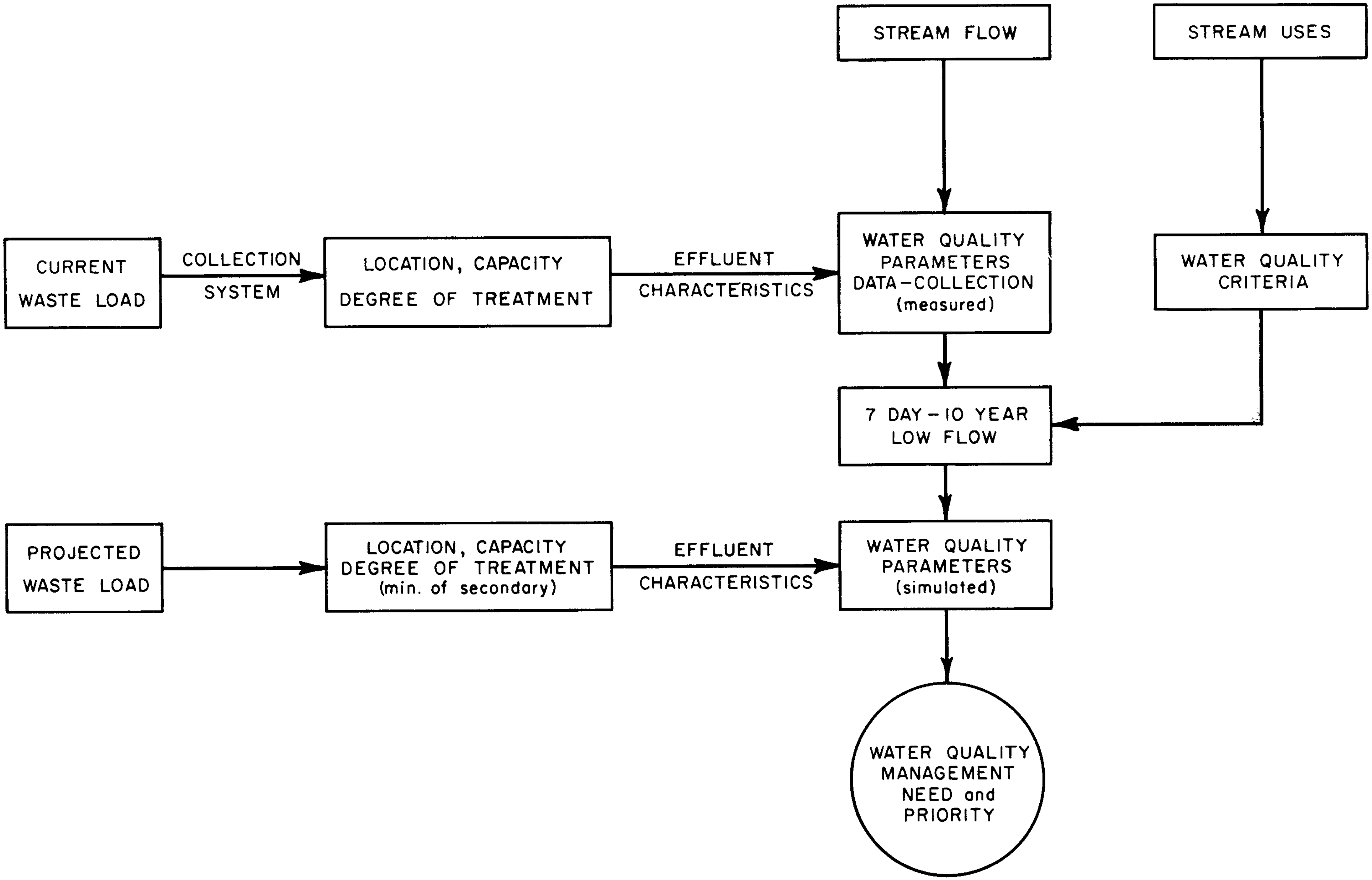


Figure 8 Water Quality Management Needs and Priority

D. EXISTING WATER QUALITY AND WASTEWATER DISCHARGERS

Existing water quality reflects the result of all wastewater discharges. Streams that are not meeting the water quality standards may be identified by comparing the existing water quality under low flow conditions with the standards established for the streams. (Because the data obtained from water quality networks and records is generally inadequate to assess the current quality of the stream, an inventory of the dischargers and treatment facilities should be made.) Inventory of existing wastewater dischargers and treatment facilities is necessary, not only for assessing the existing water quality, but more importantly, for evaluating the effectiveness of potential alternative solutions for water quality management.

The primary water quality indicators are: stream temperature, dissolved oxygen, biochemical oxygen demand, dissolved solids, pH (acidity), color, turbidity, total iron, alkalinity, amonia-nitrogen, phosphorus, toxic substances, and fecal coliform organisms.

The chemical, physical, and biological analyses for determining the concentrations or intensities of each indicator should be conducted in accordance with the *Standard Methods for Examination of Water and Wastewater* (6) published jointly by the American Public Health Association and American Water Works Association. The water quality data may be obtained from STORET (Storage-Retrieval) of the Federal Environmental Protection Agency and WAMIS (Water Management Information System) of the Bureau of Water Quality Management.

The inventory should include discharges from industrial and municipal sources, and from other sources of pollution, such as abandoned mines, construction sites, agricultural operation, animal feed-lots, etc. where identifiable. The pertinent information for existing dischargers includes plant location, ownership, wastewater flow, plant design capacity and degree of treatment of specific treatment process provided. This information may be obtained from the Water Management Information System.

E. WATER QUALITY MANAGEMENT NEEDS AND PRIORITY

The assessment of water quality management needs is necessary in effective wastewater management planning. The need may be determined by comparing the effluent requirement (implementation plan), described previously, with the current treatment facilities and their treatment levels, as shown in Figure 8. Streams that are not meeting the water quality criteria can also be identified.

The Department issues orders to those dischargers who are required to upgrade their treatment facilities. They are required to plan, obtain a permit or other approval, and construct such facilities as may be necessary to comply with the treatment requirements.

The on-going Comprehensive Water Quality Management Planning (COWAMP) effort is to establish a sound, long-range basis for water quality management for the protection of Pennsylvania's waters.

The planning effort involves carrying out nine studies which will determine methods to be implemented for the enhancement of surface and groundwater quality throughout the State. The studies will recommend plans to meet both short-term needs and projected growth requirements in the study areas. When completed, the nine COWAMP plans will be the water quality management element of the State Water Plan.

Four specific functions will be served by the COWAMP study as follows:

1. It will meet the current requirements of the Environmental Protection Agency (EPA) under the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500) and regulations promulgated thereunder by the EPA.

2. It will become a basis for formulating policies and taking actions under the Pennsylvania Clean Streams Law, the Sewage Facilities Act and Article 1, Section 27 of the Pennsylvania Constitution.

3. It will assist evaluation of sewerage projects that may be eligible for grant funds.

4. It will provide a basis for evaluating projects proposed by other agencies as they may affect, or be affected by, the water quality management plan.

The construction of municipal wastewater treatment plants is supported by construction grants provided in the Federal Water Pollution Control Act. Since adequate grant funds are not always available for all projects when they are ready to start, a priority system for determining eligibility is used.

The funding priority is based on a scoring system reflecting the relative need for the project. Relative needs are considered proportional to the number of points accumulated in each of the four categories: water pollution control, stream segment priority, population affected and enforcement status with relative weights of 60%, 20%, 10% and 10% respectively. The detailed rating system is shown in Appendix A-10.

In order to meet the needs determined in Stage I, *investigations of potential resources* are required for formulating various *alternative solutions.*

The solutions can be active or passive in nature. Active alternative solutions (devices) change, or manage, the resources to fill needs, and passive alternative solutions affect the needs so that existing resources suffice.

The economic and environmental objectives are then applied to select the *most desirable solution concepts.* These, together with the established urgency list, formulate the final conceptual plan.

A. INVESTIGATION OF POTENTIAL RESOURCES

The function of planning is to balance our human needs with available natural resources. Consequently, we must know our resource potentials (opportunities) before we can determine how various needs should be met.

Developed resources may meet additional needs through improved *management.* Likewise, undeveloped resources may be *developed* to meet the identified needs.

Undeveloped resources include, not only surface water and groundwater, but also potential dam sites and potential well fields.

Areas of potential groundwater recharge and areas suitable as a "living filter," as well as other water-saving devices, facilitate *conservation.*

Wild and scenic rivers and historic sites are valuable resources which can be managed for the enjoyment of present and future generations.

All of these potential resources should be thoroughly investigated so that feasible alternative solutions may be fully explored.

1. *Potential Resources for Management*

   Existing developed resources and facilities may furnish additional utility through further resource development and/or more efficient management, including improved rules and regulations. Examples of opportunities which should be explored before seeking a new development are:

   a. The potential for regional water supply and wastewater management. The concept of regionalization is based not only on economy of scale, but also on improved technical and financial capabilities of regionalization. Regionalization may, therefore, be effective without physical integration of the water works or treatment plants.

   b. The water supply potential of quarry or mining pits.

   c. The recreation potential of water supply reservoirs and the additional recreation potential (carrying capacity minus existing capacity) of existing recreation sites.

   d. The potential of flood plain management as a device to reduce flood damage.

2. *Potential Resources for Development*

   The maximum potential yield of a given stream is 100% of its long term average discharge. To achieve this, a storage greater than 100% of its long term average annual runoff would be required. This generalized relationship is illustrated in Figure 9.

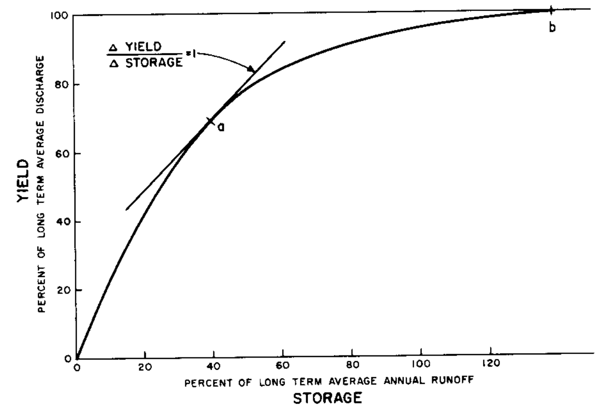


Figure 9 Yield-Storage Relationship

In searching for a "reasonably full hydrologic development," Fink and Lee (7) concluded that, for the upper Susquehanna River Basin in New York State, a yield equal to about 80% of the average discharge (runoff) or a storage equivalent to 50% of the average annual runoff can be considered as the "reasonably full hydrologic development." This point is located somewhere between points "a" and "b" on the curve shown in Figure 9.

Therefore, this "reasonably full hydrologic development" should be investigated for a given site, and the Pennsylvania Water Resources Bulletin No. 7 may be used for this purpose.

Groundwater cannot be separated from the surface water or stream runoff mentioned above. During a no-rain period or drought, the entire stream flow (surface water) is derived from groundwater. A groundwater reservoir, just as a surface reservoir, regulates the stream flow. As long as the waters pumped out of the ground are returned to the same place in the stream to which it naturally discharges, groundwater usage, for the most part, does not affect the total stream flow of the stream.

The limits of groundwater development, for conservation, should be the safe yield, defined as the maximum rate at which water can be obtained from an aquifer over long periods of time without eventually depleting the supply of water in the aquifer. Although the safe yield is difficult to determine, attempts should be made to establish the quantity of safe yield as realistically as possible.

Surface water can be developed using reservoir storage. Unfortunately, because the number of potential dam sites are limited and in competition with other land uses, they must be identified as early as possible.

The merit of a potential dam site should be based on economic, social, and environmental needs and considerations. Sizing of the reservoir should also be based on the needs, with due consideration to the hydrological full development. The concept of multiple-use should be applied wherever possible.

Potential well fields, like potential surface reservoir sites, represent areas where water may be made available (developed) economically. They should be explored for possible utilization, and may be identified using geological information, supplemented by well inventory data.

3. *Conservation of Water Resources*

Good conservation practices should be explored as a means of avoiding waste or pollution of water resources and as a means of replenishing water resources. Following are several possibilities which should be explored in greater depth:

a. Use of ground water recharge areas and recharge methods.
b. Use of land-use and land treatment practices.
c. Use of waste water spray irrigation.
d. Ways and means of reducing industrial water use and water use in individual households.

The latter could include such items as development and utilization of new pricing policies for water supply and mechanical devices designed to reduce water use in the home.

The exceptionally high quality of certain streams was recognized in the establishment of water quality standards. As a result, these streams and their drainage basins were designated as *conservation areas.* This designation carries the mandate that unless there is an overriding economic or social justification, no change will be permitted which interferes with the use of receiving waters.

One of the most effective means of conserving water is through education programs. Media such as newspapers, magazines, textbooks, radio, television and public speeches may be used to make the public aware of the economic, environmental and social values of this limited resource, as well as means and ways of conserving it. The ultimate objective of this educational process is to establish the ethic of conservation in our daily life, rather than just as an emergency measure during a crisis. Since changes involving moral concepts and life style evolve slowly, educational programs should be a continuous effort.

4. *Potential Resources for Protection and Maintenance*

The State Water Plan is concerned, not only with conservation of water resources, but also the protection and maintenance of our wild and scenic rivers. As a step toward safeguarding these invaluable resources, a Wild and Scenic River Task Force was established by the Water Resources Coordinating Committee.

The functions of this task force are to assist in formulating classification criteria for wild and scenic rivers or wild and scenic sections of rivers and streams, in accordance with the provisions of Act 283, The Pennsylvania Scenic Rivers Act, approved December 5, 1972, and to screen such rivers and sections of rivers and streams in order to establish a list for detailed study.

The task force includes representatives of the Bureaus of Resources Programming, State Parks, Forestry, Water Quality Management and the Topographic and Geologic Survey of the Department of Environmental Resources, as well as representatives of the Pennsylvania Fish, Game and Historical and Museum Commissions, the Office of State Planning and Development, and the Department of Community Affairs. Environmental groups represented include Pennsylvania Canoe Clubs, Pennsylvania Federation of Sportsmen's Clubs, Western Pennsylvania Conservancy, Pennsylvania Environmental Council, Trout Unlimited and the Sierra Club.

The Pennsylvania Scenic Rivers Act of 1972 specifically requires that a Pennsylvania Scenic Rivers system be developed and that the components of that system shall be classified, designated and administered in the following categories:

a. Wild River Areas—those rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail with watersheds or shorelines essentially primitive and waters unpolluted.

b. Scenic River Areas—those rivers or sections of rivers that are free of impoundments with shorelines or watersheds still largely undeveloped, but accessible in place by roads.

c. Recreational Rivers—those rivers or sections of rivers that are readily accessible, that may have some development along their shorelines and may have undergone some impoundment or diversion in the past.

d. Modified Recreational Rivers—those rivers or sections of rivers in which the flow may be regulated by control devices located upstream. Low dams are permitted within the reaches so long as they do not increase the river beyond bank-full width. These reaches are used for human activities which do not substantially interfere with public use of the streams or the enjoyment of their surroundings.

To qualify for inclusion in one of the four categories, the river, stream, or stream section, and the land adjacent thereto, must be in a natural, aesthetically-pleasing condition and possess outstanding scenic, recreation, geologic, fish and wildlife, historic, cultural, or other similar values.

All rivers, streams or stream sections in the natural system must also be substantially free-flowing and have water of high quality, or water that can be restored to that condition. In practice, however, these positive standards are more difficult to formulate than negative standards, as can be seen in Appendix A-7.

B. ALTERNATIVE SOLUTIONS

There are many alternative measures which may be employed in the solution of water resources problems and in meeting water needs. These measures may be corrective or preventive, structural or non-structural, active or passive.

Tables 1-4 list a number of alternative measures which may be applied in the categories of water supply, flood damage reduction, outdoor recreation, and water quality management. In each category, a number of alternative measures are individually described, including their advantages and disadvantages. Because the advantages and disadvantages are discussed without reference to the physical setting of specific problem centers or project sites, they serve only as general guides.

It must be emphasized that the measures shown may be investigated and utilized individually or in combination. Indeed, a combination of several measures may well furnish the most desirable solution.

For example, construction of a reservoir combined with development of well fields could be a more desirable solution for a particular water supply problem than either one or the other individually.

It should also be emphasized that projects which have been proposed by Federal, State, local or private entities, but which have not yet been implemented, should be examined carefully for possible inclusion as part of the State Water Plan. Further, additional uses that could be derived from existing facilities, through improved operation or management, should be explored before proposing any new development.

In screening the alternatives, proper consideration should be given to upstream-downstream, ground water-surface water, and water quantity-quality relationships.

Every alternative solution has its physical impacts, as well as, its social, economic and environmental implications. A wise choice of alternatives, or combinations of alternatives, can be made only if these impacts and implications are considered and clearly understood.

If the social and environmental impacts of a major solution could be quantified in terms of dollars, a simple economic approach could be used to make a final decision. Because continuing efforts to place dollar values on social and environmental impacts have been largely unsuccessful up to this time, it has been necessary to arrive at equitable solutions by making judgment decisions based on relative needs.

To date, this technique of "trade-off" among the social, environmental and economic needs has been applied with varying degrees of success in several multi-objective water resources planning studies conducted by Federal agencies. Indeed, the need for improving this technique has been intensified as a result of the passage of the Federal Environmental Policy Act, and Pennsylvania's Act 275 and Section 27, Article 1 of an amendment to the Pennsylvania Constitution.

Table 1

APPLICABILITY AND LIMITATIONS OF THE ALTERNATIVE SOLUTIONS TO WATER SUPPLY PROBLEMS

Alternative Solutions	Principle	Applicability and/or Advantages	Limitations and/or Disadvantages
I. Active Measures			
Surface Storage	Store high-flow water; release during low flow.	Applicable where feasible reservoir site is available. Provides multiple uses and dependable yield.	Requires retaining structures. Inundation of valley land. Increased evaporation loss from lakes.
Groundwater Development	Utilize existing "underground reservoirs."	Applicable where groundwater yield is high and the water demand is relatively small. Does not necessarily restrict the use of land surface. Provides more desirable temperature and less evaporation loss. Maintains steady yield during droughts.	Supplies small users only. Difficult to provide multiple-uses. Difficult to determine yield. Possible subsidence.
Improved Water Quality of Supply Sources	Improve water quality through control and abatement.	Applicable where quantity is not a problem but quality is. Provides additional beneficial uses.	Requires sound pollution control and regulation. Economic consideration.
In-stream Diversion	Stream flow diversion.	Applicable where demand can be met from diversion without storage.	By-passing some user downstream of the diversion point.
Inter-basin Transfer	Out-of-basin diversion.	Economic advantage to receiving basins.	Encourages over-development of receiving basin. Legal problems. Environmental concerns to both basins.
Waste Water Reclamation	a. Direct use. b. Through ground water recharge.	a. Combine waste water and water supply treatments. b. Applicable where spray irrigation sites are available. Solve both waste water and water supply problems.	a. Technical and mostly psychological problems. b. Pedologic and geologic limitations.
Interconnection	Regional management.	Applicable where surplus of water supply is available nearby a deficit area.	Economic consideration and institutional problems.
II. Passive Measures			
Metering and Pricing	Reduce demand.	An effective way of reducing demand especially when sewage charge is related to water use.	Not very effective in high income area. Economically infeasible for small water company to install meters.

Table 1 Cont.

APPLICABILITY AND LIMITATIONS OF THE ALTERNATIVE SOLUTIONS TO WATER SUPPLY PROBLEMS

Alternative Solutions	Principle	Applicability and/or Advantages	Limitations and/or Disadvantages
Rationing	Control demand.	May be used as alternative when supply drops below adequacy criteria.	Difficult to apply when supply is above adequacy criteria.
Educational Programs	Reduce demand or prevent waste by water-saving methods.	Effective way of reducing demands. Makes public aware of water as a resource to be conserved.	Usually only effective during a drought. Benefits are difficult to assess.

Table 2

APPLICABILITY AND LIMITATIONS OF THE ALTERNATIVE SOLUTIONS TO FLOOD CONTROL PROBLEMS

Alternative Solutions	Principle	Applicability and/or Advantages	Limitations and/or Disadvantages
I. Corrective Measures			
Reservoir Storage	Peak reduction by detention (store excessive water and gradually release).	Stage flood covers a great range of floods and may provide multiple uses. Applicable where suitable dam sites are available.	Inundation of valley lands.
Levee and Flood Wall	Barrier excluding flood water from developed areas.	Where local protection is feasible; i.e., existing development is too expensive to be relocated.	Creates false sense of security hence encourages further development. Danger of overtopping.
Channel Improvement	Stage reduction by increasing hydraulic efficiency.	Where suitable grades and open space are available for changes of channel configuration.	Ecological changes, high maintenance cost, higher channel erosion potential downstream.
Watershed Land Treatment and Reforestation	Increase infiltration and reduce surface runoff in upland areas.	Applicable to upland areas where soil and topographic conditions favor such measures. Reduces erosion and downstream flooding.	Not too effective on major floods.
Temporary Evacuation	Damage reduction by evacuation.	Emergency measure advisable for areas where collective action is not feasible.	Effective only with accurate forecast and timely warning. Not effective for small watersheds.
Flood Insurance	Spread cost over a long period of time. Losses taken care of by insurance.	Supplemental to flood plain zoning. Most effective if required for mortgage and development loans i.e., increases cost of development.	Does not reduce damages. Requires flood plain information and flood plain regulation.
II. Preventive Measures			
Dam and Encroachment Regulation	Prevent backwater by providing adequate flood passage.	Wherever dams and encroachments are needed. Prevents inadequate construction.	Economic consideration. Requires strong and comprehensive regulatory action.
Permanent Evacuation	Move away from the danger.	Applicable where flood is frequent and other solutions are ineffective. Completely eliminates damages.	Economic and social considerations.
Permanent Floodproofing	On-site damage reduction.	Applicable where collective action is not feasible. Could be used as a preventive measure or a corrective measure.	Requires flood plain information. Not very effective without enforcing building codes.

Table 2 Cont.

APPLICABILITY AND LIMITATIONS OF THE ALTERNATIVE SOLUTIONS TO FLOOD CONTROL PROBLEMS

Alternative Solutions	Principle	Applicability and/or Advantages	Limitations and/or Disadvantages
Flood Plain Regulation	Flood prevention using zoning ordinances, subdivision regulations, and building codes.	Environmentally sound. Minimizes future flood damage. Integrates flood control with open space policies.	Requires flood plain information, workable and strong legislative actions. Possible over-zoning. Not effective on existing development.
Tax Adjustments	Vary the tax according to land use rather than market values.	Proper use on proper land.	Needs strong Federal, State legislative actions and cooperation of local entities.
Warning Signs	Public awareness of potential danger.	Discourages improper development.	Requires flood plain information. No assurance for success.

Table 3

APPLICABILITY AND LIMITATIONS OF THE ALTERNATIVE SOLUTIONS TO OUTDOOR RECREATION PROBLEMS

Alternative Solutions	Principle	Applicability and/or Advantages	Limitations and/or Disadvantages
I. Improvement of Existing Water Areas			
Management for Multiple Uses	Multiple uses.	Full utilization and additional benefits of developed waters.	Operation, maintenance, legal, and institutional problems.
Improved Water Quality	Improve water environment with improved water quality.	Applicable to degraded streams. Multiple-use benefits.	Cost.
Improved Access and Facilities	Further development (quantity) and improvement in quality of access and facilities.	Full utilization of developed waters without new development.	Possible degradation or over-use of facilities.
Low Flow Augmentation (quantity)	Enhance water environment with augmented flow.	Applicable to low-yield streams during summer season. Will enhance aquatic environment and recreation values.	Potential reservoir sites. Cost allocation.
Flood Plain Regulation and Land Use Control	Proper use of water and land areas.	Reduces operation and maintenance costs. Multiple benefit (flood damage reduction). Provides and maintains additional open space.	Opportunity cost.
Enhancement of Natural Environment	Enrich the recreational experience.	Improves recreational quality.	Cost.
II. Development of New Areas			
Low In-channel Dam or Inflatable Dam with Access and Facilities	Maintain adequate depth of water for recreation without introducing flood damages upstream.	Avoids inundation of valley. Increases recreational potential.	Operation and maintenance problems.
Reservoir Storage with Access and Facilities	Create new water area.	Multiple uses.	Potential dam sites. Inundation of valley.
Enhancement of Natural Environment	Enrich the recreational experience.	Improves recreational quality.	—

Table 3 Cont.

APPLICABILITY AND LIMITATIONS OF THE ALTERNATIVE SOLUTIONS TO OUTDOOR RECREATION PROBLEMS

Alternative Solutions	Principle	Applicability and/or Advantages	Limitations and/or Disadvantages
III. Preservation of Wild and Scenic River and Fish and Wildlife Habitat	Preservation of invaluable resources for the benefit of present and future generations as well as fish and wildlife.	Only applicable where they exist.	Opportunity cost.

Table 4

APPLICABILITY AND LIMITATIONS OF THE ALTERNATIVE SOLUTIONS TO WATER QUALITY PROBLEMS

Alternative Solutions	Principle	Applicability and/or Advantages	Limitations and/or Disadvantages
I. Water Quality Maintenance (Non-acid)			
Advanced Waste Treatment	Removal of pollutants by chemical, physical and biological treatment processes.	Effective for removal of refractory substances. Applicable where secondary treatment is insufficient to meet water quality standards.	Requires more complex treatment units. Can be expensive.
Streamflow Augmentation	Dilution (to reduce concentration of pollutants to reasonable levels).	Provided at low-flow areas, heavily polluted streams and where secondary treatment is insufficient to meet water quality standards.	Economic consideration for structures. Not a substitute for treatment.
Pipeline Relocation of Effluent Discharge Points	Diversion of waste discharge from streams of low assimilative capacity to those of high assimilative capacity.	Applicable in streams of low assimilative capacity.	Difficulty in locating stream of high assimilative capacity. Economic consideration. Change in flow characteristics of streams.
Mechanical Re-aeration of Streamflow	Oxygen transfer to increase D.O. content of stream.	Applicable in heavily polluted streams and in relatively deep and slow-moving water.	Aeration units hinder boating activity. Requires warning signs. Noise from drive units.
Spray Irrigation	Utilization of the capability of soil to renovate wastewater.	Maximum utilization of natural resources.	Possible pollution of ground water supply. Maximum recommended application rate is 2 inches per week. Requires lagoons for winter storage.
Sediment Control	Land treatment, land-use control and sediment retention.	Applied where lands lack vegetative cover and in areas under urbanization.	Areas involved and natural conditions. Economic consideration.
Reduced Waste Loading	Domestic water use reduction by metering and pricing; industrial process modification by waste classification and re-use of wastewater.	Minimization of pollutional effects of wastes on receiving stream. Treatment cost reduction.	Unreliable means of waste volume reduction. Not applicable in all areas.

Table 4 Cont.

APPLICABILITY AND LIMITATIONS OF THE ALTERNATIVE SOLUTIONS TO WATER QUALITY PROBLEMS

Alternative Solutions	Principle	Applicability and/or Advantages	Limitations and/or Disadvantages
II. Water Quality Restoration (Coal Mine Drainage)			
Chemical Neutralization of Acid Mine Drainage Waste	Addition of alkaline substances (e.g., lime) to neutralize acid mine wastes.	Applicable in surface and in subsurface mining operations.	Difficulty in collecting acid mine wastes for treatment. High costs of chemicals and sludge removal. Lime neutralization may add hardness to treated water.
Streamflow Augmentation	Dilution of acid and mineral salts to reduce acid concentration to tolerable levels.	Reduces concentration of mine pollutants to tolerable level. Increases assimilative capacity of stream receiving wastes.	Difficulty in impounding good quality water. Additional costs of chemicals for alkaline releases. Economic consideration for impoundment structures.
Surface Mine Reclamation	Restoration of areas disturbed by mining operation by backfilling, regrading and planting grass and trees.	Applicable in areas disturbed by strip mining and deep mine subsidence.	Effective only with proper backfilling, regrading and planting fast growing trees. Expensive measure.
Underground Mine Sealing	Exclusion of air (oxygen) by flooding the mine.	Applicable in deep mines (shaft, slope and drift).	Temporary adverse effect on groundwater quality.

The State Water Plan should, of course, evaluate the social, economic, and environmental consequences of each alternative solution, or each combined solution.

It must be understood, however, that the level of detail of the evaluation cannot exceed the level of detail of the Planning effort and that the State Water Plan initially evaluates social, economic and environmental impacts on a broad basis, utilizing citizen input and professional judgment to screen alternatives.

The following factors will, to the extent possible, be considered in the screening process:

1. *Social Factors*

   The U. S. Water Resources Council lists real income distribution, life, health, safety and emergency preparedness under the social account. Most of these concerns are considered in the Standards and Criteria established for the State Water Plan effort.

   The principal ingredients of the social well-being objective—equity and freedom (8)—can be best addressed through an improved cost-benefit sharing scheme, as well as, the restructuring of water laws and institutional arrangements, if required. The latter are examined and will be included in the report on Pennsylvania's "Water Laws and Institutional Arrangements."

   Because local participation is critical to the identification of alternative environmental futures and the development of waste water management recommendations, the achievement of a high level of local participation is a necessary and important part of both the Comprehensive Water Quality Management Plan (COWAMP) and State Water Plan efforts.

   The public participation program is designed to solicit public inputs so that social preference at the local level can be heard and considered (9).

   While intended to achieve State and Federal water quality goals, the actual implementation of the specific recommendations of COWAMP will depend largely on local, subregional and regional acceptance.

2. *Economic Factors*

   Standards and criteria used in the planning process have their social, economic and environmental implications. Their impacts are generally much greater than those of individual projects, since the size of a project is determined by the standards and criteria.

   When the economic evaluation is made at the project level, alternatives are ranked either by a least-cost or a benefit-cost concept. The least-cost concept is generally applied to single-purpose projects, and the benefit-cost concept, to multi-purpose projects. Depending upon the level of detail of the study, the cost of each alternative may, or may not, be evaluated. Also, contribution of a project toward multiple uses and regional benefits may, or may not, be quantified.

   In COWAMP, an Economic-Financial model (ECOFIN) is being developed. ECOFIN will facilitate the cost-effective analysis of a large number of alternative wastewater management systems. The model will identify a set of cost-effective alternatives from which an environmentally and socially acceptable alternative may be selected.

3. *Environmental Factors*

   The evaluation technique for environmental factors is still in its infancy. Several methods have been suggested for indexing environmental impacts. A comprehensive review of these methods was recently made by Nicholas and Biswas (10). To date, the methods proposed by Leopold et al. (11) and Battele Columbus Laboratories (12) are probably the best known, the latter being more sophisticated than the former.

   Qualitative measures can be used for comparing impacts of various alternatives on a particular environmental component. However, the overall impact cannot be assessed unless the relative importance of each environmental component is determined.

   Application of a numerical evaluation system is limited by data availability and the ability to set criteria for relating environmental parameters to numerical values. Another drawback of a numerical system is the difficulty of correlating the resulting score with real impacts. For example, an impact tabulation may show −50 for one alternative and −30 for another. Although the impact of the former is definitely higher than the latter in the numerical system, the severity of the impact may not be proportional. For this reason, descriptive terms are probably more useful than a numerical evaluation.

C. DEVELOPMENT OF STATE WATER PLAN

As previously stated, the purpose of this planning effort is to develop a flexible State Water Plan for the wise management of the Commonwealth's water and related land resources.

Initially, the possibility of developing two or three alternative plans was considered, but was rejected in favor of a single, flexible plan which would incorporate the economic, social and environmental objectives of all levels of government and society.

This type of plan is developed, then, by identifying present and future water needs, and problems, and their urgency, along with alternative ways the needs may be met or the problems solved while considering the physical, economic, social and environmental advantages and disadvantages of the alternative solutions. Only after review by Federal, State and local interests and entities, to establish feasibility and acceptability, are the solutions considered most desirable recommended for implementation.

Finally, it must be emphasized that the State Water Plan is subject to change and will be modified from time-to-time as the data base, standards and criteria, and method of analysis are improved, and as demands and needs, as well as, economic, social and environmental changes occur and new problems appear.

REFERENCES

1. *General Specifications for Preparation of a Comprehensive Water Quality Management Plan* (COWAMP), Attachment A, Department of Environmental Resources, Commonwealth of Pennsylvania, Harrisburg, 1974.
2. Stewart, Robert H. and I. Metzer, "Industrial Water Resources," Paper presented at the Annual American Water Works Association Conference, Washington, D. C., June 23, 1970.
3. *Statewide Comprehensive Outdoor Recreation Plan* prepared by the Office of State Planning and Development, Commonwealth of Pennsylvania, Harrisburg, June, 1971.
4. *Outdoor Recreation Horizons,* Pennsylvania Department of Environmental Resources (formerly Forests and Waters), Commonwealth of Pennsylvania, Harrisburg, 1970.
5. *Outdoor Recreation for America,* A Report to the President and to the Congress by the Outdoor Recreation Resources Review Commission, Washington, D. C., January, 1962.
6. *Standard Methods for the Examination of Water and Wastewater,* Twelfth Edition, by APHA, AWWA and WPCF. American Public Health Association Inc., New York, New York, 1965.
7. Finck, John A. and W. H. Lee, "Reasonably Full Hydrologic Development of Reservoir Sites." *Water Resources Bulletin,* American Water Resources Association, Vol. 7, No. 2, April, 1972, pp. 285-293.
8. Bracken, Darcia Daines, "Social Goals and Evaluation of Resources Commitments," *Water Resources Bulletin,* American Water Resources Association, Vol. 9, No. 3, June, 1973, pp. 485-493.
9. Burke III, Roy, J. P. Heaney and E. E. Pyatt, "Water Resources and Social Choice," *Water Resources Bulletin,* American Water Resources Association, Vol 9, No. 3, June, 1973, pp. 433-447.
10. Nicholas, H. Coomber and A. K. Biswas, "Evaluation of Environmental Intangibles," General Press, Bronxville, New York, 1973.
11. Leopold, L. B., F. E. Clarke, B. B. Hanshaw and J. R. Balsley, *A Procedure for Evaluating Environmental Impact,* U. S. Department of the Interior, Geological Survey, Circular 645, Washington, D. C. 1971.
12. Whitman, Ira L., N. Dee, J. T. McGinnis, D. C. Fahringer and J. K. Baker, "Design of An Environmental Evaluation System." A Final Report to Bureau of Reclamation, U. S. Department of the Interior, Washington, D. C., June 30, 1971.
13. *Water Deficits for Urban Metropolitan Areas,* A Report Prepared by Anderson-Nichols for U. S. Army Corps of Engineers Northeast Water Supply Study, Contract No. DACW 52-71-C001, Corps of Engineers, North Atlantic Division, New York, New York, May, 1971, p.14.
14. Reberts, Wyndham J., S. C. Csallany and N. G. Towery, "Forecasting Water Demands," *Journal of Sanitary Engineering,* Vol. 96, SA 6 ASCE, December, 1970, pp. 1,349-1,360.
15. Csallany, Sandor C. and J. C. Neill, "Statistical Analysis of Water Consumption," *Water Resources Bulletin,* Vol. 8, No. 1, February, 1972, pp. 77-86.
16. O'Connor, J. D. and W. E. Dobbins, "Mechanism of Recreation in Natural Streams," Transactions American Society of Civil Engineers, Vol. 123, 1958, pp. 641-665.
17. Streeter, N. W. and E. B. Phelps, U. S. Public Health Service, Bulletin 146, 1925.

APPENDIX A

PLANNING STANDARDS AND CRITERIA

Appendix A-1

PUBLIC HEALTH SERVICE DRINKING WATER STANDARDS[a]—1962

Standards promulgated by the Public Health Service, U. S. Department of Health, Education, and Welfare, Effective April 5, 1962, for potable water used by carriers subject to the Federal Quarantine Regulations.

(Superseding Standards adopted Feb. 6, 1946)

A. BACTERIOLOGICAL QUALITY

The presence of organisms of the coliform group as indicated by samples examined shall not exceed the following limits:

1. When 10 ml standard portions are examined, not more than 10 percent in any month shall show the presence of the coliform group. The presence of the coliform group in three or more 10 ml portions of a standard sample shall not be allowable if this occurs:
   a. In two consecutive samples;
   b. In more than one sample per month when less than 20 are examined per month; or
   c. In more than 5 percent of the samples when 20 or more are examined per month.

   When organisms of the coliform group occur in 3 or more of the 10 ml portions of a single standard sample, daily samples from the same sampling point shall be collected promptly and examined until the results obtained from at least two consecutive samples show the water to be of satisfactory quality.

2. When 100 ml standard portions are examined, not more than 60 percent in any month shall show the presence of the coliform group. The presence of the coliform group in all five of the 100 ml portions of a standard sample shall not be allowable if this occurs:
   a. In two consecutive samples;
   b. In more than one sample per month when less than five are examined per month; or
   c. In more than 20 percent of the samples when five or more are examined per month.

   When organisms of the coliform group occur in all five of the 100 ml portions of a single standard sample, daily samples from the same sampling point shall be collected promptly and examined until the results obtained from at least two consecutive samples show the water to be of satisfactory quality.

3. When the membrane filter technique is used, the arithmetic mean coliform density of all standard samples examined per month shall not exceed one per 100 ml. Coliform colonies per standard sample shall not exceed 3/50 ml, 4/100 ml, 7/200 ml, or 13/500 ml in:
   a. Two consecutive samples;
   b. More than one standard sample when less than 20 are examined per month; or
   c. More than five percent of the standard samples when 20 or more are examined per month.

   When coliform colonies in a single standard sample exceed the above values, daily samples from the same sampling point shall be collected promptly and examined until the results obtained from at least two consecutive samples show the water to be of satisfactory quality.

B. PHYSICAL CHARACTERISTICS

Drinking water should contain no impurity which would cause offense to the sense of sight, taste, or smell. Under general use, the following limits should not be exceeded:

Turbidity	5 unit
Color	15 units
Threshold Odor Number	3

C. CHEMICAL CHARACTERISTICS

Drinking water shall not contain impurities in concentrations which may be hazardous to the

[a]Only limits are presented herein.

health of the consumers. It should not be excessively corrosive to the water supply system. Substances used in its treatment shall not remain in the water in concentrations greater than required by good practice. Substances which may have deleterious physiological effect, or for which physiological effects are not known, shall not be introduced into the system in a manner which would permit them to reach the consumer.

1. The following chemical substances should not be present in a water supply in excess of the listed concentrations where, in the judgment of the Reporting Agency and the Certifying Authority, other more suitable supplies are or can be made available.

Substance	Concentration in mg/1
Alkyl Benzene Sulfonate (ABS)	0.5
Arsenic (As)	0.01
Chloride (Cl)	250.
Copper (Cu)	1.
Carbon Chloroform Extract (CCE)	0.2
Cyanide (CN)	0.01
Fluoride (F)	(See fluoride)
Iron (Fe)	0.3
Manganese (Mn)	0.05
Nitrate (No_3)	45.
Phenols	0.001
Sulfate (SO_4)	250.
Total Dissolved Solids	500.
Zinc (Zn)	5.

2. The presence of the following substances in excess of the concentrations listed shall constitute grounds for rejection of the supply:

Substance	Concentration in mg/1
Arsenic (As)	0.05
Barium (Ba)	1.0
Cadmium (Cd)	0.01
Chromium (Hexavalent) (Cr^{+6})	0.05
Cyanide (CN)	0.2
Fluoride (F)	(See fluoride)
Lead (Pb)	0.05
Selenium (Se)	0.01
Silver (Ag)	0.05

3. Fluoride—When fluoride is naturally present in drinking water, the concentration should not average more than the appropriate upper limit in the Table. Presence of fluoride in average concentrations greater than two times the optimum values in the Table shall constitute grounds for rejection of the supply.

   Where fluoridation (supplementation of fluoride in drinking water) is practiced, the average fluoride concentration shall be kept within the following upper and lower control limits:

Annual average of maximum daily air temperatures[1]	Recommended control limits—Fluoride concentrations in mg/1		
	Lower	Optimum	Upper
50.0-53.7	0.9	1.2	1.7
53.8-58.3	0.8	1.1	1.5
58.4-63.8	0.8	1.0	1.3
63.9-70.6	0.7	0.9	1.2
70.7-79.2	0.7	0.8	1.0
79.3-90.5	0.6	0.7	0.8

D. RADIOACTIVITY

1. The effects of human radiation exposure are viewed as harmful and any unnecessary exposure to ionizing radiation should be avoided. Approval of water supplies containing radioactive materials shall be based upon the judgment that the radioactivity intake from such water supplies when added to that from all other sources is not likely to result in an intake greater than the radiation protection guidance[2] recommended by the Federal Radiation Council and approved by the President. Water supplies shall be approved without further consideration of other sources of radioactivity intake of Radium-226 and Strontium-90 when the water contains these substances in amounts not exceeding 3 and 10 $\mu\mu$c/liter, respectively. When these concentrations are exceeded, a water supply shall be approved by the certifying authority if surveillance of total intakes of radioactivity from all sources indicates that such intakes are within the limits recommended by the Federal Radiation Council for control action.
2. In the known absence[3] of Strontium-90 and alpha emitters, the water supply is acceptable when the gross beta concentrations do not exceed 1,000 $\mu\mu$c/liter. Gross beta concentrations in excess of 1,000 $\mu\mu$c/liter shall be grounds for rejection of supply except when more complete analyses indicates that concentrations of nuclides are not likely to cause exposures greater than the Radiation Protection Guides as approved by the President on recommendation of the Federal Radiation Council.

[1]Based on temperature data for a minimum of five years.

[2]The Federal Radiation Council, in its Memorandum for the President, Sept. 13, 1961, recommended that "Routine control of useful applications of radiation and atomic energy should be such that expected average exposures of suitable samples of an exposed population group will not exceed the upper value of Range II (20 $\mu\mu$c/day of Radium-226 and 200 $\mu\mu$c/day of Strontium-90)."

[3]Absence is taken here to mean a negligibly small fraction of the above specific limits, where the limit for unidentified alpha emitters is taken as the listed limit for Radium-226.

Appendix A-2

PLANNING CRITERIA FOR DETERMINATION OF THE ADEQUACY OF WATER SUPPLY SOURCES

It is recommended by the Water Supply Task Force that the proposed criteria be used for planning, including the development of the State Water Plan.

The proposed criteria are not intended, in present form, to be applied as part of State regulatory requirements. Because of the many parameters which should be considered in a regulatory system, it is necessary for each case to be given separate and individual consideration.

The criteria does not include an allowance for fire protection, since it is felt that this should be determined by each community in order to reflect the particular capabilities and needs of each locality.

A. SURFACE WATERS

1. *Trigger Point Criteria:*

   When the projected demand of a water supplier five years hence will equal net yield of the existing supply source(s), this constitutes a trigger point as which the source(s) would be considered inadequate in view of planning and construction schedules for the development of additional source capacity.

   Maximum daily demands should be used in the trigger point determination for those systems which take water directly from a stream. This can be determined by multiplying the average demand by the historic ratio of peak day to average day demands. Where this ratio is not known, it is suggested that the average daily demand should be multiplied by 2.0 to obtain peak demand for suppliers of less than 10 mgd., and 1.5 for those over 10 mgd. For those suppliers which have *sufficient storage facilities* only the daily water requirements need to be met. Sources such as reservoirs, lakes and other large impoundments need only meet the average daily requirement.

2. *Selection of Reference Gaging Station:*

   Whenever an intake or a reservoir is located on an ungaged watershed, selection of a reference gaging station is required. The station must be one of the stations used in the DER Water Resources Bulletin No. 7, Long-Duration Low Flow of Pennsylvania Streams, or the Water Resources Bulletin No. 1, and must have similar conditions in geology and climate as suggested in Bulletin No. 7.

3. *Net Yield for Reservoirs:*

   The net yield shall be determined based on a 50-year drought having a duration which is critical for the amount of active storage provided in the reservoir. Yield-storage-frequency relationships have been developed for 143 streams by the Department of Environmental Resources. Gross yields for water supply reservoirs can be determined directly from these curves. However, to determine net reservoir yields storage for required releases, evaporation, seepage and sedimentation must also be taken into account.

   The net reservoir yield is determined as follows:

   a. Determine the critical duration from yield-storage-frequency curves.

   b. Determine storage required for conservation released by multiplying the duration by the required release (.15 csm is the normal conservation release).

   c. Determine storage required for evaporation by the method described in Water Resources Bulletin No. 7.

   d. Determine the dead storage required for sediment. The U. S. G. S. sediment report currently under preparation is recommended.

   e. Determine the amount of storage required for seepage. Unless the permeability coefficient, or measured seepage is known, this can usually be considered negligible. Where the permeability coefficient is known, use Darcy's equation to compute seepage.

   f. Subtract storage determined in steps b through e from the reservoir storage to find usable water storage.

   g. Select a reference stream gage and determine the net yield by entering the yield-storage-frequency curve at the intersection of the 50-year return period with the usable water supply storage of the reservoir.

4. *Net Yield for Streams:*

The criterion for sources that are taken directly from streams or rivers with little or no impoundment shall be based on a 50-year, 7-day flow rate. It is suggested that "Water Resources Bulletin No. 1, Pennsylvania Streamflow Characteristics-Low Flow Frequency and Flow Duration," published by the Pennsylvania Department of Forests and Waters in April 1966, be used as the primary reference. When more updated information on low flow frequency and duration is available, it should be used. Normally, this can be obtained from the Harrisburg office of the U. S. Geological Survey.

5. *Additional Considerations:*

When flow augmentation, diversions, or other complexities affect the flow conditions, the situation should be analyzed appropriately and consistent with the intent of these minimum criteria.

B. GROUND WATER

All public supplies depending entirely on ground water should be able to meet the following criteria:

1. In the event of a power failure the system shall be able to meet the average demand for 24 hours. This may be achieved by using elevated storage, by using auxiliary power for pumping, or by interconnections to other public supplies that have full auxiliary power or elevated storage.
2. To guard against well (or spring) failure or contamination, the system must be able to meet the peak daily demand with the best well (or spring) out of service. The capacity of interconnections to any other public supply may be used in lieu of system capacity.
3. In addition to the above criteria, the total capacity of wells, springs and interconnections to other public supplies must exceed the peak daily demand by 20 percent.
4. Where long-term records of pumpage are available, the capacity of a well or group of wells can be based on the maximum amount of water that could be pumped from the well during drought periods. Where pumpage records are not available or valid the combined yield of the wells shall be obtained from a pump test which should entail at least 48 hours of continual and simultaneous pumping of all the wells at times of low water table (usually during late summer or early fall). The capacity of a spring shall be the lowest flow on record and modified by any limitations of the collection installation.
5. Each well shall be so constructed that measurements can be made of the depth to water in the well. Daily measurements of water level and pumpage shall be made and records of these measurements shall be maintained to provide a history of well-field operation.

Appendix A-3

LOW FLOW CRITERIA

It is recommended by the Low Flow Task Force that the proposed criteria be used for planning and as a general guide for regulating water resources of the State. The criteria are established to protect and enhance the streamflow for many instream and downstream uses.

For reservoirs, a conservation release of a *specified discharge* is required regardless of the amount of inflow. For diversions, however, the criteria require the passing of the natural flow when it is below a *specified discharge*. Both the specified discharges can be determined from Figure 10.

The right-hand side of the graph prescribes the release requirement from a dam and reservoir. The amount of release in cubic feet per second per square mile of the drainage area (CSM) depends upon the natural $Q_{7\text{-}10}$* of the stream at the reservoir site and the storage capacity expressed as percent of average annual runoff retained as conservation storage. Conservation storage includes active storages for all purposes except for flood control. The $Q_{7\text{-}10}$ should take into account the effect of any upstream augmented flow at the time of consideration. The $Q_{7\text{-}10}$ may be found or extrapolated from Water Resources Bulletin No. 1. For example:

Assume that a dam is located in an area where the average annual runoff is 20 inches and the $Q_{7\text{-}10}$ including regulated flow is 0.10 CSM. If the reservoir retains a storage of 10-inch runoff from the drainage area above the dam, the percent difference between the $Q_{7\text{-}10}$ and .25 CSM (PDF) can be determined by the intersection of a vertical line drawn from 50 percent (10 inches/20 inches) point, and the curve, which is 80 percent or 0.8. The re-

*Average consecutive seven-day low flow having a ten-year return period or a 10 percent chance of occurrence each year.

lease requirement, therefore, is $Q_{7\text{-}10}$ + PDF $(0.25 - Q_{7\text{-}10}) = 0.10 + 0.8\ (0.25 - 0.10) = 0.1 + 0.12 = 0.22$ CSM.

Discharges below which compensation for consumptive use is required to maintain the natural flow are specified on the left-hand side of the graph. For water-quality-limited streams or reaches, this discharge is 100 percent of the $Q_{7\text{-}10}$. However, for effluent-limited streams or reaches, depending upon the size of drainage area, this discharge may be reduced to 65 percent of the $Q_{7\text{-}10}$. In order to prevent further degradation of water quality, diverted flow from an effluent-limited reach upstream from a water-quality-limited reach should be returned to the stream before it enters the water-quality-limited reach. For example:

Assume a company needs water from Stream A which is classified by the Department as an effluent-limited stream. If $Q_{7\text{-}10} = 0.1$ CSM and the drainage area above the point of diversion is 100 square miles or $Q_{7\text{-}10} = 0.1 \times 100 = 10$ cfs then the curve indicates that the specified discharge is about 90 percent of the $Q_{7\text{-}10}$ or 9 cfs. Further assuming 0.5 cfs as the consumptive water use, the company may divert the flow without compensating for the consumptive use if the stream flow is equal to or greater than 9.5 cfs. When the stream flow is less than 9.5 cfs, diversion is allowed only if the consumptive water use is properly compensated for. The entire diversion is considered consumptive if the discharge point of the returned flow is far enough from the point of diversion to interrupt the downstream and instream uses, or if the water is diverted from one basin but discharged at the other basin.

The following requirements accompany the criteria:

1. When storage capacity of an impoundment is exhausted, it becomes subject to regulation as a diversion.
2. The taking of water from a stream and returning it in the same immediate vicinity undiminished in quantity and quality is a diversion to which the above criteria do not apply.
3. The incremental future consumptive uses shall be compensated.

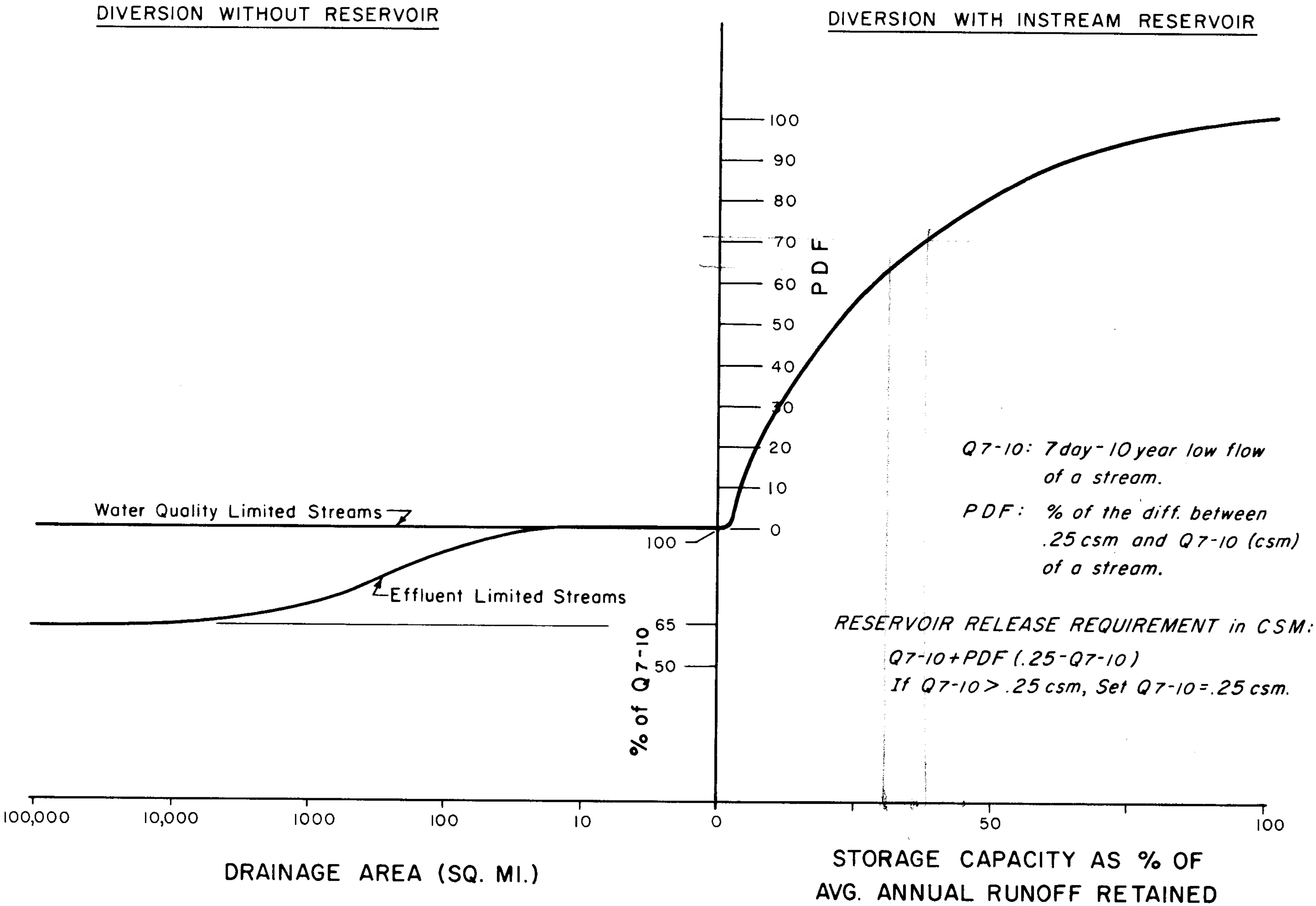


Figure 10 Low Flow Criteria

Appendix A-4

RECREATION PARTICIPATION[a] AND ACTIVITY STANDARD

Recreation Participation

Regional Participation Rate (Age Group 12 and Over)

Office of State Planning and Development Planning Regions[b]

Year 1960	1	2	3	4	5	6	7	8	9	10	11	12	13	State Aver-age
Picnics	63.8	55.6	44.2	45.5	50.3	54.5	47.4	53.6	51.1	45.9	48.8	60.2	56.1	57.0
Camping	5.2	4.5	3.6	3.7	4.1	4.4	3.8	4.3	4.1	3.7	3.9	4.9	4.5	4.6
Swimming	58.8	51.2	40.7	41.9	46.3	50.2	43.7	49.4	47.0	42.3	45.0	55.5	51.7	52.5
Boating	5.0	4.4	3.5	3.6	4.0	4.3	3.7	4.2	4.0	3.6	3.9	4.8	4.4	4.5
Fishing	6.9	9.9	15.8	16.4	9.9	12.0	13.7	12.6	13.6	15.4	12.7	8.9	10.6	9.5
Year 1976														
Picnics	67.5	60.7	52.2	48.2	55.4	60.0	51.4	56.7	54.2	49.8	52.3	62.6	63.2	61.0
Camping	5.5	5.0	4.3	4.0	4.5	4.9	4.2	4.7	4.4	4.1	4.3	5.1	5.2	5.0
Swimming	68.6	61.7	53.0	49.0	56.4	60.9	52.3	57.7	55.1	50.6	53.2	63.6	64.2	62.0
Boating	6.0	5.5	4.7	4.3	5.0	5.4	4.6	5.1	4.9	4.5	4.7	5.6	5.7	5.5
Fishing	6.6	10.0	15.0	18.0	10.1	11.7	14.2	12.3	14.3	16.6	13.5	8.8	10.7	9.5
Year 1985														
Picnics	70.4	63.7	54.7	50.4	59.9	64.5	54.8	60.6	57.7	53.3	56.2	66.0	67.9	65.0
Camping	8.7	7.8	6.7	6.2	7.4	7.9	6.7	7.5	7.1	6.6	6.9	8.1	8.4	8.0
Swimming	70.4	63.7	54.7	50.4	59.9	64.5	54.8	60.6	57.7	53.3	56.2	66.0	67.9	65.0
Boating	6.5	5.9	5.1	4.7	5.6	6.0	5.1	5.6	5.3	4.9	5.2	6.1	6.3	6.0
Fishing	7.5	11.6	16.7	21.7	11.7	13.3	16.6	14.2	17.1	20.0	16.0	9.8	12.3	10.5
Year 2000														
Picnics	72.9	67.3	53.5	55.1	60.9	66.0	57.4	64.9	61.9	55.6	59.1	72.9	68.0	69.0
Camping	12.7	11.7	9.3	9.6	10.6	11.5	10.0	11.3	10.8	9.7	10.3	12.7	11.8	12.0
Swimming	73.9	68.3	54.3	55.9	61.7	66.9	58.2	65.9	62.8	56.4	60.0	74.0	69.0	70.0
Boating	6.8	7.3	5.8	6.0	6.6	7.2	6.2	7.1	6.7	6.1	6.4	7.9	7.4	7.5
Fishing	8.5	13.3	18.5	27.0	13.2	15.2	19.5	16.5	21.2	24.9	19.5	11.1	14.0	12.0

Participation Rates (Age Group 5-11): No Regional Differences

	1960	1976	1985	2000
Picnics	57.0	61.0	65.0	69.0
Camping	4.6	5.0	8.0	12.0
Swimming	90.0	90.0	90.0	90.0
Boating	4.5	5.5	6.0	7.5
Fishing	9.5	9.5	10.5	12.0

Average Number of Days Per Participant Per Season (Age Group 12 and Over): No Regional Differences

	1960	1976	1985	2000
Picnics	4.8	6.0	8.0	10.0
Camping	7.3	8.0	9.0	10.0
Swimming	11.9	16.0	18.0	22.0
Boating	9.1	10.3	10.7	12.0
Fishing	9.1	10.3	10.7	12.0

Average Number of Days Per Participant Per Season (Age Group 5-11): No Regional Differences

	1960	1976	1985	2000
Picnics	4.8	6.0	8.0	10.0
Camping	7.3	9.0	9.0	10.0
Swimming	20.0	26.9	30.0	37.0
Boating	9.1	10.3	10.7	12.0
Fishing	9.1	10.3	10.7	12.0

[a]Participation rate and frequency are being updated in the current SCORP activity.

[b]Planning areas are shown on Figure 11. These regions have been replaced by the 10 uniform regions shown in Figure 1.

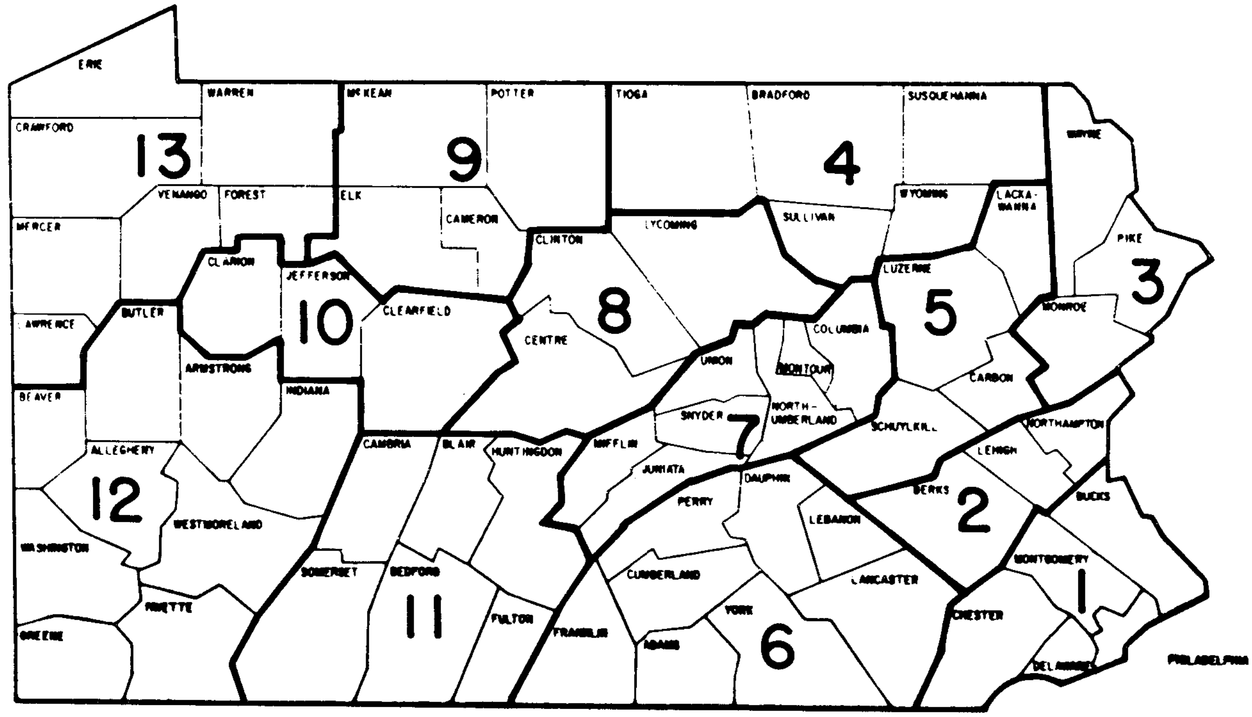


Figure 11 Office of State Planning and Development Planning Regions

ACTIVITY STANDARD METHODOLOGY

Activity	Units Per Acre	People Per Unit	Turnover Factor	Recreation Days/Week	Weeks Per Summer Season
Picnicking					
High Density	18	4.5/table	1.5	3	13
Medium Density	15	4.5/table	1.5	2.5	13
Low Density	10	4.5/table	1	2	13
Camping					
High Density	10	4/site	1	3.5	13
Medium Density	8	4/site	1	3	13
Low Density	6	4/site	1	3	13
Swimming—Beach					
High Density	—	5[a](20)[b]/ft	2	2.5	13
Medium Density	—	3(12)/ft	2	2.5	13
Low Density	—	2(8)/ft	2	2.5	13
Swimming—Pool					
High Density		.04[a](.12)[b]/ft^2	3	3.5	13
Medium Density		.04(.12)/ft^2	3	3.0	13
Low Density	1 acre = 43,560 ft^2	.04(.12)/ft^2	3	2.5	13
Boating—Non-Power					
High Density	2	2/boat	2	2.5	13
Medium Density	1⅓	2/boat	2	2.5	13
Low Density	1	2/boat	2	2.5	13
Boating—Limited Power					
High Density	1	3/boat	2	2.5	13
Medium Density	⅔	3/boat	2	2.5	13
Low Density	½	3/boat	2	2.5	13
Boating—Unlimited[c]					
High Density	½	3.5/boat	2	2.5	13
Medium Density	⅓	3.5/boat	2	2.5	13
Low Density	⅕	3.5/boat	2	2.5	13
Fishing	No standard has been established as yet. Usage estimates are provided by the Pennsylvania Fish Commission.				

[a]The figure represents the number of swimmers each *water* unit accommodates.

[b]The figure in the parenthesis indicates the total number of swimmers each unit facility accommodates, taking into account swimmers who are on the beach, back-up and buffer areas or land area surrounding a pool.

[c]Unlimited Power boat is a powered boat with a motor greater than 10 horsepower.

SUGGESTED STANDARDS FOR THE 10 UNIFORM REGIONS

Uniform Region	1	2	3	4	5	6	7	8	9	10
Standard for All Activities	H	H	M	L	L	M	M	L	M	H

where H—High Density (Low Standard), M—Medium Density (Medium Standard), and L—Low Density (High Standard)

Appendix A-5

STATE RESPONSIBILITY IN SUPPLYING RECREATION FACILITIES[a]

Department of Environmental Resources (%)

Uniform Region	Picnicking	Camping	Swimming	Boating[b]	Fishing[b]
1	33	50	12	5	5
2	33	50	12	5	5
3	33	50	12	5	5
4	40	50	12	5	5
5	40	50	12	5	5
6	33	50	12	5	5
7	33	50	12	5	5
8	40	50	12	5	5
9	33	50	18	5	5
10	33	50	12	5	5

[a]Being updated in conjunction with the current SCORP activity.

[b]The percents responsible for boating and fishing do not reflect the true State Responsibility. Those responsibilities of the Pennsylvania Fish Commission are shown below:

Pennsylvania Fish Commission

	Fishing
Stocking	85%
Access	65%
Patrolling	90%

	Boating
Facilities	50%
Patrolling	100%

Appendix A-6

SUGGESTED CRITERIA FOR BASIC STATEWIDE ACCESS AREA PLAN

Access areas can be classified into three basic types; namely, (A) fishing and canoeing areas (no power units), (B) fishing and pleasure boating use and (C) pleasure boating use. All areas investigated must have water quality, area, and depth acceptable for the intended use.

Areas will be geographically located so as to best serve the public, but in any given area, the investigation team should search for the best sections of the waterway prior to examining specific land areas. The overall acquisition and development cost estimates will be analyzed and sound overall judgment used to determine the final choice of land areas to be purchased.

A priority list will be necessary to guide the investigation team so as to perform the work as economically as possible.

The following general acquisition and development criteria shall be used as a guide during the investigation and acquisition stages of all land to be purchased, except that in highly populated areas, such as Pittsburgh, acquisition costs, area sizes, etc., shall be fitted to available sites. This does not necessarily preclude the acquisition of areas for parking where public launching facilities are available.

A. FISHING AID CANOEING

1. *Acquisition Criteria*
    - a. Provide adequate public walk-in access
    - b. Provide for 15-car parking area development (if adequate adjacent public parking is not available)
    - c. Control shoreline (including wading and boating privileges upstream and downstream except on lake access areas)
    - d. Area must be located preferably within 600 feet of an existing public road
2. *Development Required* (minimum)
    - a. Parking for 15 cars (if not otherwise available)
    - b. Clearing for access
    - c. Signs (including waterfront signs)

B. FISHING AND PLEASURE BOATING

1. *Acquisition Criteria*
    - a. Public road preferably within ½ mile
    - b. Provide sufficient area for access road development
    - c. Provide sufficient area for complete 50-car capacity development (includes adjacent available free public parking)
    - d. Minimum shoreline of 200 lineal feet
    - e. Located at least ½ mile from existing commercial access
    - f. Located at least 1 mile from publicly-owned land that could be developed economically
2. *Development Required* (minimum)
    - a. Access road
    - b. Parking area for 50 cars
    - c. Boat launching ramp, 24 feet in width
    - d. Landing and loading dock, 80 feet in length
    - e. Mooring area and cable, 80 feet in length
    - f. Sanitary facilities
    - g. Picnic area
    - h. Signs

C. PLEASURE BOATING

1. *Acquisition Criteria*
    - a. Public road preferably within ½ mile
    - b. Provide sufficient area for access road development
    - c. Provide sufficient area for complete 50 cars with trailer development (includes adjacent available free public parking)
    - d. Minimum shoreline of 200 lineal feet
    - e. Located at least ½ mile from existing commercial access
    - f. Located at least 1 mile from publicly-owned land that could be developed economically
2. *Development Required* (minimum)
    - a. Access road
    - b. Parking for 50 cars with trailers
    - c. Boat launching ramp, 40 feet in width
    - d. Two landing and loading docks, 80 feet in length
    - e. Sanitary facilities
    - f. Picnic area
    - g. Signs

It should be noted that the publication of the Fish Commission's planning criteria for acquisition and development for areas giving access to fishermen and boaters on public waters of the Commonwealth in no way relinquishes the Commission's jurisdiction over these projects and that the Fish Commission retains the authority to depart from such criteria whenever the Commission's investigations show such changes to be made in the best long range interest of the fishing and boating public.

Appendix A-7

WILD AND SCENIC RIVERS CLASSIFICATION CRITERIA

The Wild and Scenic Rivers Task Force recommended the following classification criteria. These criteria were approved by the Environmental Quality Board at the May 16, 1974 meeting.

ALL CLASSIFICATIONS

1. *Water Volume*

   A river preferably should have *sufficient volume of water* during normal years to permit, during the recreation season, full enjoyment of water-related outdoor recreational activities generally associated with comparable rivers. Flow augmentation is acceptable if water volume is inadequate for boating and additional water supply can be provided reasonably and economically without diminishing the scenic, recreation, fish and Wildlife, or other values of the segment.

2. *Length*

   A river or river segment must be long enough to provide a rewarding recreational experience. Generally, in urban areas, any segment included in the rivers system should be *at least 5 miles long*. In outer urban areas, a segment should be *at least 15 miles long*. Rural areas should include river segments *at least 25 miles in length*. For either urban, outer-urban or rural segments, a shorter stretch that possesses most of the desired outstanding qualifications and values may be considered for inclusion in the system.

WILD CLASSIFICATION

Wild rivers provide free-flowing water that supports water based recreation and fish and wildlife native to the segment. The shorelines visible from the river or its edge present a pleasing pristine view. Segment access is by foot and/or non-powered water craft.

1. *Impoundments:*

   Free-Flowing; low dams, diversion works, or other structures are not permitted. Future construction within the segment restricted. Upstream impoundment construction shall be contingent on environmental or other adverse impacts.

2. *Water Quality:*

   Water Quality must be capable of meeting *minimum criteria for desired types of recreational use, especially primary contact recreation*, except where such criteria would be exceeded by natural background conditions. In addition, the water presently must be capable of supporting the *propagation of aquatic life, including fish which normally would be adapted to the habitat of the stream* under the most desirable natural quality conditions.

3. *Development:*

   Shorelines or watersheds essentially primitive. Shorelines are free of habitation and other substantial evidence of man's intrusion, including waterway modification with a direct and adverse effect on values. Watershed natural-like in appearance. A limited amount of livestock grazing and hay production, and one or two inconspicuous dwellings permitted. All conservation methods employed must be in keeping with the river environment.

4. *Accessibility:*

   Generally inaccessible by road. No roads or other provisions for overland motorized travel permitted within a narrow incised river valley, or if the river valley is broad, within ¼ mile of, and parallel to, the river bank for a distance of about 1 mile. The presence, however, of one or two inconspicuous roads leading to the river area may be permissible.

SCENIC CLASSIFICATION

Scenic rivers contain free-flowing water that can or is being restored to support water based recreation and fish and aquatic life. The view from the river or its banks is a pleasant intermixture that is still predominately wild, but contains some pastoral countryside. The segment is accessible intermittently by roads.

1. *Impoundment:*

   Free-flowing stream; low dams, diversion works, or other structures are not permitted. Future construction within segment restricted. Upstream impoundment construction may be contingent on adverse impacts.

2. *Water Quality:*

   Water Quality should be capable of meeting minimum criteria for desired types of recreation, except where such criteria would be exceeded by natural background conditions.

In addition, the water should be capable of supporting *propagation of aquatic life normally adapted to habitat of the stream* or capable of being restored to that quality.

3. *Development:*

   Shorelines or watersheds largely primitive. Shorelines still present an overall natural character, but some agricultural land and a modest amount of waterway modification permitted. Small communities or any concentration of habitation must be limited to relatively short stretches. Watersheds with a minimum of easily discernible development. Row crops, timber harvest, and other resource use permitted if accomplished without a substantially adverse effect on natural appearance.

4. *Accessibility:*

   Accessible by roads, which may occasionally bridge river area. Short stretches of conspicuous or longer stretches of inconspicuous and well-screened roads or railroads paralleling the river area may be permitted.

RECREATION CLASSIFICATION

Recreational rivers provide interesting combinations of free-flowing with relatively short stretches of impounded water that can or are being restored to sustain suitable recreation and aquatic and fish life. The visible shorelines, with considerable human modifications, still blend into a pleasant readily accessible river landscape.

1. *Impoundments:*

   Water should essentially not have characteristics of an impoundment for any significant distance, if an impoundment is present. Future construction within the segment restricted.

2. *Water Quality:*

   Water Quality should be capable of meeting *minimum criteria for desired types of recreation,* except where such criteria would be exceeded by natural background conditions. In addition, the water should be capable of supporting *propagation of aquatic life normally adapted to habitat of the stream* or is capable of and is being restored to that quality.

3. *Development:*

   Shorelines may be extensively developed. Lands may be developed for the full range of agricultural uses and could include small residential developments.

4. *Accessibility:*

   Readily accessible, with likelihood of paralleling roads or railroads along river banks, possibility of several bridge crossings and numerous river access points.

MODIFIED RECREATION CLASSIFICATION

Modified recreational rivers offer calm water than can or is being restored to support appropriate water-based recreation and fish life. Visible shoreline development may be extensive provided it does not inhibit public use or detract from their enjoyment of the river.

1. *Impoundments:*

   Water may have characteristics of an impoundment. Flow may be regulated by upstream control devices. Low dams are permitted if river remains in full-bank width during period of normal flow.

2. *Water Quality:*

   Water Quality should be capable of meeting *minimum criteria for desired types of recreation,* except where such criteria could be exceeded by natural background conditions. In addition, the water should be capable of supporting *propagation of aquatic life normally adapted to habitat of the stream* or capable of, and in process of being restored to that quality.

3. *Development:*

   Shorelines may be extensively developed. Lands may be developed for the full range of agricultural uses and could include small communities as well as dispersed or clustered residential commercial-industrial development.

4. *Accessibility:*

   Readily accessible with likelihood of paralleling roads or railroads along river banks, possibility of several bridge crossings and numerous river access points.

Appendix A-8

WATER USES AND WATER QUALITY CRITERIA

The following is an excerpt from Chapter 93—WATER QUALITY CRITERIA of the Rules and Regulations of the Department of Environmental Resources. The provisions of this Chapter set forth water quality criteria for the waters of this Commonwealth. These criteria are based upon water uses which are to be protected and shall be considered by the Department in its regulation of discharges.

* * * * *

§ 93.2. Protected water uses.

Water uses which shall be protected, and upon which the development of water quality criteria shall be based, are set forth, accompanied by their identifying symbols, in the following Table 1:

TABLE 1

Symbol — Protected Use

1.0—*Aquatic Life*

- 1.1—*Cold Water Fishes.* Maintenance and propagation of the family *Salmonidae* and fish food organisms.
- 1.2—*Warm Water Fishes.* Maintenance and propagation of fish food organisms and all families of fishes except *Salmonidae.*
- 1.3—*Migratory Fishes.* Passage, maintenance and propagation of anadromous and catadromous fishes, and other fishes which ascend to flowing waters to complete their life cycle.
- 1.4—*Trout* (Stocking only). Warm water fishes and trout stocking.

2.0—*Water Supply*

- 2.1—*Domestic Water Supply.* Use by humans after conventional treatment for drinking, culinary and other purposes.
- 2.2—*Industrial Water Supply.* Use by industry for inclusion into products, processing and cooling.
- 2.3—*Livestock Water Supply.* Use by livestock and poultry for drinking and cleansing.
- 2.4—*Wildlife Water Supply.* Use for waterfowl habitat and by wildlife for drinking and cleansing.
- 2.5—*Irrigation.* Used to supplement precipitation for growing of crops.

3.0—*Recreation*

- 3.1—*Boating.* Power boating, sail boating, canoeing and rowing for recreational purposes.
- 3.2—*Fishing.* Use of the water for the legal taking of fish.
- 3.3—*Water Contact Sports.* Use of the water for swimming and related activities.
- 3.4—*Natural Area.* Use of the water as an esthetic setting to recreational pursuits.
- 3.5—*Conservation Area.* Waters used within and suitable for the maintenance of an area now or in the future to be kept in a relatively primitive condition.

4.0—*Other*

- 4.1—*Power.* Use of the water energy to generate power.
- 4.2—*Navigation.* Use of the water for the commercial transfer and transport of persons, animals and goods.
- 4.3—*Treated Waste Assimilation.* Use of the water for the assimilation and transport of treated waste waters.

§ 93.3. Standard water uses.

(a) Those uses followed by an "X" in Table 2 in subsection (c) of this section were considered in determining the water quality criteria applicable to the particular waters listed in § 93.6 of this Title (relating to specific waters) except where otherwise indicated in such section.

(b) Those uses followed by an "O" in Table 2 in subsection (c) of this section were considered only where specifically set forth in § 93.6 of this Title (relating to specific waters).

(c) The following Table 2 shall show standard water uses and their symbols:

TABLE 2

Category	Where Considered
1.0—*Aquatic Life*	
1.1 Cold Water Fish	O
1.2 Warm Water Fish	X
1.3 Migratory Fish	O
1.4 Trout (Stocking Only)	O
2.0—*Water Supply*	
2.1 Domestic	X
2.2 Industrial	X
2.3 Livestock	X
2.4 Wildlife	X
2.5 Irrigation	X

TABLE 2—Continued

Category	Where Considered
3.0—*Recreation*	
3.1 Boating	O
3.2 Fishing	X
3.3 Water Contact Sports	X
3.4 Natural Area	X
3.5 Conservation Area	O
4.0—*Other*	
4.1 Power	X
4.2 Navigation	O
4.3 Treated Waste Assimilation	X

§ 93.4. General water quality criteria.

(a) Water shall not contain substances attributable to municipal, industrial or other waste discharges in concentration or amounts sufficient to be inimical or harmful to the water uses to be protected or to human, animal, plant or aquatic life.

(b) Specific substances to be controlled shall include, but shall not be limited to, floating debris, oil, scum and other floating materials, toxic substances and substances which produce color, tastes, odors, turbidity or settle to form sludge deposits.

§ 93.5. Specific water quality criteria.

(a) Waters of this Commonwealth for which specific criteria have been established are listed in § 93.6 of this Title (relating to designated water uses).

(b) References to specific criteria shall be keyed to the standard list of specific criteria set forth in subsection (c) of this section and to the groups of criteria set forth in subsection (d) of this section.

(c) The following Table 3 shall display the standard list of specific water quality criteria:

TABLE 3

Symbol	Item	Criteria
a	*pH*	
		a_1 — Not less than 6.0 and not more than 8.5.
		a_2 — Not less than 6.5 and not more than 8.5.
		a_3 — Not less than 7.0 and not more than 9.0.
b	*Dissolved Oxygen*	
		b_1 — Minimum daily average 6.0 mg/l; no value less than 5.0 mg/l.
		b_2 — Minimum daily average 5.0 mg/l; no value less than 4.0 mg/l.
		b_3 — Minimum daily average not less than 5.0 mg/l; during periods 4/1 to 6/15 and 9/16 to 12/31, not less than 6.5 mg/l as a seasonal average.

TABLE 3—Continued

Symbol	Item	Criteria
		b_4 — Minimum daily average not less than 3.5 mg/l; during periods 4/1 to 6/15 and 9/16 to 12/31, not less than 6.5 mg/l as a seasonal average.
		b_5 — For the period 2/15 to 7/31 of any year minimum daily average of 6.0 mg/l, no value less than 5.0 mg/l. For the remainder of the year minimum daily average of 5.0 mg/l, no value less than 4.0 mg/l.
		b_6 — No value less than 7.0 mg/l.
		b_7 — For the epilimnion of lakes, ponds, and impoundments, minimum daily average of 5.0 mg/l, no value less than 4.0 mg/l.
		b_8 — For lakes, ponds and impoundments only, no value less than 5.0 mg/l at any point.
		b_9 — Minimum daily average 7.0 mg/l, no value less than 6.0 mg/l.
c	*Iron*	
		c_1 — Total iron not more than 1.5 mg/l.
		c_2 — Dissolved iron not more than 0.3 mg/l.
d	*Temperature*	
		d_1 — Not more than 5° F. rise above ambient* temperatures; not to be increased by heated waste discharges to temperatures in excess of 58° F.; not to be changed by more than 2° F. during any one-hour period.
		d_2 — Not more than a 5° F. rise above ambient* temperature or a maximum of 87° F., whichever is less; not to be changed by more than 2° F. during any one-hour period.
		d_5 — Not to exceed the following temperatures in the month indicated:

Month	Temperature, °F.
January	50
February	50
March	60
April	70
May	80
June	90
July	90
August	90
September	90
October	78
November	70
December	57

* ambient temperature—The temperature of the water body upstream of a heated waste discharge or waste discharge complex. The ambient temperature sampling point should be unaffected by any sources of waste heat.

d_6 — For the period 2/15 to 7/31 not more than 5° F. rise above ambient temperature or a maximum of 74° F., whichever is less, not to be changed by more than 2° F. during any one-hour period; for the remainder of the year not more than a 5° F. rise above ambient temperature or a maximum of 87° F., whichever is less, not to be changed by more than 2° F. during any one-hour period.

d *Temperature*

d_7 — Not more than 5° F. above the average daily temperature during the 1961-66 period which is shown below or a maximum of 86° F., whichever is less.

Average Daily Temperature
1961-1966
(Temperatures may be interpolated)

Date	Zones 01.040 and 01.050, Delaware Estuary, Head of tide to River Mile 108.4 (about 1 mile below Pennypack Creek)	Zone 01.030, Delaware Estuary, River Mile 108.4 (about 1 mile below Pennypack Creek) to Big Timber Creek	Zones 01.010 and 01.020, Delaware Estuary, From Big Timber Creek to Pennsylvania-Delaware State Line
	°F.	°F.	°F.
January 1	37	41	42
February 1	35	35	36
March 1	38	38	40
April 1	46	46	47
May 1	58	58	58
June 1	71	71	72
July 1	79	79	80
August 1	81	81	81
September 1	78	79	78
September 15	76	77	76
October 1	70	70	70
November 1	59	61	60
December 1	46	50	50
December 15	40	45	45

d_8 — Not more than 5° F. rise above the ambient temperatures until stream temperatures reach 50° F., nor more than 2° F. when temperatures are between 50° F. and 58° F., nor shall such temperatures exceed 58° F., whichever is less, except in designated heat dissipation areas.

d_9 — As a guideline the maximum length of heat dissipation areas shall not be longer than 3,500 feet measured

TABLE 3—Continued

from the point where the waste discharge enters the stream. The width of heat dissipation areas shall not exceed two-thirds the surface width measured from shore to shore at any stage of tide or the width encompassing one-fourth the cross-sectional area of the stream, whichever is less. Within any one heat dissipation area only one shore shall be used in determining the limits of the area. Where waste discharges are close to each other, additional limitations may be prescribed to protect stream uses. Controlling temperatures shall be measured outside the heat dissipation area. The rate of temperature change in the heat dissipation area shall not cause mortality of the fish.

d_{10}— As a guideline the maximum length of heat dissipation areas shall not be longer than 3,500 feet or twenty times the average stream width, whichever is less, measured from the point where the waste discharge enters the stream. Heat dissipation areas shall not exceed one-half the surface stream width or the width encompassing one-half of the entire cross sectional area of the stream, whichever is less. Within any one heat dissipation area, only one shore shall be used in determining the limits of the area. Where waste discharges are close to each other additional limitations may be prescribed to protect water uses. Controlling temperatures shall be measured outside the heat dissipation zone. The rate of temperature change in designated heat dissipation areas shall not cause mortality of the fish.

d_{11}— As a guideline the maximum length of heat dissipation areas shall not be longer than 1,000 feet or twenty times the average width of the stream, whichever is less, measured from the points where the waste discharge enters the stream. Heat dissipation areas shall not exceed one-half the surface stream width or the width encompassing one-half of the entire cross sectional area of the stream, whichever is less. Within any one heat dissipation area, only one shore shall be used in determining the limits of the area. Where waste discharges are close to each other, additional limitations may be prescribed to protect water uses. Controlling temperatures shall be measured outside the heat dissipation zone. The rate of temperature change in designated heat dissipation areas shall not cause mortality of the fish.

e *Dissolved Solids*

- e_1 — Not more than 500 mg/l as a monthly average value; not more than 750 mg/l at any time.
- e_2 — Not more than 1,500 mg/l at any time.
- e_3 — Not to exceed 133 percent of background or 500 mg/l, whichever is less.
- e_4 — Not to exceed 133 percent of background.

f *Bacteria*

- f_1 — The fecal coliform density in five consecutive samples shall not exceed a geometric mean of 200 per 100 ml.
- f_2 — (Coliforms/100 ml)—Not more than 5,000/100 ml as a monthly average value, nor more than this number in more than 20% of the samples collected during any month, nor more than 20,000/100 ml in more than 5% of the sample.
- f_3 — (Coliforms/100 ml)—Not more than 5,000/100 ml as a monthly geometric mean.
- f_4 — (Fecal coliforms/100 ml)—Maximum geometric mean of 770/100 ml; samples shall be taken at a frequency and location to permit valid interpretation.

g *Turbidity*

- g_1 — Not more than 30 units during the period 5/30 to 9/15, nor more than a monthly mean of 40 units or a maximum of 150 units during the remainder of the year.
- g_2 — Maximum monthly mean 40 units, maximum value not more than 150 units.
- g_3 — Not more than 100 units.
- g_4 — For the period 5/15 to 9/15 of any year, not more than 40 units; for

the period 9/16 to 5/14 of any year, not more than 100 units.

- g_5 — Maximum monthly mean of 10 units, maximum 150 units unless exceeded by natural conditions.
- g_6 — Maximum monthly mean of 20 units, maximum of 150 units, unless exceeded by natural conditions.
- g_7 — Maximum monthly mean of 30 units, maximum of 150 units, unless exceeded by natural conditions.

h *Threshold Odor Number*

Not more than 24 at 60° C.

i *Alkalinity*

- i_1 — Not less than 20 mg/l.
- i_2 — Between 20 and 120 mg/l.
- i_3 — Between 20 and 100 mg/l.

j *MBAS (Methylene Blue Active Substance)*

- j_1 — Not more than 0.5 mg/l.
- j_2 — Not more than 1.0 mg/l.

k *Total Manganese*

Not more than 1.0 mg/l.

l *Fluoride*

Not more than 1.0 mg/l.

m *Cyanide*

Not more than .025 mg/l.

n *Sulfate*

Not more than 250 mg/l or natural levels, whichever is greater.

o *Chlorides*

- o_1 — Not more than 150 mg/l.
- o_2 — Not more than 250 mg/l.
- o_3 — Not more than 200 mg/l.
- o_4 — Maximum 15-day mean 50 mg/l.

p *Phosphate*
(total soluble as PO_4)

- p_1 — Not more than 0.10 mg/l or natural levels, whichever is greater.
- p_2 — Not more than 0.30 mg/l or natural levels, whichever is greater.
- p_3 — Not more than 0.40 mg/l or natural levels, whichever is greater.
- p_4 — Not more than 0.03 mg/l or natural levels, whichever is greater.

q *Phenol*

- q_1 — Not more than 0.005 mg/l.
- q_2 — Maximum 0.02 mg/l.

TABLE 3—Continued

r *Color*

r_1 — Not more than 50 units.

r_2 — For the period 5/15 to 9/15 of any year, not more than 20 units, for the period 9/16 to 5/14 of any year, not more than 50 units.

s *Copper*

s_1 — Not more than 0.02 mg/l.

s_2 — Not more than 0.10 mg/l.

t *Zinc*

Not more than 0.05 mg/l.

v *Ammonia Nitrogen*

v_1 — Not more than 0.5 mg/l.

v_2 — Not more than 1.5 mg/l.

w *Radioactivity*

w_1 — Alpha emitters, maximum 3 pc/1; beta emitters, maximum 1,000 pc/l.

TABLE 3—Continued

x *Hardness*

x_1 — Maximum monthly mean 150 mg/l.

x_2 — Maximum monthly mean 95 mg/l.

(d) The following Table 4 shall display groups of criteria:

TABLE 4

Criteria	Group A	Group B	Group C
pH	a_1	a_1	a_1
Dissolved Oxygen	b_1, b_8	b_2, b_7	b_5
Iron	c_1	c_1	c_1
Temperature	d_1	d_2	d_6
Dissolved Solids	e_1	e_1	e_1
Bacteria	f_1	f_1	f_1

(e) The list of specific water quality criteria does not include all possible substances that could cause pollution. For substances not listed, the general criterion that these substances shall not be inimical or injurious to the designated water uses applies. The best scientific information available will be used to adjudge the suitability of a given waste discharge where these substances are involved.

Appendix A-9

WASTE LOAD ALLOCATIONS POLICY AND PROCEDURES

(Subject to Change)

A. POLICY

Water quality standards have been established for all surface waters in the Commonwealth. In some waters, under the conditions set forth in this policy, waste load allocations will be made to assure consistent actions, orderly pollution control and prevention plans and equitable treatment requirements.

A comprehensive water quality management and regionalization plan should be prepared for all zones which require waste load allocations. Regional facilities shall be planned to meet waste load allocations for the pollution abatement cycle, although construction may be phased on a timely basis.

Waste load allocations will be made when:

1. Waters in a stream section or zone are polluted by discharges that have been treated to meet the minimum treatment requirements specified in the Rules and Regulations.
2. Waters in a stream section or zone may be polluted during the pollution abatement cycle by discharges that would be treated to meet the minimum treatment requirements specified in the Rules and Regulations.
3. Minimum treatment requirements have not been established for a particular waste either by regulation or policy.
4. Waters are designated as Conservation Areas or are waters of outstanding quality and character such as:
   a. Natural lakes and ponds over 20 acres.
   b. Public recreation areas.
   c. Public water supply impoundments.
   d. Certain multi-purpose impoundments.
   e. Clean "limestone" streams.
   f. Clean "freestone" streams over 50 square miles drainage area.

When waste load allocations are made, the assimilation capacity of the receiving waters will be considered and the allocations will be made on the basis of equitable apportionment of the assimilation capacity.

A reserve will be established for all zones in which waste load allocations are made, and waste load allocations will be made so that the assimilation capacity is distributed between existing waste discharges and a reserve.

In comprehensive watershed projects involving a regional plan, waste load allocations may be set by the project participants to the extent that they will meet applicable water quality criteria.

The allocation procedure is an administrative device to allow the Department to treat waste discharges equitably and does not establish a transferable property right.

B. PROCEDURE

1. Establish a Reserve

   The reserve will be the capacity required to assimilate probable future growth during the pollution abatement cycle. The size of the reserve will depend upon the rate of growth and the number of years for which the growth is projected. The length of the pollution abatement cycle must consider the useful life of the facility, the financing period and the state of waste treatment technology. The period must be long enough to permit financial and facilities planning but short enough to assure that treatment requirements do not greatly exceed waste treatment technology. For the latter, the period should not place requirements beyond those advanced waste treatment methods that can be planned for at the time the decision is made. The following minimum pollution abatement cycles are recommended:

   a. For sewage and sewage-like industrial wastes—15 years.

   b. Other wastes—10 years.

   c. For Conservation Areas and other water outlined in A-4—25 years.

2. Allocations

   Allocation between the reserve and present and specifically proposed discharges will be done as follows:

   a. Determine the present raw waste load in the pollution abatement zone.

   b. Determine the specifically proposed raw waste load. This is the capacity of existing waste treatment works in excess of the present load at each treatment works.

   c. Determine the future raw waste load at regional facilities designated by the comprehensive regional plan for the pollution abatement cycle. Consider this a specifically proposed load.

   d. Determine the total future raw waste load for the pollution abatement cycle.

   e. Total the present and specifically proposed non-regional facilities raw waste loads plus the future regional facilities raw waste loads and subtract this from d. The remainder represents the reserve fraction.

   f. Determine the assimilation capacity.

   g. Establish an assimilation capacity reserve directly proportional to the reserve fraction and equitably distribute the remaining assimilation capacity among present and specifically proposed non-regional facilities and the regional facilities.

3. Allocations should be made on the basis of pound per day or other mass flow considerations to the extent that this is possible and practical. The following evaluation procedure is generally used when making waste load allocation determinations:

   a. Oxygen Consuming Materials

      (1) For receiving waters where the dilution flow in the zone is at least two times as great as the flow of the wastewater containing oxygen consuming materials, the waste load allocation will be a load allocation in pounds per day, based on an equal percentage reduction of the oxygen consuming material from the raw waste.

      (2) For receiving waters where the dilution flow in the zone is less than two times as great as the flow of the wastewater containing oxygen consuming materials, the wastewater provides considerable flow augmentation and the total pounds per day that may be discharged will vary with wastewater flow. In these situations the waste load allocation will be based on equal effluent concentrations of the oxygen consuming materials.

   b. Suspended Solids

      Suspended solids allocations should be based on equal effluent concentrations. In some zones it may be necessary to differentiate between organic and inorganic suspended solids and set a separate allocation for each.

c. Waste Heat (Thermal) Discharges

Equal percentage reduction of waste heat.

d. When two or more substances are synergistic the limiting concentration must be reduced to meet the formula:

$$\frac{Ca}{La} + \frac{Cb}{Lb} + \ldots + \frac{Cn}{Ln} = 1$$

Where

Ca, Cb, . . . , Cn = Limiting concentration of substance a, b, . . . , n when synergism occurs.

La, Lb, . . . , Ln = Limiting concentration of substance a, b, . . . , n when there is no synergism.

n = Total number of synergistic substances.

This equation can be solved as follows:

$$Ca = \frac{La}{n}, Cb = \frac{Lb}{n}, \ldots, Cn = \frac{Ln}{n}$$

e. For other substances, waste load allocations generally will be made on basis of equal effluent concentration in the segregated waste stream carrying the substances. In carrying out this principle it must be recognized that the volume of water used can change. Allocations may be made in the form of a pound per day limit or a mass-flow relationship (Pt-Co Color units times flow, for example) that will recognize water use reduction and still meet water quality criteria.

4. Reduction of Assimilation Capacity by "Outside" Activities:

The assimilation capacity of an established pollution abatement zone can be reduced by new discharges not within the zone or by diversion of water.

When a new discharge not within the zone is proposed a waste load allocation will be made for the new discharge if minimum treatment would create pollution and/or the new discharge will reduce the assimilation capacity of the established zone.

If the treatment needed to prevent pollution does not reduce the assimilation capacity of the established zone, use this to determine the allocation for the new discharge.

If the treatment needed to prevent pollution will reduce the assimilation capacity of the established zone, and this treatment exceeds that required for the established zone, the loss in assimilation capacity will be taken from the reserve.

If the treatment needed to prevent pollution will reduce the assimilation capacity of the established zone, and this treatment is less than that required for the established zone, treatment requirements for the new discharge will be increased until either the reduction in assimilation capacity is eliminated or the treatment is equal to that required in the established zone. The lesser of these requirements will be used to set the waste load allocation of the new discharge and any reduction of assimilation capacity will be taken from the reserve.

Any reduction in assimilation capacity created by diversion of water will be taken from the reserve.

5. The reserve will be used for all new waste loads and increases of waste loads that are not part of or located within the service area of regional facilities. Regional facilities have been allocated a portion of the reserve in the original allocation. New discharges in a regional service area that are not part of the regional plan will receive no permit or allocation from the reserve and will be required to treat such that the discharge is not worse than the receiving stream quality estimated at critical stream flow. No new or increased discharge, wherever located, will be allocated more than 100% of the reserve.

6. Any increase in assimilation capacity will be placed in the reserve for that pollution abatement cycle. Increases in assimilation capacity can occur from streamflow augmentation, changes in water quality standards or criteria, removal of waste loads, advances in treatment performance, etc.

7. When a waste load is moved from Pollution Abatement Zone A to an adjacent Pollution Abatement Zone B, the removed waste load allocation will be placed in the reserve of Zone A in accordance with (6) and the reserve of Zone B will be used to allocate a waste load in accordance with (5).

8. At the end of each pollution abatement cycle or whenever 75% or more of the reserve has been allocated, whichever comes first, a new reserve will be established and new waste load allocations will be made. Treatment levels will have to remain at least as high as previous levels in reallocations.

C. DEFINITIONS

The following definitions are used for the purpose of this Policy and Procedure:

Water Quality Criteria—Levels of water quality, determined scientifically, necessary to permit a designated use. Water quality criteria are applicable to all waters of the Commonwealth.

Waste Load Allocation—A specific limit on the discharge of wastes, as opposed to a requirement of waste treatment performance. May be expressed as total waste load (pounds per day) or as a limiting concentration (mg/l).

Assimilation Capacity—The amount of waste that can be added to a water and not cause pollution.

Pollution Abatement Cycle—The period of time needed to plan, design, finance, construct and operate pollution control works.

Zone—A body of water or a portion thereof, and its environs, having similar and/or cumulative water quality problems and a similar abatement plan.

Pollution Abatement Zone—A zone within which the assimilation capacity must be equitably allocated.

Equitable—Equal and fair.

Water Quality Goals—Levels of water quality, not water quality criteria, established by board policy as a part of water quality standards.

Pollution—Water quality lower than water quality criteria or water quality goals, or water quality that adversely affects designated uses.

Water Quality Standards—Regulations that specify protected water uses, water quality criteria and water quality goals, together with a pollution abatement plan.

Comprehensive Water Quality Management and Regional Plan—A facility and administrative plan for wastewater collection and disposal that provides adequate service on a timely basis and meets water quality criteria and goals in an efficient manner.

Appendix A-10

PRIORITY RATING FACTORS—FEDERAL GRANTS

The following is an excerpt from Chapter 103—Financial Assistance of the Rules and Regulations of the Department of Environmental Resources. These sections set forth the priority rating system for determining eligibility for Federal grants for the construction of municipal waste water treatment plant.

* * * * *

§ 103.9. Priority Rating Factors.

(a) Priority among eligible projects shall be established according to the applicant's accumulation of points in each of following categories weighted as shown:

(1) Water Pollution Control—60%
(2) Stream Segment Priority—20%
(3) Population Affected—10%
(4) Enforcement Status—10%

(b) A project's total priority points shall be the sum of the points assigned in each of the individual rating factors.

§ 103.10. Water Pollution Control.

(a) The number of points for water pollution control shall be based on the extent to which the project will eliminate detrimental effects of pollution and public health hazards from existing discharges of sewage, including malfunctioning on-lot disposal systems or will prevent detrimental effects that would be caused by discharges from areas presently unsewered.

(b) The following point values shall be used to determine rating points for this factor:

Use Factor	Points Based on Degree of Effect		
	Slight	Moderate	Great
Domestic Water Supply	9	11	14
Public Bathing	1	6	11
Fish & Aquatic Life	6	9	11
Boating, Recreation & Aesthetics	3	6	9
Industrial Water Supply	3	6	9
Irrigation	1	2	3
Stock Watering	1	2	3

(c) Slight effect is considered where up to an estimated 20 percent of the normal potential benefits attributable to the use are precluded by the discharge(s).

(d) Moderate effect is considered where an estimated 20 to 60 percent of the normal potential benefits attributable to the use are precluded by the discharge(s).

(e) Great effect is considered where greater than an estimated 60 percent of the normal potential benefits attributable to the use are precluded by the discharge(s).

§ 103.11. Stream Segment Priority.

(a) Priority points attributable to this factor will be assigned in accordance with the following:

Category I—these segments represent water quality segments and certain designated effluent limited segments (based on high growth potential and complexity of pollution problems)—15 points.

Category II—these segments represent effluent limited segments (except those in Category I) and certain designated water quality limited segments (based on lower growth potential and less complex pollution problems)—10 points.

Category III—these segments represent segments in which streams are significantly affected by mine drainage or pollution from non-point sources—8 points.

(b) Designated stream segment categories shall be those identified in the Program Plan submitted to the U. S. Environmental Protection Agency in accordance with Section 106 of the Federal Act.

(c) In addition to the points above, an additional 5 points shall be assigned to projects located in those basins or portions thereof receiving national priority as designated by the Administrator of the U. S. Environmental Protection Agency and those located in the Lake Erie drainage basin.

§ 103.12. Population Affected.

(a) Priority points attributable to this factor shall be assigned as follows:

Project Equivalent Population	Priority Points
1- 2,000	3
2,001- 5,000	6
5,001-50,000	9
greater than 50,000	10

(b) Project Equivalent Population shall be the initial population equivalent to be served by the project.

§ 103.13. Enforcement Status.

Priority points attributable to this factor shall be assigned in accordance with one of the following:

(1) The project has been developed to comply with an order issued by the Department to construct facilities or participate in a wastewater management system necessary to provide compliance with water quality standards or to abate pollution or public health nuisances; or the municipality has significant documented public health nuisances to be relieved by the proposed project or has treatment facilities which produce an effluent of lesser quality than that quality needed to meet water quality standards, but an order directing correction has not yet been issued—10 points.

(2) There has been filed, after the effective date of this subchapter, an action for contempt of court or an action in equity or mandamus, against the municipality for failure to comply with a previous order of the court, the Department or its predecessor agency—7 points.

§ 103.14. Other Considerations.

In the event that two or more projects receive the same number of total rating points, the relative rank of the projects will be based on points awarded under the water pollution control factor, the higher rank being assigned to that project with the higher water pollution control points. If, after this test, the projects remain tied, the factors of stream segment priority, then population affected, then enforcement status, in that order, shall be used to break ties.

(b) In the case of a regional project for which the Department has on hand separate applications from participating municipalities and each portion of the regional project is essential to the integrity of the project, the Department shall rank all portions of the project together as a single project and assign the same number of rating points to each separate application. All portions of the regional project shall be processed and certified as concurrently as possible to allow simultaneous funding.

APPENDIX B

REPORT OUTLINES

Appendix B-1

TENTATIVE OUTLINE FOR SUB-BASIN SUMMARY REPORT

Chapter

I—SUB-BASIN GOALS AND OBJECTIVES FOR WATER RESOURCES PLANNING

A. Goals of the sub-basin.

B. Conflicts with goals and objectives of the State Water Plan.

C. Resolution of conflicts.

II—PHYSICAL FEATURES AND RESOURCES

A. Basin Orientation: location, area, adjacent sub-basins and counties, major cities, major streams, sub-basin delineation.

B. Climate and Hydrology: temperature, frost-free days, precipitation, hurricane path, wind, sunshine, humidity, evapotranspiration; high, mean, and low flow statistics.

C. Topography: topographic region, variation in elevation and its hydrologic implication.

D. Geology: geologic region, general geology and its hydrologic implication.

E. Mineral Resources: water use implications of major mineral extraction.

F. Soil: characteristics and hydrologic implications of dominating soils.

G. Forest Resources: distribution and its relation to watershed management and wildlife.

H. Fish and Wildlife Resources.

III—DEMOGRAPHIC ECONOMIC AND CULTURAL ASPECTS

A. Historical Setting: historical development of the area, effect of its particular environment on the future.

B. Economy and Employment: industries, employment, income.

C. Population: projections and distribution.

D. Water Uses and Problems: general water uses, flood problems, water quality problems.

E. Transportation: highway density, navigation.

F. Land Use: general land use categories and trends.

IV—DEVELOPED WATER RESOURCES, PROBLEMS AND FUTURE NEEDS

A. Water Uses:

Public—adequacy by waterworks.
Self-supplied industrial—by watershed.
Electric power—by watershed and plant location.
Consumptive use and reuse studies at selected stations.

B. Flood Damage Reduction: demand and supply analysis by drainage basin; urgency list based on tangible and intangible information; flood warning system; flood plain information and flood insurance eligibility.

C. Outdoor Recreation: demand and supply analysis by activity, by county and by region of a 2-hour driving distance; identify need and urgency.

D. Wild and Scenic Rivers: qualified reaches and their order of preference.

E. Water Quality Management: water uses and criteria, dischargers and existing treatment facilities, analysis of water quality data; identify streams that meet the standards and streams of high priority for abatement (includes sediment).

F. Navigation: (refer to Corps of Engineers work, extract the important points.)

V—RESOURCE OPPORTUNITIES AND ALTERNATIVE SOLUTIONS

A. Present Stage of Development: conservation storage by watershed, expressed as percent of average annual runoff; reservoir surface area expressed as percent of the drainage area; extent of groundwater development.

B. Potential Resources: compare existing development with hydrologic optimal to determine remaining potential; determine groundwater potential.

C. Resource Management Alternatives: additional supply available from existing facilities through management e.g., regional management of water supply system, management or modification of developed waters and existing facilities.

D. Resource Development and Conservation Alternatives: apply where management fails to satisfy the need; identify and evaluate proposed projects by others, available water conservation measures.

E. Resources Preservation: identify wild and scenic rivers, including wetlands; potential dam sites and well fields, and discuss the significance of their preservation.

VI—RECOMMENDATIONS

A. Accept or reject projects proposed by others.

B. Conclusions regarding Resource Management, Resource Development and Conservation alternatives, and Resource Preservation.

C. Recommended programs.

D. Areas and alternatives needing further studies.

REFERENCES

APPENDIX—COORDINATION AND PUBLIC PARTICIPATION

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TENTATIVE OUTLINE FOR WATER RESOURCES DATA SYSTEM (WARDS) REPORT

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II—INTRODUCTION

III—COMPUTER SYSTEMS

IV—PART I—DATA

A. Area Base Data

B. Mapping

1. Stream Map
2. Watershed Maps and Report

C. Demographic Base Data

1. Economy and Employment (OSPD)
2. Population (OSPD)
3. Population Allocation to MCD and Watershed
   a. Straight Line
   b. Density
   c. Parabolic
4. Resolution of Differences in Allocation

D. Hydrologic Data

1. Rainfall
   a. Intensity—Frequency—Duration
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   c. Antecedent Precipitation
2. Surface Flow
   a. Floods—Frequency Studies
   b. Low Flow
      (1) Short Duration—W. R. Bulletin No. 1
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V—PART II—COMPLETED PLANNING REPORTS AND ON-GOING PLANNING ACTIVITIES

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B. On-Going Planning Activities

APPENDIX C

DETAILED METHODOLOGY

Appendix C-1

PUBLIC WATER SUPPLY PROJECTION

The following procedures are programmed for computer analysis (by waterworks) of the future water supply demand:

1. Create a water service data file such that for every waterworks inventoried there is a separate record on file for each municipality served by that waterworks.
2. Create a population array such that for every municipality there is a population for each decade k.
3. Read the water service file (sorted according to municipality served) sequentially and for any case where two or more waterworks combined claim to serve more than 100% of any given municipality, recompute the percent of population in that municipality served by each waterworks according to:

$$PCT_{i,j,1970} = (100 - \sum_{i} PCT_{i,j,1970}) \times \frac{PCT_{i,j,1970}}{\sum_{i} PCT_{i,j,1970}} + PCT_{i,j,1970}$$

where $PCT_{i,j,1970}$ is the percent of population in municipality j served by waterworks i in year 1970.

4. Compute the unserved population for each municipality:

$$UNSRVD_j = \frac{(100 - \sum_{i} PCT_{i,j,1970}) \times POP_{j,1970}}{100}$$

where $UNSRVD_j$ is the unserved population in municipality j.

5. Assume unserved population constant with time. Thus, percent unserved, and hence percent served population will not be constant. Therefore, compute percent of total served population in each municipality which is served by each waterworks:

$$PCTSRV_{i,j} = (PCT_{i,j,1970} / (1.0 - UNSRVD/POP_{j,1970})$$

which is held constant in the future.

6. Sort water service file according to waterworks, read water service file sequentially and compute a 1970 GPCD (gallons per capita per day) figure for each waterworks:

$$GPCD_{i,1970} = \frac{TOTLWATRUSE_{i,1969}}{365 \times \Sigma_j (POP_{j,1970} - UNSRVD_j \times \frac{PCTSRV_{i,j}}{100})}$$

where $TOTLWATRUSE_{i,1969}$ is the 1969 yearly water use for waterworks i. (Note 1969 yearly use is used because 1970 yearly use is not available on the 1970 inventory.)

7. Compute future GPCD figures for each waterworks:

$$GPCD_{i,k} = GPCD_{i,k-1} + (a - GPCD_{i,k-1}) \times \frac{b}{c} \times GPCD_{i,1970}$$

where a = regional maximum GPCD selected
b = maximum allowed yearly percent increase of GPCD
c = difference between regional maximum GPCD and regional minimum GPCD

8. Compute future population served by waterworks in each municipality:

$$POPSRVD_{i,j,k} = (POP_{j,k} - UNSRVD_j) \times \frac{PCTSRV_{i,j}}{100}$$

9. Compute future water use in each municipality:

$$WATERUSE_{i,j,k} = POPSRVD_{i,j,k} \times GPCD_{i,k} \times 365$$

10. Compute future total water use for each waterworks:

$$TOTLWATRUSE_{i,k} = \Sigma_j WATERUSE_{i,j,k}$$

The output of this computer model serves as the basis from which hand adjustments can be made if better data become available. Areas that are not presently served but which could be served in the future, will also be identified.

Derivation of Per Capita Use

Projection of future per capita use in GPCD is a difficult task. AWWA recommends using an increase of 1GPCD/year (13). Some consultants use the increase of 1% per year. Illinois State Water Survey (14) related the GPCD to population to develop the demand-trend curve for the State. A parallel curve, passing through a point defined by the present population and GPCD of a municipality may be used to predict the GPCD of the municipality as shown in Figure 12. The following equation was developed:

$$GPCD = 45 \log \frac{P}{40} - 17 \qquad \ldots\ldots (4)$$

where P is the population

Csallany and Neill (15), also of Illinois State Water Survey, ran regression analyses, trying to find the good predictors which would explain the variation of water consumption in GPCD. Eleven predictors were available from 31 municipal waterworks. With various degree of success, the good predictors are: *age of waterworks, estimated population* and *average consumption (%)*, commercial and industrial. Since the age of waterworks and the population are correlated the relationship shown in Figure 12 is reasonable.

The Water Supply Appendix (R) of the NAR Study employed a series of curves, developed for the Ohio River Basin Framework Study, to predict the future GPCD of non-industrial public water supplies. These curves are shown in Figure 13. These curves indicate that the GPCD increases with time. Since the population also increases with time, Figures 12 and 13 have a common ground. However, Figure 13 sets an upper limit of about 200 GPCD at which the future GPCD becomes asymtotic. A mathematical model was developed using regression analysis. The form of the equation used in the model is:

$$Q = K\,(P)^{0.825}\,(Y)^{0.308} \qquad \ldots\ldots (5)$$

Q = Public water requirement in m.g.d.
P = Population served in 1,000's
Y = Per capita income in dollars
K = Constant which varies for each area and is determined by conditions in the base year.

The public water supply projection of the State Water Plan follows the concept similar to that of Figure 13. However, the regional maximal GPCD is set by observing the existing per capita usage figures within the region. Our preliminary study on 78 communities in subbasin 3 shows a definite positive trend which confirms the Illinois Study. Nevertheless, Figure 13 provides more flexibilities. Our prediction model for Philadelphia area is:

$$GPCD_k = GPCD_{k-1} + (275 - GPCD_{k-1}) \times \frac{0.15}{250} \times GPCD_{1970}$$

where K represents decades
for 1970, K = 1 and $GPCD_o = GPCD_{1970}$
and $GPDC_1 = GPCD_{1980}$

The constants 275, 250 and 0.15 can be adjusted for a particular subbasin. This methodology will be improved whenever possible.

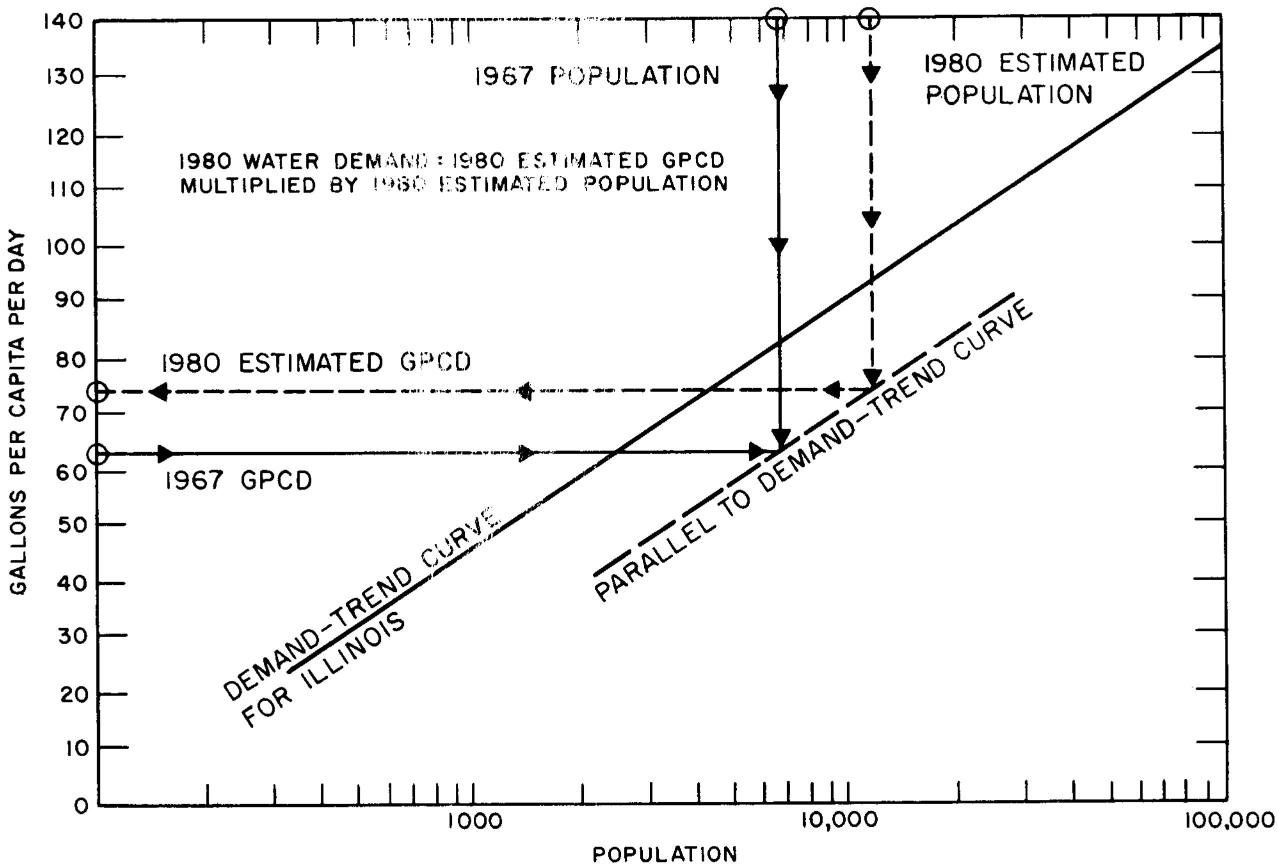

Figure 12 Estimating Future Water Demand in Illinois

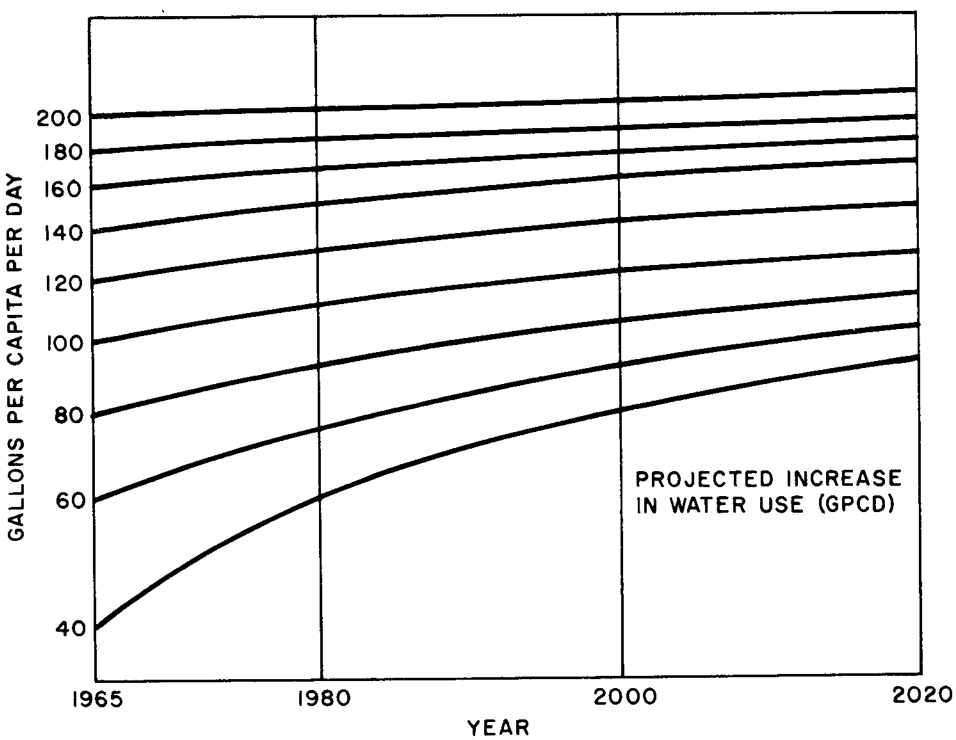

Figure 13 Estimating Future Per Capita Water Use, North Atlantic Regional Water Resources Study

Appendix C-2

FLOOD CONTROL NEEDS AND URGENCY

The objective of the analysis described herein is to determine the flood control needs and to identify the order of urgency.

A. METHOD OF ANALYSIS

Flood control needs may be derived from residual annual damage, and the order of urgency established according to the residual annual damage per square mile of the basin as well as the rate and type of development taking place in the watershed. Although this is a valid method, it is quite involved. It requires not only determination of floods of various return periods at all potential damage centers and damage reaches, and the corresponding stage-damage relationship, but also flood routing through reservoirs and channels; hence considerable time, manpower and detailed field data are required.

The alternative method introduced here serves the same purpose, but is more expedient. The method is based on an analysis of the historical flood damage and the flood control investment on an annual basis. The analysis requires *historical* flood damage data and flood frequency information, as well as an inventory of the existing and proposed (to date) flood control structures.

The annual flood damage indicates that, at least historically, a certain amount of damages were experienced annually on the average. Since it represents the damage under the condition where no flood control measures were provided, damages saved by the flood control investments are added to the historical data.

The flood control investment in a designated watershed (study unit) should be taken as that part of the investment which benefits the watershed. Whenever a flood control reservoir in a study unit benefits the other downstream study units, the investment to each of these study units may be proportioned according to the amount of damages saved in each study unit, by that reservoir. Existing flood plain regulation measures certainly reduced flood damages. The historical damages would have been higher without them. Since the historical damage does not include those reduced by such measures, the existing land-use control investment is excluded from the study. However, future land-use control should be considered as investment.

B. STUDY UNIT

The study unit should be delineated prior to the study. In a water resources planning study, problems and needs generated in a watershed are not necessarily met within the watershed as exemplified by outdoor recreation. In flood control, problem solving requires treating the river system as a whole, therefore, the watershed is the ideal unit.

Figure 14 shows a subbasin of the Delaware River within the Commonwealth of Pennsylvania. The total area, approximately 2200 square miles in size, was originally divided into 10 subareas, A through J for inventory purposes. For flood control analysis, areas A through F were combined. Areas G, H, I and J may be studied separately; however, areas G and J were also combined because of a data constraint. These four unit areas are used as an example to illustrate the analysis. The figures presented here are tentative.

C. AVERAGE ANNUAL FLOOD DAMAGE

Two basic data are required in order to determine the average annual flood damage: flood damage data and flood frequency information. A statewide flood damage inventory consisting of damage information through 1968 has been completed and the update for Agnes damage is nearly complete. In the inventory, flood damages were identified for most of the major floods at all known damage centers and reaches. Actual damages, in dollars, were adjusted to the 1969 price level, according to the construction cost index published in *Engineering News Record.* Examples of the damage centers are shown in Figure 14. Flood frequency information was made available by the U. S. Geological Survey using historical peak floods of each year including the Agnes flood. Data were analyzed assuming Log Pearson Type III distribution.

The flood damage-frequency curve may be developed for each one of the watersheds using information mentioned above, namely flood damage data and flood frequency information. Flood damages are a function of several flood random variables, such as peak, volume, duration, velocity, sediment and pollution. Very frequently, flood damage and the flood random variables are to a high degree mutually dependent. In reality, data on flood damages and their relation to the many flood variables are so scarce that a better result cannot be obtained with a more sophisticated method of analysis. It is, therefore, assumed that the flood damage frequency may be represented by the frequency of the peak of the flood causing the damage. Figure 15 shows the damage-frequency curve of subareas A through F defined by several historical flood events.

Both the basin-wide (unit area) flood damage and the basin-wide frequency of the corresponding flood are required in order to locate a flood event on the damage-frequency curve. The basin-wide flood damage may be calculated directly from the damage inventory. However, a weighting procedure is required for determining the basin-wide frequency of the flood because of the spatial variation of the frequency of a flood. For example, the return period of the 1955 flood in the subarea A through F varies from 52 years at subarea A to 13 years at subarea F. In order to assign the basin-wide return period of this flood, the return periods were weighted by areas applicable to the gaging stations within the basin. Table 5 details this procedure. The weighted return period of 19.42 years (or a 5.15% probability of occurrence) and the total damage of 8.8 million dollars locate the 1955 flood event in Figure 15.

Table 5

BASINWIDE FLOOD FREQUENCY OF 1955 FLOOD

Subarea A Through F

Gaging Station	Watershed	Drainage Area Square Miles	Weighting Factors	Flood Return Period in Years	Weighted Return Period in Years
4695	A	341	0.178	52	9.25
4705	B	300	0.156	24	3.74
4710	C	358	0.187	5	0.94
4720	D	330	0.172	15	2.58
4730	E	362	0.189	7.1	1.34
4745	F	226	0.118	13.3	1.57
		1917	1.000		19.42

The total area under the curve represents the historical annual flood damage of the basin. Since this damage represents direct damage only, the indirect damage is then added. The indirect damage, expressed as percent of the direct damage, varies according to the population density of the watershed and the type of development. Table 6 lists the historical *total annual damages*, D_T, for each of the four unit areas.

D. AVERAGE ANNUAL FLOOD CONTROL INVESTMENT

In order to determine the average annual flood control investment, a complete inventory on the existing and proposed flood control structures is required. Information pertaining to flood control projects are available from various sources, including Federal River Basin Study reports, Department of Environmental Resources project reports and files, Corps' reports, and Soil Conservation Service work plans. Examples of these structures are also shown in Figure 14.

The basin-wide annual flood control investments were determined as follows:

1. Tabulate all the single-purpose and multipurpose flood control structures within the unit areas, their shares of capital costs, maintenance and operation costs, and their project lifetime. For multipurpose structures, list only the cost allocated for flood control purposes.
2. Adjust all the costs to the same price levels as the flood damage.
3. Amortize the capital costs over the project lifetime using an appropriate interest rate.
4. Add the amortized capital cost to the maintenance and operation costs.

The sum of the amortized capital costs and the maintenance and operation costs of all the flood control structures within the basin is the basin-wide annual flood control investment. In order to take into account the effectiveness of existing structures, the annual flood control investment (cost) is multiplied by the benefit-cost ratio of each project and aggregated to form *total annual benefit*, S_T, for each of the four unit areas as presented in Table 6.

E. NEED AND URGENCY

The potential maximal flood control need can be represented by the difference, D_T-S_T. With limited financial resources, these figures may be used to apportion the future investment. To identify the urgency of need, both tangible and intangible factors should be considered. The tangible is developed from the preceding analysis. The intangible consists of the rate and type of development taking place in the watershed and historical loss of life due to the flood.

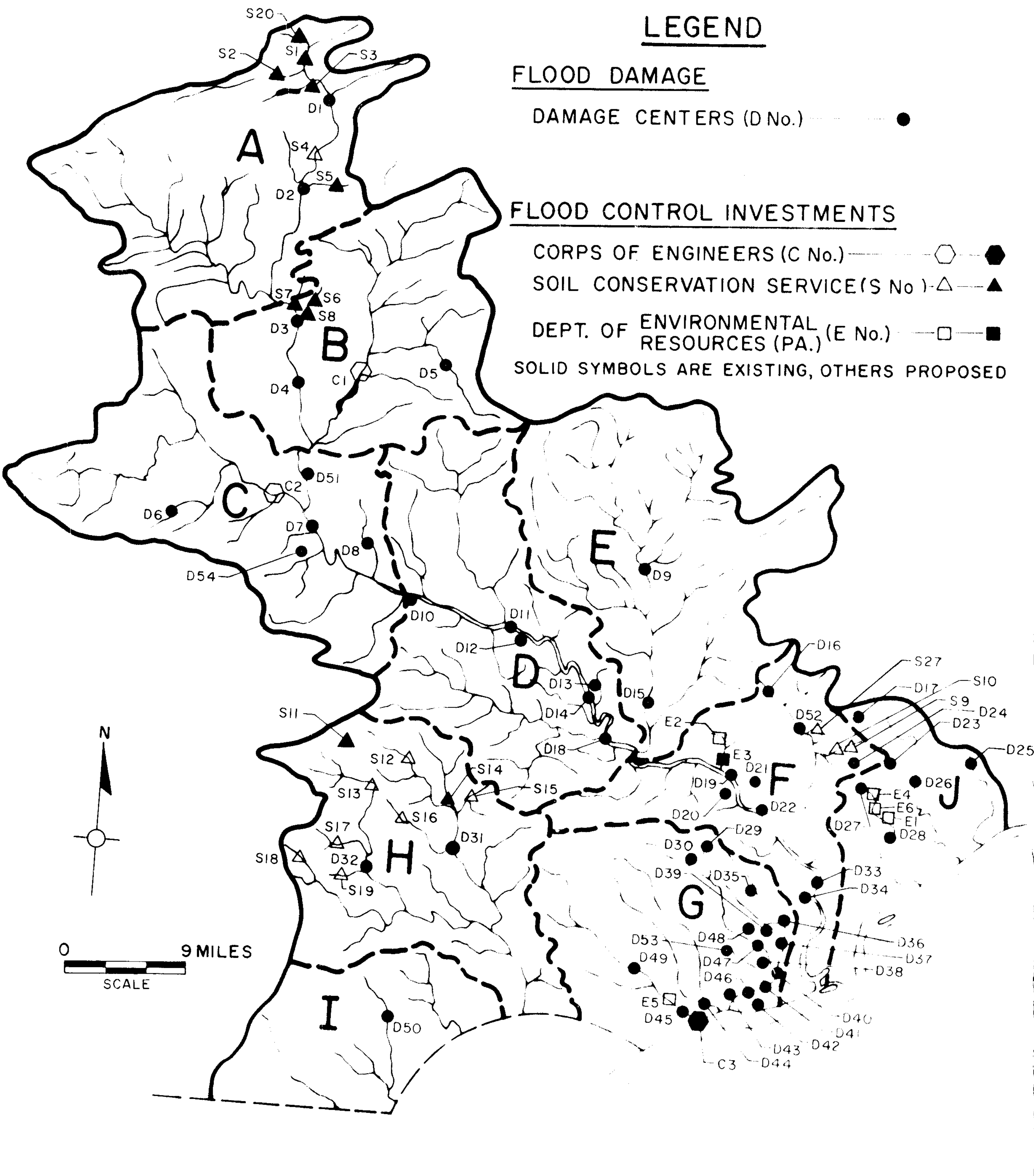

Figure 14 Flood Damage Areas and Flood Control Measures

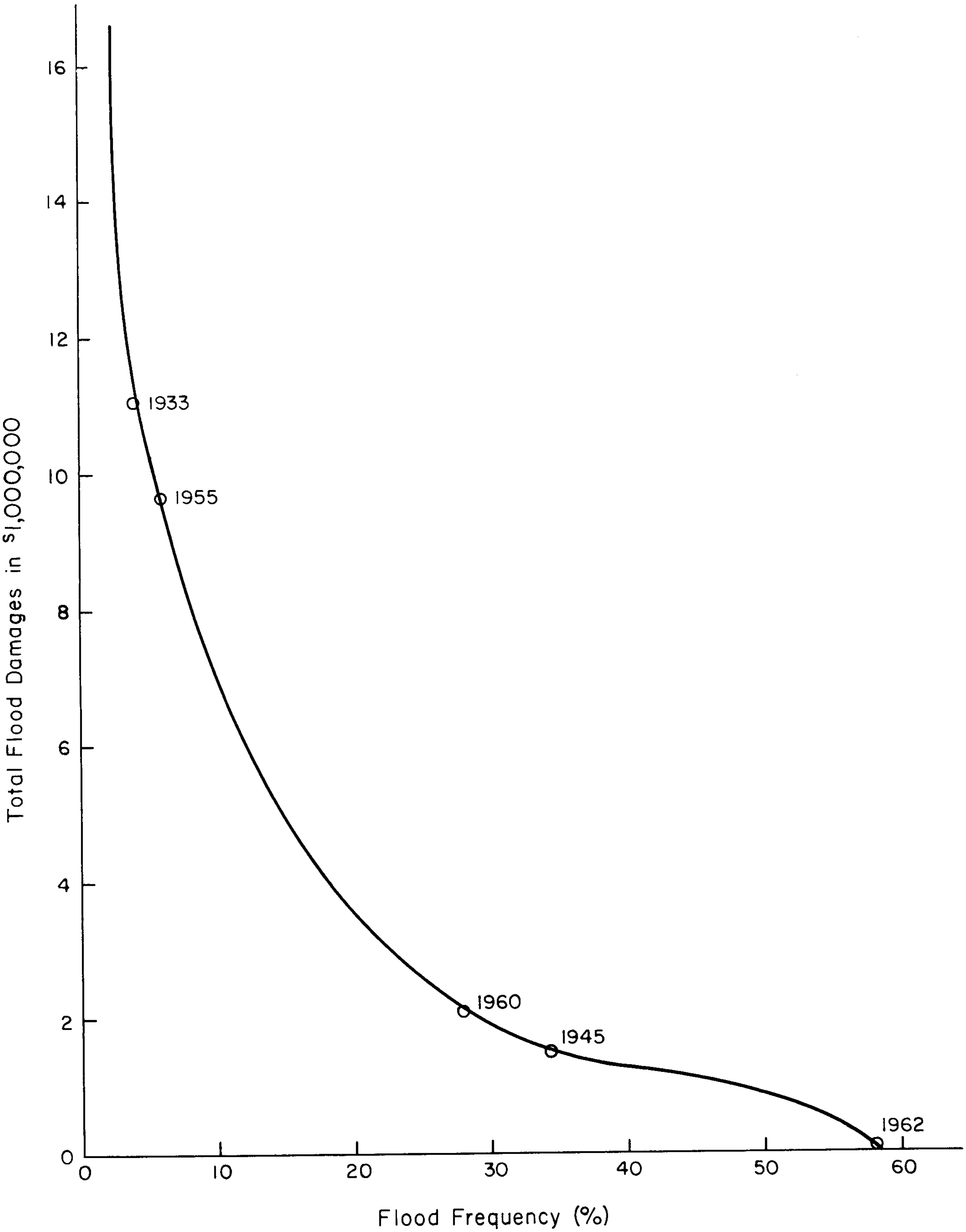

Figure 15 Flood Damage—Frequency Curve A-F

Table 6

TOTAL ANNUAL DAMAGE, TOTAL ANNUAL BENEFIT AND URGENCY INDEX

Watershed (Unit Area)	Drainage Area Sq. Mi.	Total Annual Damage $D_T = D + I$ in $1,000	D $/sq. mi.	Total Annual Benefits S_T in $1,000	S $/sq. mi.	D−S	S/D	Urgency Index (D−S) (1−S/D)	Potential Maximum Investment $D_T - S_T$ $1,000
With proposed* Structures in S_T									
A-F	1917	6388	3332	1538	802	2530	0.241	1920	4850
G&J	393	2551	6491	108	275	6216	0.042	5955	2443
H	301	621	2063	317	1053	1010	0.510	495	304
I	98	18	184	0	0	184	0	184	18
Without proposed* Structure in S_T									
A-F	1917	6388	3332	307	160	3172	0.048	3020	6081
G-J	393	2551	6491	42	107	6384	0.017	6275	2509
H	301	621	2063	99	329	1734	0.159	1458	522
I	98	18	184	0	0	184	0	184	18

* "Proposed" refers to projects proposed prior to the State Water Plan but not under construction at the time this study is made.

Appendix C-3

BOATING DEMAND ESTIMATE

The following steps detail the procedures by which the 1968 boating participation rate is arrived at.

1. All the waterway patrolmen of the Fish Commission were asked to estimate the number of non-registered boats in 1971 for each of the 67 counties in the State. The statewide registered—non-registered boat ratio was 114,770 versus 99,600 excluding out-of-State boats. A similar survey by Parks superintendents showed a ratio of 2 to 1 appearing in the reservoirs.
2. Using patrolmen's estimates and assuming that the ratio holds true for 1968, we have: 94,800 registered boats and $94{,}800 \times (99{,}600)/(114{,}770) = 80{,}000$ (rounded off) non-registered boats in the State in 1968.
3. Assuming three persons per registered (powered) boat and two persons per non-registered boat, we may estimate the total participants in the State:

   $3 \times 94{,}800 + 2 \times 80{,}000 = 444{,}400$ persons
4. There are about 500 rental boats available in State Parks. Because of high turnover factor, these rental boats may be considered equivalent to 2,000 private-owned boats, using 2.5 persons per rental boat, we have a total of

   $444{,}400 + 2.5 \times 2{,}000 = 449{,}400$ participants.
5. The total population 5 years or older in 1968 was 10,638,669 persons. Therefore, the participation rate is 449,400/10,638,669 or 4.2%.
6. To allow for possible incomplete registration and out-of-State boats, we adopt 5% participation rate for boating. This includes *water skiing,* because it is impractical to separate it from the boating activity.

This Statewide participation rate is further adjusted for regional differences and projected for the future. In doing that the original ratios suggested by the consultant are maintained.

Appendix C-4

RECREATION DEMAND COMPUTATION

It is projected that by year 1980, the Philadelphia region will have 136 million activity days of picnicking, of which the State is to be responsible for one-third, or 4½ million activity days. Translated into picnic grounds and picnic tables, the State is responsible for providing 17,100 tables within 950 acres of picnic grounds.

To arrive at the number of picnic tables for which the State is responsible in 1980, the following calculations are made:

State Responsibility (Activity Days)

Activity Days	×	State % of Responsibility	=	State Activity Days
13,639,912		33%		4,501,171

The State will be responsible for 4½ million activity days of picnicking in the Philadelphia region by 1980.

Unit Standard

People/Unit	×	Turnover Factor	×	Recreation Days/Week	×	Weeks/Season	=	Activity Days/Unit
4.5		1.5		3		13		263

Area Standard

Units/Acre	×	People/ Unit	×	Turnover Factor	×	Recreation Days/Week	×	Weeks/ Season	=	Activity Days/Acre
18		4.5		1.5		3		13		4,739

Therefore, one picnic table satisfies 263 activity days of picnicking, and one acre of high density picnicking satisfies 4,739 activity days.

Units Required—State

State Responsibility (Activity Days)	÷	Unit Standard	=	Units Required State
4,501,171		263		17,100

Acres Required—State

State Responsibility (Activity Days)	÷	Area Standard	=	Acres Required State
4,501,171		4,739		950

Therefore, the State is responsible for 17,100 picnic tables on 950 acres of land in the Philadelphia region by 1980.

Next, it is determined that of the 17,100 picnic table demand for which the State is responsible, it will need to supply only 10,250 tables. Since the Philadelphia region is characterized by an outflow of recreationists, surrounding states are designated to provide the remaining 6,850 tables to meet the 1980 demand.

Appendix C-5

WATER QUALITY MODELING AND IMPLEMENTATION PLAN DEVELOPMENT

The subsequent sections discuss the data base and the basic computations and formulations involved, operational modeling techniques and implementation plan development methods currently used by the Department of Environmental Resources. The water quality modeling process has gone through several iterations of refinement since generally initiated in 1967 and the process is constantly evolving. The basic principles will continue in the future, but details will be refined and changes made to respond to recognized needs.

A. DATA BASE

Natural and man-made conditions affect water quality and make up the two general data groups:

1. *Natural Conditions*

   Natural conditions are not significantly subject to man-made changes in most instances. Important natural conditions vary in time and in locations. The major considerations and the information sources are:

   a. Streamflow—For most substances, critical streamflow conditions occur during drought. Droughts are caused by rainfall deficiencies, the most critical period being summer and early fall. Drought flows are measured by the U. S. Geological Survey at permanent and partial low flow stations throughout the State. By using statistical methods, drought flows of various durations and recurrences are identified for the stations.

   The drought flow used by the Department in most implementation plans is the one in ten year, seven day average minimum flow.

   Since there are more wastewater discharge points than there are streamflow measurement stations, streamflow estimates must be made for many locations. These estimates are made using the unit yield (cubic feet per second of streamflow per square mile of drainage area or cfsm) of nearby stations. The nearby stations selected are those which have similar geology and climate.

   At present, Water Resources Bulletin No. 1, *Low-Flow Frequency and Flow Duration* April 1966 is the principal data source for streamflows.

   b. Drainage Area—The watershed drainage area at a discharge point is used to estimate streamflow. This information is presently required to be determined as a part of wastewater discharge permit applications.

   Water Resources Bulletin No. 6, *Gazetteer of Streams* December 1970, provides drainage areas for about 6,500 named streams and is extensively used. Water Resources Bulletin No. 5, *Dams, Reservoirs, and Natural Lakes* 1970, provides the drainage area tributary to these bodies of water. The drainage areas at most gaging stations are given by the U. S. Geological Survey.

Where these sources do not provide sufficient information the drainage area is directly measured from topographic maps.

c. Temperature—Water temperature is affected principally by the seasonal variations in air temperature and other meteorological conditions. In smaller streams, the amount of groundwater flow during the summer and the amount of shade are important.

Since the conditions affecting temperature are complex, actual water temperature measurements have been used whenever available. Extrapolations to similar areas are made when specific data are not available.

d. Stream Channel Characteristics—The depth, width and gradient of stream channels are important modeling parameters. The gradient is usually taken from U. S. Geological Survey topographic maps. Average depth and effective flow width are measured in the field although estimates are frequently made on the basis of experience.

a. Natural Water Quality—Natural water quality is necessary for establishing background conditions and appropriate implementation plans. For example, the toxicity of many substances to fish and aquatic life depends on the pH, alkalinity and hardness of the water. In many cases, pollutants also occur naturally and the permissible increment that may be discharged will depend on natural or background conditions. In some areas, natural water quality will violate water quality criteria.

Natural water quality must be measured. For many natural constituents, the quality during low flow can be related to the geology of the drainage areas, so that extrapolations are possible. Other natural conditions having a significant impact on water quality are swamps and marshes, which have high organic content and high color.

2. *Man-Made Conditions*

Man's activities can have a significant impact on basically natural conditions in certain areas. This applies principally to streamflows, stream shading and stream channel characteristics. These are noted and accounted for in the modeling effort and implementation plan development.

In addition to these changes, the following are the most important conditions:

a. Point Wastewater Discharges—Municipal and industrial discharges have a major impact on water quality. Data relating to the location, quality and amount of these discharges are taken from permits and surveillance information. Development of the implementation plan requires use of *waste load projections*. For municipal wastes, the comprehensive sewerage plans are most commonly used. For industrial wastes, the best available data are used, usually the economic growth projections or employment projections by industry type. Wasteload increases are then uniformly distributed to existing industries.

b. Land Use—In addition to point sources of wastewater discharge, land use has an impact on water quality. Land use is considered in implementation plan development as creating non-point sources of pollutants. At present the considerations are largely judgmental and are not universally applied. They include drought flow reductions from paved areas, sediment and bacteria contamination from surface drainage, elevated summer temperatures, and a generally large "background" organic load.

In critical areas such as the Lower Schuylkill the Department has gone to the waste dischargers directly to obtain information on future growth. The overall growth has coincided with the broad projections but individual projections are highly variable.

B. OPERATIONAL MODELING TECHNIQUES

Two basic water quality models are used: one for conservative materials where dilution is the only parameter, and one for non-conservative materials where stream self-purification characteristics as well as dilution are important. A special case of the non-conservative materials model in general use and currently utilized by the Department, is the dissolved oxygen model. A thermal model is under development. In all types of water quality models, the basic functional consideration is mass balance, that is, what goes in must come out.

The basic steps used in the operational modeling techniques are:

1. Determine a water quality goal and identify natural water quality relevant to the goal. A water quality goal is a level of water quality necessary to permit a designated use. This level of water quality expressed in numerical limits becomes water quality criteria.

   Example: Water quality criteria = Average daily value of dissolved oxygen not less than 5.0 mg/l

   Natural water quality are:

   Water temperature = 20° C

   Background D.O. (from extrapolation) = 8.5 mg/l at 20° C

   Background total BOD (from extrapolation) = 2.5 mg/l

2. Identify and locate point sources of wastewater; quantify the wastewater characteristics.

   Example:

Dischargers—	A	B	C
Wasteflow (MGD)—	0.15	0.20	0.5
Total Raw BOD (lb/day)—	58	175	100
Water Sources—	well	stream	stream

3. In hydrologic sequence, starting upstream quantify the water balance. This is natural streamflow plus streamflow augmentation less water withdrawals plus wastewater discharges. Generally, water withdrawals from storage reservoirs and groundwater are not subtracted from the flow since they represent a draft on storage in excess of natural flow. This results in total water flows that exceed natural streamflows.

4. Identify water quality discontinuities. A water quality discontinuity is a location where water quality abruptly changes. Examples are point source wastewater discharges, tributary streams, waterfalls and dams (aeration), and lakes (aeration).

5. Identify all the physical and hydraulic characteristics of the streams and other parameters such as the reaeration and deoxygenation coefficients.

   Examples:

Actual Temperature	= 25° C
Length of reach	= 5,000 feet (from map)
Average depth	= 1.5 feet (field data)
Effective flow width	= 5 feet (field data)
Slope	= 80/5500 (from map)
Deoxygenation rate	= 1.5 per day (assumed)
Reaeration rate	= 24 per day (computed from field data)

   Dissolved oxygen modeling requires determination of all these values. For other non-conservative materials, reaeration is not needed. For conservative materials, time of travel, reaeration and deoxygenation coefficients are not needed.

6. Computations and Formulations—Water quality modeling is done for each watershed. The watershed is divided into zones in such a way that all waste discharges within one zone would have similar and/or cumulative water quality problems and similar abatement plans. Each zone is further divided into reaches from which waste and stream data are collected. The following computational procedures constitute the model:

   a. Time of travel—For each reach, time of travel is calculated using the stream channel dimensions and total flow.

$$t = \frac{lhw}{\text{total flow}} \qquad \text{.......... (6)}$$

where t = time of travel
l = length of reach
h = average depth of flow
w = effective flow width

   b. Reaeration coefficient—For each reach, a reaeration coefficient, r, is calculated using O'Connor and Dobbins (16) equations selected on the basis of the Chezy coefficient, c, and two types of turbulence in the stream: isotropic and non-isotropic. The distinction between these two types of turbulence is based on a value of the Chezy coefficient equal to 17. The Chezy coefficient is,

$$c = \frac{u}{(hS)^{1/2}} \qquad \text{.......... (7)}$$

   If the Chezy coefficient exceeds 17, the nature of turbulence is isotropic and the reaeration coefficient (in terms of physically measurable parameters and accounting for dimensional constants) is equal to:

$$r = \frac{0.044\ u^{1/2}}{h^{3/2}} \text{ at } T = 20^\circ \text{ C} \qquad \text{.......... (8)}$$

   Similarly, if the Chezy coefficient is less than 17, the nature of turbulence is non-isotropic and the reaeration coefficient is,

$$r = \frac{48.5\ S^{1/4}}{h^{5/4}} \text{ at } T = 20^\circ \text{ C} \qquad \text{.......... (9)}$$

where c = Chezy's coefficient
u = flow velocity, feet/day
S = slope of the stream channel, feet/feet
h = average depth of flow, feet

c. Mass Balance—A mass balance is performed for each reach. Output is generally in concentration. The stream concentration of a water quality parameter is determined by:

$$C_s = \frac{C_n \triangle Q_n + C_w Q_w + C_u Q_u}{\triangle Q_n + Q_w + Q_u} \quad \text{.......... (10)}$$

where C_s = stream concentration at head of reach
C_n = natural concentration
$\triangle Q_n$ = accrued streamflow (net accrued natural flow)
C_w = wastewater concentration
Q_w = wastewater flow
Q_u = total flow, previous upstream reach
C_u = stream concentration at the foot of the previous upstream reach

d. Dissolved Oxygen Sag—The Streeter-Phelps (17) equations are used in the mathematical modeling. The basic formulas for conditions at downstream reach are:

$$D_u = \frac{kL_a}{r-k} (e^{-kt} - e^{-rt}) + D_a e^{-rt} \quad \text{.......... (11)}$$

$$L_u = La e^{-kt} \quad \text{.......... (12)}$$

where D_u = D. O. deficit at the bottom of the reach
k = deoxygenation coefficient
L_u = BOD at downstream reach
L_a = BOD at upstream reach
D_a = D. O. deficit at upstream reach
e = Naperian base
t = time of travel

The stream assimilative capacity is determined at a point in the stream where the minimum allowable dissolved oxygen concentration is located. This point is referred to as the critical point. Critical conditions within the reach can be tested as follows:

If $(r.Da)/k > L_a$, the critical point is at the discharge point.

If $(r.Da)/k < L_a$, then the critical point occurs downstream and is found by the following equations:

$$t_c = \frac{1}{r-k} \ln \left\{ \frac{r}{k} [1 - \frac{r-k}{k} (\frac{Da}{La})] \right\} \quad \text{.......... (13)}$$

$$D_c = \frac{kL_a}{r} e^{-kt_c} \quad \text{.......... (14)}$$

where t_c = critical time
D_c = critical D. O. deficit
r, k, La, Da as previously defined.

C. IMPLEMENTATION PLAN DEVELOPMENT

Currently, three types of computations are performed to determine the treatment requirements. These are:

1. Equal Percentage Reduction. In this case all wastes are treated, by computation and simulation, to achieve the same percentage reduction of pollutants from the raw wastes.
2. Equal Effluent Concentration. All wastes are treated by computation, and simulation, to achieve equal concentration of the pollutants.
3. Maximum Load. Each discharge is treated, by computation and simulation starting at the upstream discharge point to discharge all the wastes that the reach can take without violating the water quality goal. Residual pollutants in the stream are sequentially carried to each reach where assimilative capacity is proportionally reduced.

Dilution condition is the general criterion used to determine the type of treatment requirements. For receiving waters where the dilution flow in the zone is at least 2 times as great as the flow of the wastewater containing oxygen consuming materials, equal percentage reduction is generally specified. For receiving waters where the dilution flow in the zone is less than 2 times as great as the flow of the wastewater containing oxygen consuming materials, the wastewater provides considerable flow augmentation and the total pounds of BOD per day that may be discharged will vary with wastewater flow. In this situation, equal effluent concentration is usually required.

The equations in the preceding section are used to compute the treatment requirements. In the equal percentage reduction case, percentage reduction values are set starting with 75% (which is equivalent to secondary level of treatment) up to 95% at 5% increment. Corresponding values for initial BOD, La, and D.O. deficit, Da, are calculated by using Equation (10). Equations (11) and (12) are the basic equations for the calculations of dissolved oxygen deficit and BOD values at downstream conditions. However, since the point of most significance to determine the treatment requirement is at the critical point, Equations (13) and (14) are used to calculate the critical dissolved oxygen deficit value for every level of percentage reduction set.

Knowing the minimum dissolved oxygen to be maintained in the stream as dictated by the Water Quality Criteria, the allowable critical dissolved oxygen deficit value is computed as follows:

Allowable Dc = D. O. saturation − D. O. min. conc.

where D. O. saturation = D. O. saturation value at a given temperature

D. O. min. conc. = min. D. O. in the stream or the D. O. goal

If the allowable critical D. O. deficit value (Dc) falls between the critical D. O. deficit values for two levels of percentage reduction set, the required percentage reduction is determined by interpolation.

If the allowable critical D. O. deficit value falls beyond the computed critical D. O. deficit value for the maximum level of percentage reduction set, the percentage reduction required is obtained by extrapolation. Once the percentage reduction required is determined, the remaining percentage may be calculated and is indicative of the stream assimilative capacity.

Equal effluent concentration may be calculated by using Equation (10) rearranged as follows:

$$C_x = \frac{C_s\,(Q_w + \triangle Q_n + Q_u) - (C_n \triangle Q_u + C_u\,Q_u)}{Q_w}$$

In this equation, C_s is the allowable BOD based on the minimum allowable dissolved oxygen to be maintained in the stream. C_x value is then the allowable effluent concentration required to meet water quality criteria. Other notations are as previously defined.

Calculation for maximum load requirement is done in the same procedure as for the first two cases but calculation is done individually for each waste discharger.

In some waters waste load allocations are required. The waste load allocations are carried out in accordance with the Department Policy and Procedure on Waste Load Allocations as shown in Appendix A-9.

TERMINOLOGIES

GENERAL TERMS

CONSERVATION

Protecting resources from loss, waste or harm and improving and renewing the quality and usefulness of the resource.

CRITERIA*

A rule or test by which something can be judged or a limit which must be met to protect a resource use.

DEMAND

Requirement of facilities or resources.

DEVELOPMENT

Structural measures or change of natural status for achieving certain objectives.

GOALS

The ideal end toward which effort is directed. The goal provides a specific direction or bearing by which the ideal condition is approached. The ideal end is not necessarily attainable.

LEVEL A STUDY

Framework studies provide general guides to future water resources development. The studies indicate which regions or subregions in an area have water problems calling for prompt and detailed planning efforts as well as those where such problems are less critical. In addition, these studies provide a substantial contribution of fact and analyses useful in subsequent detailed plan formulation. Normally, framework plans are the first phases of the comprehensive plan which would be prepared by a river basin commission established either under the Water Reources Planning Act, or by other legislation.

The Framework Study and Plan does not provide a basis for Congressional authorization of specific projects. However, they are useful to the Congress and planning agencies to insure that project proposals are consistent with the regional plan and thus achieve the advantages of coordinated Federal-State Planning.

LEVEL B STUDY

These are comprehensive studies by a river basin commission or other Federal-State coordinating organization that extend the planning scope beyond the Level A studies to define and evaluate projects. The Level B study is in sufficient detail, including project detail and project formulation, to comprise a basis for authorization of those Federal, State and local assisted projects to be initiated in the next 10 to 15 years.

LEVEL C STUDY

These are studies of narrower geographic or analytic scope, usually by a single agency, that normally relate to one project, purpose or proposal for preservation or improvement of water and related land resources. The studies indicate the relationship of the proposed programs and projects to the comprehensive plan for the river basin or region or, if no comprehensive plan has been completed, the relationship to probable later development needed or to be undertaken in the basin or region.

*Criteria implement the standard. However, sometime "standards" and "criteria" are used synonymously.

Both standards and criteria are employed to assess the relevance and/or sufficiency of plans or projects in the pursuit of the desirable goals and objectives.

MANAGEMENT

It includes all aspects of development, regulation, conservation and preservation of resources. It requires a good plan.

NEED

The difference between the demand and the supply when demand is greater than supply.

OBJECTIVES

Attainable steps to be taken or points to be emphasized on the way toward meeting or attempting to meet the goal. The objective attempts to approach the goal.

POLICY

A judicious set of authoritative decisions used as guidelines for an operation. A policy is a definite course or method of action selected from among alternatives and in light of given conditions to guide and determine present and future decisions.

PRESERVATION

Protecting resources from disturbance, damage, or spoiling, or to limit the development of uses.

REGULATION

Controlling human behaviors and/or resources characteristics according to rules of the society or laws of Nature, in order to achieve a desired outcome. Development (such as dams, wastewater treatment), conservation and preservation may be required so that regulation can be achieved.

SOLUTION CONCEPT

The expression of a problem resolution in terms of devices and measures with general location and magnitude.

STANDARD

A rule or model with which other things like it are to be compared or an enforceable limit. Usually, it consists of several criteria. (Also, see recreation activity standard and water quality standard.)

SUPPLY

Availability of facilities or resources.

UTILIZATION

Practical uses.

WATER RELATED LAND

Land on which projected use and/or management practices may significantly affect the runoff pattern or quality of the water resources to which it relates and land that is significantly affected by existing or proposed measures for management or use of the water resources to which it relates.

HYDROLOGY TERMS

BASE FLOW

The fair-weather flow of streams. Discharge entering stream channels as effluent from the groundwater reservoir.

EVAPOTRANSPIRATION

Water withdrawn from a land area by direct evaporation from water surfaces and moist soil and by plant transpiration, no attempt being made to distinguish between the two.

FLOW DURATION CURVE

A cumulative frequency curve that shows the percentage of time that specified discharges are equaled or exceeded.

GAGING STATION

A particular site on a stream, canal, lake, or reservoir where systematic observations of gage height or discharge are obtained continuously or periodically.

RECURRENCE INTERVAL (RETURN PERIOD)

The average interval of time within which a given flood will be equaled or exceeded once; also the average interval of time within which a flow equal to or lower than a given low flow will occur once.

RUNOFF

The water draining from a watershed.

WATERSHED (DRAINAGE BASIN)

A part of the surface of the earth that is occupied by a drainage system, which consists of a surface stream or a body of impounded surface water together with all tributary surface streams and bodies of impounded surface water.

WATERSHED AREA (DRAINAGE AREA)

The watershed area at a point in the stream refers to the area of the earth from which the water concentrates toward that point, through the drainage system.

YIELD

Capacity to produce as applied to streams, wells, crops, etc.

WATER SUPPLY TERMS

AQUIFER

A formation, group of formations, or part of a formation that is water bearing. Also called groundwater reservoir.

CONSUMPTIVE USE

The quantity of water discharged to the atmosphere or incorporated in the products of a process such as vegetative growth, food processing, or an industrial process.

DEPENDABLE YIELD

Yield of a surface stream with or without storages during a drought of specified return period such as 50 years or 7 day—50 year low flow, or the reported yield of wells.

DRAFT

Withdrawal of water or demand.

GPCD

Unit of water use per person in *gallon per capita per day*.

LOW FLOW FREQUENCY CURVE

A graph showing the magnitude and frequency of minimum flow for a specified period of time (duration).

RECHARGE

Addition of water to an aquifer by infiltration of precipitation through the soil, by seepage from streams or other bodies of surface water, by flow of groundwater from another aquifer, or by pumpage of water into an aquifer through recharge wells; also, the water added by these processes.

RECIRCULATION

Water reused within a plant unit. Sometimes, it also means water discharged by one unit and reused by other units in the same plant.

REUSE

Water that is discharged by one user and is used by other users. Sometimes, it also means water discharged by one unit and used by other units in the same plant.

SAFE YIELD

The rate at which water can be withdrawn from an aquifer without causing eventual depletion or contamination of the supply.

TOTAL WATER USED

Total water withdrawal which does not include recirculation.

FLOOD DAMAGE REDUCTION TERMS

DAMAGE-FREQUENCY CURVE

A graph showing the flood damages and their probabilities of occurrence. The total area under the curve represents the annual damage.

DIRECT DAMAGE

Physical damage to buildings and their contents, utilities, livestocks and crops.

FLOOD FREQUENCY CURVE

A graph showing the average interval of time within which a flood of a given magnitude will be equaled or exceeded once.

FLOOD PLAIN

A strip of relatively smooth land bordering a stream, built of sediment deposited in the slack water beyond the influence of the swiftest current.

INDIRECT DAMAGE

Loss of income due to interruption of business, cost of flood fighting and evacuation, care and rehabilitation of flood victims.

OUTDOOR RECREATION TERMS

ACTIVITY DAY

An activity day is a significant portion of a recreation day during which the recreationist participates in one activity. Therefore, a recreationist who swims in the morning and picnics in the afternoon has experienced two activity days of recreation.

ACTIVITY STANDARD

Number of activity days which each acre or unit of facility can accommodate per recreation season. The standard varies geographically.

LATENT DEMAND

The difference between the full-desire demand and the satisfied demand. The causes of latent demand, such as lack of time to participate or lack of facilities are called opportunity factors.

PARTICIPATION RATE

Number of persons, expressed as percent of population excluding those 4 years or under, who engage in a specified recreation activity.

RECREATION DEMAND

The desire to participate in outdoor recreation activities during some significant part of a day or overnight activity. The current demand subject to the supply constraint is called satisfied demand.

TURNOVER

The number of times a given facility or site is utilized per day.

WATER QUALITY MANAGEMENT TERMS

ACIDITY

The capacity of water for neutralizing a basic solution. Acidity is caused by the presence of hydrogen ion produced by hydrolysis of the salts of strong acids and weak bases.

ADVANCED WASTE TREATMENT

Advanced waste treatment refers to any method or process not now in common use, and is used after conventional treatment to remove refractory low level difficult-to-remove substances. Organic removals are generally greater than 95% and other constituents, such as ammonia and nitrogen are removed to produce an effluent with very low levels of these indicators.

ALKALINITY

The capacity of water for neutralizing an acid solution. Alkalinity of natural waters is due primarily to the presence of hydroxides, bicarbonates and carbonates.

BENEFICIAL USE

A use of water that is, in general, productive of public benefit, and which promotes the peace, health, safety and welfare of the people of the State.

BIOCHEMICAL OXYGEN DEMAND (BOD)

A common test used in assessing the strength of organic wastewaters. It measures the quantity of oxygen used in the biochemical oxidation of organic matter in a specified time at a specified temperature and under specific conditions. The higher the value of BOD the greater the pollution potential of the material.

COLIFORM BACTERIA

A group of bacteria predominantly inhabiting the intestines of man or animal which are used as indicators of fecal pollution and/or inadequately treated sewage. Coliform bacteria are not in themselves pathogenic but are indicators of potential public health hazards from water-borne disease.

DISSOLVED OXYGEN (D.O.)

The amount of oxygen dissolved in water. The solubility of atmospheric oxygen in fresh water ranges from 14.6 mg/l at O° C to about 7 mg/l at 35 C° under 1 atmosphere of pressure. Since it is a poorly soluble gas, its solubility varies directly with the atmospheric pressure at any given temperature. Its concentration in water is also affected by chemical and biological sources such as wastewater, algae and plants.

DISSOLVED SOLIDS

The dissolved mineral constituents in water; they form the residue that remains after evaporation and drying.

HARDNESS

A property of water which causes an increase in the amount of soap that is needed to produce foam or lather and that also produces scale in hot-water pipes, heaters, boilers and other units in which the temperature of water is increased materially. Hardness is produced almost completely by the presence of calcium and magnesium salts in solution. The following scale may assist the reader in appraising hardness:

Degree of hardness	Hardness range (mg/l)
Soft	0-60
Moderately hard	61-120
Hard	121-180
Very hard	Above 180

MILLIGRAM PER LITER (MG/L)

A unit of the concentration of a constituent in water or wastewater. It represents .001 gram of a constituent in 1,000 ml of water. It is approximately equal to one part per million. The term has replaced parts per million in water quality management.

NITROGEN COMPOUNDS

The different forms of nitrogen are organic-nitrogen, ammonia-nitrogen, nitrite-nitrogen (NO_2-N) and nitrate-nitrogen (NO_3-N). Ammonia-nitrogen is the initial product in the decomposition of nitrogenous organic matter mostly found in human and animal wastes. Oxidation of ammonia results in the formation of nitrite, an unstable form of nitrogen. Nitrite-nitrogen is rapidly and easily converted to nitrate-nitrogen. Other sources of nitrates are from chemical fertilizer plants, field fertilization and industrial wastes. Nitrate concentration is of particular interest in relation to the other forms of nitrogen. The presence in water of nitrate in excess of about 10 mg/l has been responsible for the occurrence of methemoglobinemia or cyanosis in bottle-fed infants.

PARTS PER MILLION (PPM)

The number of weight or volume units of a minor constituent present with each one million units of the major constituent of a solution or mixture. It was formerly used to express the results of most water and wastewater analyses but has been replaced by the ratio, milligrams per liter.

pH

Technically, it is the reciprocal of the logarithm of the hydrogen ion concentration. It expresses the intensity of the acid or alkaline condition of a solution. A pH of 7.0 indicates a neutral condition. An acid solution has a pH less than 7.0 and a base or alkaline solution has a pH greater than 7.0. The lower the pH the more acid the solution. The higher the pH the greater the alkalinity of the solution.

SECONDARY TREATMENT

Reduction of pollutional properties of organic (usually sewage and some industrial wastes) accomplished by settling the waste and subjecting it to a biological treatment process and disinfection. The organic component of the waste is reduced in the process by 85%.

SPECIFIC CONDUCTANCE

A measure of the ability of water to conduct an electrical current. It is expressed in microhms at

25°C. It is a measure of dissolved mineral in water and increases with increasing concentration of dissolved minerals.

TERTIARY TREATMENT

Tertiary treatment suggests a single additional step applied only after conventional primary and secondary waste treatment, e.g., chemical treatment of a secondary effluent for removal of phosphorus. Organic constituents are normally reduced up to 95% in tertiary treatment and other constituents such as phosphorus and ammonia are often reduced.

TURBIDITY

The term "turbid" is applied to waters containing suspended matter that interferes with the passage of light through the water or in which visual depth is restricted. The turbidity may be caused by a wide variety of suspended materials such as clay, silt, finely divided organic matter, microscopic organisms and similar substances. Turbidity in water has public health implications due to the possibilities of pathogenic bacteria encased in the particles and thus escaping disinfection. Turbidity interferes with water treatment (filtration), and affects aquatic life. Excessive amounts of turbidity make water aesthetically objectionable.

WATER POLLUTION

As defined in the Clean Stream Law "Pollution" shall be construed to mean contamination of any waters of the Commonwealth such as will create or is likely to create a nuisance or to render such waters harmful, detrimental or injurious to public health, safety or welfare, or to domestic, municipal, commercial, industrial, agricultural, recreational, or other legitimate uses, or to livestock, wild animals, birds, fish or other aquatic life, including but not limited to such contamination by alternation of the physical, chemical or biological properties of such waters, or change in temperature, taste, color or order thereof, or the discharge of any liquid, gaseous, radioactive, solid or other substances into such waters. More simply it refers to quality levels resulting from man's activities that interfere with or prevent water use or uses.

WATER QUALITY

The chemical, physical and biological properties of water.

WATER QUALITY CRITERIA

A specific level or range of levels of water quality necessary for the protection of a water use.

WATER QUALITY INDICATORS

Constituents or characteristics of water that can be measured to determine its suitability for use.

WATER QUALITY MANAGEMENT

Planning for protection of water quality for various beneficial uses, for the provision of adequate wastewater collection and treatment for municipalities and industries and for activities that might create water quality problems and regulating and enforcing programs to accomplish the planning goals and laws and regulations of the Commonwealth dealing with water pollution control.

WATER QUALITY STANDARD

An enforceable level of water quality to be maintained in the Commonwealth waters. A water quality standard normally consists of a criteria, a plan, and program to take the necessary water pollution control actions to attain the criteria.