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THE ECONOMIC VALUE OF REMOTE SENSING OF EARTH RESOURCES FROM SPACE AN ERTS OVERVIEW AND THE VALUE OF CONTINUITY OF SERVICE

VOLUME V

INLAND WATER RESOURCES

Prepared for the
Office of the Administrator
National Aeronautics and Space Administration
Under Contract NASW-2580

October 31, 1974

NOTE OF TRANSMITTAL

This resource management area report is prepared for the Office of the Administrator, National Aeronautics and Space Administration, under Article I.C.1 of Contract NASW-2580. It provides backup material to the Summary, Volume I, and the Source Document, Volume II, of this report. The interested reader is referred to these documents for a summary of data presented herein and in the other resource management areas.

The data presented in this volume are based upon the best information available at the time of preparation and within the resources of this study. This includes a survey of existing studies plus Federal budgets and statutes. Nonetheless, there are, of course, uncertainties associated with any projection of future economic benefits, and these data should be used only with this understanding.

ECON acknowledges the contributions of Elliot Wetzler, Wes Peterson, and Martin Putnam who authored this volume.

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ABSTRACT

Annual hard benefits of $57.2 million are estimated for an ERTS system in the inland water resource management area. Of this amount, $50.6 million in hard benefits can be attributed to new capabilities for managing inland water resources, particularly in the field of power generation, agriculture, and urban water supply. This $50.6 million estimate is based on the results of ECON's ad hoc case study of the Feather River. The Feather River study used conservative assumptions in deriving estimated benefits. In addition to hard benefits, soft annual benefits of between $50.1 million and $121.1 million are estimated for inland water resources. These benefits are obtained in the area of equal capability (cost savings) and increased capability (equal budget) benefits. These benefits are estimated by applying conservative assumptions to Federal budgeting information, Congressional appropriation hearings, and ERTS technical capabilities. No quantitative estimates of benefits are made in the area of monitoring and controlling water pollution, but it is almost certain that benefits of significant magnitude exist in this area.

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1.0 INTRODUCTION AND OVERVIEW: INLAND WATER

Inland water is one of our most important resources. In the U.S., it has traditionally been treated as if it had no cost and as if there were no limits to its availability. In recent years, there has been greater recognition of the adverse effects of urban and industrial growth on water quality as well as the possibility of inadequate water supplies in densely-populated areas. In addition to these new concerns, traditional water management problems, such as flooding, take on increased importance as the pressures mount to develop flood plains and other marginal areas. Proper management of this valuable and potentially scarce resource has thus taken on greater importance.

Earth resources survey satellites can provide, through more extensive and improved information, considerable benefits in the water resources areas. These benefits are of three types:

(1) Equal-capability - benefits which result from cost reductions in mapping, surveying, monitoring and management activities which would otherwise be carried out by a more costly means

(2) Increased-capability - benefits which arise from increases in the output of these activities

(3) New-capability - benefits which arise from resource management activities which would be otherwise technically unfeasible or economically unjustified

This section of the study aims to estimate for each of the above categories the annual benefits to water-resources management that would be brought about by an ongoing ERS satellite system with approximately the capabilities of the Earth Resources Technology Satellite (ERTS). The methods and models used to estimate the first two types of benefits are outlined in Volume II. The new-capability benefit in one important water-resources activity, reservoir management, is explored in a case study on the California Feather River Project (Appendix F).

A summary of these benefits by resource management function and by applicable Federal Agency is given in Tables 3.1 and 3.2, at the end of this chapter.

The inland water resources discussed in this section of the study include surface and ground water, snow, ice and glaciers, and water impoundment systems and watersheds. Coastal

wetlands and estuaries are included under other headings. Water is a dynamic resource, changing from liquid to vapor through evaporation, from liquid to solid through freezing and moving from one place to another through precipitation, surface drainage and movement in underground aquifers. Actions affecting water at one stage of the hydrologic cycle will have implications for later stages. What is taken out or put into a stream at one point may have serious local, national and international repercussions further downstream. Understanding these relationships and predicting future effects of particular actions are often very difficult in the absence of comprehensive information. The ability to obtain synoptic coverage of large areas is becoming essential and represents one of the greatest potential benefits of an earth resources survey (ERS).

Many of the broad water resources management activities stand to benefit from the improved information provided by ERS. Reservoir management is carried out with a wide variety of objectives in mind. Reservoirs have frequently been built to control flooding and assure water supplies. In many cases, these reservoirs include hydro-electric and recreational facilities. Selection of reservoir sites requires extensive studies and a great deal of information. Once the site has been selected and a dam has been constructed, information on snow cover and predicted run-off is essential in order to make better decisions on reservoir draw-down. Whatever the purpose, construction and management of man-made water impoundment systems requires many decisions which will be improved with better, more timely information.

Reservoir management and construction is not the only means to control flooding and water supply. In recent years, more emphasis has been placed on non-structural approaches to flood control, such as land-use planning in flood plain areas. Mapping potential flood regions is an important management activity where remote sensing could clearly make a contribution. Improved planning and early warning as well as reservoir construction and management can reduce significantly the annual damage resulting from disastrous floods.

Assuring an adequate water supply for recreational purposes and urban, industrial, commercial and agricultural needs involves many activities besides reservoir management. These activities include planning, distribution, water rights and water use legislation, and conservation. In many of these activities, the quality of the decisions made, depends on the reliability of the information used to make them. With the growth in population and industrial development, water supplies are increasingly related to water quality and pollution control. Present legislation in the U.S. means that water pollution identification, control and abatement is becoming a major activity

in the area of inland water resources management. Water quality standards have been set and programs are being designed to achieve these standards. The enormous complexity of the decisions which will have to be made results from the trade-off between water quality and growth as well as the need to monitor and control the large number of water systems within the country. Demand for better information will increase as the need for more, complex decisions rises.

This summary of some of the major management functions for water resources in the U.S. is designed as an overview. Detailed descriptions of the necessary activities and the information needed to carry out these activities, are contained in the resource management function reports in Appendix A.

1.1 Federal Government Activities

The Federal government has wide responsibilities in water resource management and development. Generally, the Federal government provides financial and consulting assistance to state agencies, plans and executes large-scale programs which are beyond the means of state and local authorities or involve areas which include several states. The Federal government participates in many interstate river basin agreements and is the major source of construction funds.

Specific Federal programs include the following:

- The inland waterway program designed to improve and maintain navigable waterways.
- Food and fiber programs designed to increase agricultural production through water resources development.
- Acreage limitations and subsidies in reclamation programs designed to assure irrigation water for small farmers.
- Flood control programs to reduce flood losses.
- Municipal and industrial water supply programs to aid municipalities and industries to obtain sufficient water.
- Erosion and sedimentation damage control programs.
- Recreation, fish and wildlife programs.

There are several Federal agencies involved in these and other Federal water resources programs. The Soil Conservation Service (SCS) of USDA assists local soil conservation districts in water management, erosion control and other related

activities. SCS also constructs and manages water impoundment systems for irrigation and erosion control.

Many agencies within the Department of the Interior are involved in water resources. Foremost among these is the U.S. Geological Survey which collects information on stream-flow, snow melt and runoff, ground and surface water. The Bureau of Reclamation is one of the major Federal construction agencies involved in land reclamation and construction of water impoundment systems. In addition to these agencies, there are several regional power administrations charged with building and maintaining hydro-electric power facilities.

The Army Corps of Engineers (civil) is another important construction agency. For Federal construction projects, Congress authorizes funds for specific projects developed by the Engineers, SCS or the Bureau of Reclamation. The flood control program of the Corps of Engineers involves substantial financial outlays for construction of dams as well as flood plain mapping.

E.P.A. is the major Federal agency involved in water pollution control. Its functions are primarily to assist states in designing programs to meet water quality standards, to carry out research on water pollution control and to help in the enforcement of standards. Much water pollution control is left to state and local agencies with E.P.A. acting as an advisor on planning and methods of control.

Appendix D contains detailed descriptions of the responsibilities of all Federal agencies involved in water resources management and development as well as budgetary information on these agencies. In addition, the statutes authorizing or requiring Federal action in each resource management area are included in the RMF's.

1.2 State and Local Government Activities

State and local officials are involved in a wide variety of activities related to inland water resources. Many of these activities are carried out in cooperation with other states and various agencies of the Federal government. In addition, every state has some system of water law which allows regulation and adjudication of water use within the state's boundaries. Most states are developing state water plans in order to regulate and assure adequate water supply and water quality.

A number of Federal agencies assist and cooperate with state agencies. These include:

- E.P.A. and the 10 regional E.P.A. offices provide planning assistance to state and local environmental offices charged with enforcement and execution of programs to meet water quality standards.

- Soil Conservation Service of USDA works with state soil and water conservation districts.

- Municipal & Industrial Water Supply programs of the states receive financial and planning assistance from HUD & FHA as well as the right to store water in reservoirs owned by the Federal government and the Soil Conservation Service.

- The Army Corps of Engineers, Bureau of Reclamation, U.S. Geological Survey and other agencies provide the states with consulting and technical services. For example, the Corps of Engineers is increasingly providing information on flood plains for use in developing land-use policies by the states.

There are also many regional organizations including River Basin Commissions, Interstate and Federal-Interstate Water compacts and the Great Lakes Basin Commission. These regional groups regulate water allocation, control pollution and floods and frequently develop comprehensive river basin plans along rivers which go through several states. Examples of State activities are:

- Colorado (source: report of the Colorado Division of Water Resources, State Engineer's Office): This division is charged with enforcement of state water laws, distribution of surface and ground water, reservoir safety and stream flow studies. A request has already been made to NASA for ERTS services and Colorado State University is using ERTS data in several water studies. Colorado is represented on the boards of ten interstate river compacts including the Upper Colorado River Basin Compact. Water rights are based on the doctrine of prior appropriation and the State Engineer must administer water rights, issue permits for ground water acquisition (wells) and other water rights acquisition. There are approximately 3.5 million acres of irrigated land in Colorado. Almost 10 million acre-feet of water are distributed annually for irrigation and urban and rural water supply. The State Water Division plans and excutes water diversions from storage areas lying to the west of the Continental Divide to the eastern part of the state for use in Denver and to irrigate large, fertile areas of farm-land.

- In California, there are at least the following agencies concerned with water (source: Controllers Report, 1971-72):

Agency	Total Expenditure in FY 71/72 dollars
Colorado River Board	155,375
Klamath River Compact	9,725
Dept. of Water Resources	15,610,669
Water Resources Control Board	4,050,057

  The Dept. of Water Resources is responsible for the planning, design, construction and operation of state water facilities. It compiles data on water resources and use, investigates surface and underground water supplies, cooperates in snowmelt and run-off forecasts, administers water rights and interstate water compacts and assists in land reclamation. The State Water Resources Control Board is concerned with water rights, water pollution and planning and research to preserve water quality. The state Environment Quality Council works with local agencies in pollution control. Other agencies involved in water resources are the Dept. of Conservation, the Dept. of Fish and Game, Reclamation Board, etc.

- In New Mexico the State Engineer carries out the following activities (source: State Budget): administration of water rights, hydrographic surveys and water rights adjudication, collection of basic data and water resources investigations, and administration of interstate stream compacts. In FY 70/71, the State Engineer had a budget of $1,670,000.

In summary, state and local officials have wide responsibilities for local water resources management and development. Many state universities carry on extensive research in water resources for use by water planners and administrators in state agencies. The types of state and local agencies involved in water resources include the following:

- soil and water conservation districts
- state and local environmental protection agencies
- State Engineer, State Department of Water Resources or State Division of Water Resources.
- State Departments of Natural Resources or Conservation

- State Fish and Game Departments
- State Departments of Parks & Recreation
- River Basin Commissions and Compacts.

1.3 Economic and Technical Models for Estimating Benefits

Benefits to Federal and intergovernmental agencies are estimated by the following procedure:

1. Equal-capability benefits

   a. Programs which mandate ERS-relevant activities are located by examination of Federal budget and congressional hearings.

   b. The proportion of the appropriate program budget which is devoted to data collection activities that fall within demonstrated ERTS capabilities is conservatively estimated by reference to agency budget justifications, congressional hearings, and the results of research by ERTS principal investigators. The result is then divided among those ERTS activities which employ ERTS photographic and multispectial scanner (MSS) capabilities, including thermal infrared, and those which make use of the ERTS remote data-collection system (DCS).

   c. The cost savings for ERTS photographic and MSS capabilities over aircraft has been conservatively estimated at 80%. (ECON, Inc., The Role of ERTS in the Establishment and Updating of a Nationwide Land Cover Information System, Draft, Princeton, N.J., 15 August 1974) In the case of DCS-applicable activities, the incremental cost of data-collection platforms partly offsets savings due to increased efficiency of data transmission and collection. Savings due to DCS are therefore assumed to be somewhat less than one-third as great as savings due to ERTS photographic and MSS capabilities. The equal-capability benefits for a given data-collection activity are therefore

      $$ECB = .25AD + .8A\ (1-D)$$

      where ECB = equal capability benefit

      A = budget allocation to ERTS-applicable data collection activities

      D = fraction of program to be implemented by DCS.

d. The results of (c) are allocated among the relevant RMFs.

2. Increased-capability benefits

As the source document discusses in more detail, benefits due to increased capability are calculated on the assumption that the budget appropriation for ERS-relevant activities remains unchanged after the introduction of an ERS. Under free-market assumptions this corresponds to a situation in which demand for a good (in this case, information) is unit-elastic (see Figure 1).

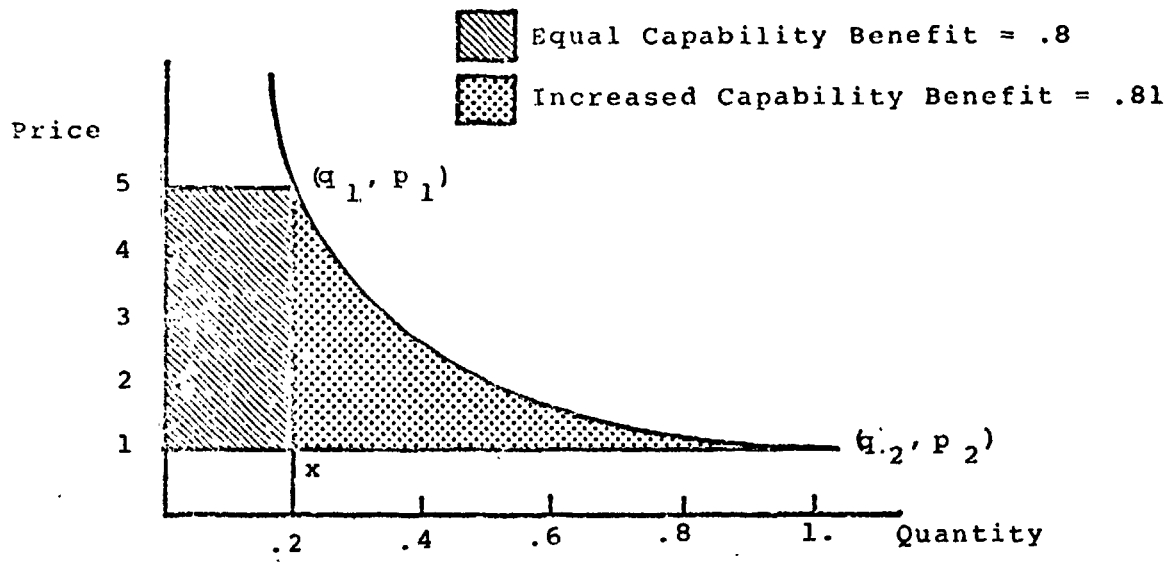

Figure 1 Equal-Capability and Increased Capability Benefits from ERTS Photographic and MSS Functions

The increased-capability benefit is equal to the value to the user of the additional quantity of information minus its cost. This corresponds to the area $(q_1,p_1)(q_2,p_2)(X)$ in Figure 2, assuming a demand curve that is unitary elastic $(p = 1/q)$. Hence, in the case of ERS imaging capabilities,

$$ECB_p = \int_{.2}^{q} \frac{1}{q}\, dq - .8 = .81$$

The increased-capability benefits in this case are thus approximately equal in magnitude to the equal-capability benefits. For DCS-applicable activities, the corresponding result is

$$ECB_D = \int \frac{1}{q}\, dq - .25 = .037$$

For these activities the increased-capability benefit is equal to approximately 15% of the equal-capability benefit.

In some cases the increased-capability benefit may be smaller than that given by the formulas presented above due to dependence of demand for ERTS data-collection activities on other programs within the same budget category. An attempt has been made to compensate for possible biases from this and other sources by conservative estimates of the proportion of each budget for which an ERS system is likely to be relevant.

1.4 Current ERTS Activities

The names, addresses and phone numbers of the principal investigators studying the applicability of ERTS type information in the area of inland water resources are listed in Appendix G. This appendix also includes descriptions of the work being done and reports of significant results. Names and titles

are included under each resource management function (RMF). These listings show the work being done which is relevant to particular resource management functions.

In some instances, details of the work being done by a particular investigator were not available. However, many of the investigators have reported significant results which appear to be extremely useful. In the area of surveying lakes and identifying water pollution, several investigators have been able to achieve interesting interpretations based on ERTS imagery. For example, Baumgardner found that he could distinguish deep water, shallow water and shallow water with dead trees and stumps using ERTS imagery. Lind was able to recognize the boundary between turbid and clear lake water as well as algal blooms and pollution plumes from point sources near lake. Pluhowski identified sediment plumes and the mechanism by whic nearshore suspended sediments are swept out into Lake Ontario.

Another area where remote sensing has proved to be particularly useful concerns snow, ice and glaciers. Meier has found ERTS to be an excellent means to inventory glaciers, study glacier movements and the dynamics of glacier development, as well as other theoretical and empirical glaciology questions. He feels that more frequent ERTS passes during the snowmelt season would be advantageous. Generally, snow mapping and surveying can be done very effectively with ERTS imagery. Barnes found that more detailed snow maps could be obtained with ERTS and the time required to make snow charts was reduced to two hours from the six hours needed using aerial surveys. Cooper also found satellite imagery useful in providing improved snow contour maps. In studying tundra areas, Holmgren concludes that ERTS data provides entirely new information on break-up characteristics of drainage basins, development of drainage patterns and open water and changes in snow cover.

Several investigators are very enthusiastic about remote sensing for lake ice surveys. Jelacic feels that ERTS imagery offers the opportunity of increasing knowledge of lake freezing cycles and lake atmosphere interactions. Wiesnet presents very positive assertions on ERTS:

> "ERTS is the most outstanding lake ice reconnaissance platform yet devised. The detailed images of lake ice and lake ice features exceeds any prior sensor platform combination in terms of interpretability and information content. By using it in conjunction with NOAA-2, it ought to revolutionize the ice-forecasting ability of NOAA's lake forecasters....the greater ground resolution

of ERTS-1 and its cartographic fidelity make it outstanding as a snow mapping satellite. It has no peer in this respect".

Many of the investigators are examining the impact of remote sensing on interpretation time and management functions which need very current information. Wiesnet found snow cover mapping to be six times faster with ERTS-1 than with U-2 photography. Thorley estimated the times required for high altitude aircraft imagery interpretation to be seven times greater than with ERTS-1. Schumann details the use of ERTS information on a near-real times basis in managing and operating Arizona reservoirs. The information was used to anticipate the flow into two reservoirs allowing managers to draw-down water levels without causing flooding. Losses due to flooding in Phoenix were far smaller than those of the winter and spring of 1972-73.

Table 1 shows the estimated potential annual equal capability benefit of an ERS satellite system to specific Federal programs of government agencies, listed alphabetically The magnitude of these benefits is determined by the economic and technical models for estimating benefits that are described earlier in this volume and by an evaluation of the budgetary and program information given in Appendix B. For ready comparison, both program budgets and equal capability benefits are given. The values shown in Table 1 are aggregations of equal capability benefits across government programs given for the individual RMF's in Appendix A.

Table 2 presents the estimated potential annual equal capability, increased capability, and new capability benefits of an ERS Satellite System by resource management function. The values given for these benefits also appear under the individual RMF's in Appendix A. Derived from the same tables in Appendix A, Tables 1 and 2 are consistent with each other. Appendix A, in effect, provides a cross referencing of benefits by RMF and government program. Benefits both by government program (Table 1) and by RMF (Table 2) are presented here for the convenience of the reader.

1.5 Estimate of ERTS Economic Capabilities

Table 1 Summary of Potential Benefits to Federal Agencies from an ERS Satellite System

Government Agency	Relevant Program Item	Program Budget $ thousands	Number of Relevant RXP's	Estimated Equal Capability Benefit, This Program, $ thousands, 1973
Alaska Power Administration	Resource Development Studies	190	3	(32 - 94)
Army Corps of Engineers	Stream Gaging	5,105	2	(1000 - 1200)
	Lake Erie Waste Water Management Study	670	4	
	Flood Plain Information Reports	5,750	5	200 (700 - 3000)
	Northeastern U.S. Water Study	1,950	3	(60 - 900)
Bonneville Power Administration	Power Supply and Scheduling	1,260	9	(108)
Delaware River Basin Commission	Water Quality Management	632	3	(30 - 54)
	Flood Loss Reduction	76	3	(24 - 60)
Environmental Protection Agency	Water Quality Technical Assistance and Planning	11,477	6	(300 - 780)

Note: Figures in parentheses are order-of-magnitude estimates which are not supported by in-depth case studies

Source: ECON, Inc.

Table 1 Summary of Potential Benefits to Federal Agencies from an ERS Satellite System (con't)

Government Agency	Relevant Program Item	Program Budget $ thousands	Number of Relevant RMP's	Estimated Equal Capability Benefit, This Program, $ thousands, 1973
Environmental Protection Agency	Water Quality Municipal Source Control	14,951	3	(270 - 540)
	Water Quality Enforcement	11,450	3	(550 - 1100)
	Research and Development on Processes and Effects	18,371	8	(400 - 800)
	Abatement and Control: Water Quality Ambient Trend Monitoring	5,274	7	(115 - 460)
	Abatement and Control: Water Quality Control Agency Support	40,000	9	(450 - 1980)
Susquehanna River Basin Commission	Appraisal of Measures to Reduce Future Flood Damages	126	4	(8 - 24)
Tennessee Valley Authority	Water Control Operations	1,370	7	(280 - 350)
	Regional Water Quality Management: Water Quality Inventory	718	6	(60)
	Flood Control Operations	425	4	(12)
	Preliminary Investigations	90	1	(7 - 30)
U.S. Dept. of Agriculture	Technical Programming, Installation Services and Snow Surveys	165,703	14	3,080 (4,720 - 12,600)
U. S. Dept. of Agriculture, Forest Service	Water Pollution Abatement	16,733	6	(270 - 480)
U.S. Dept. of Agriculture, Soil Conservation Service	River Basin Surveys and Investigations	15,561	5	(1200)
	Small Watershed Project Investigations and Planning	12,756	1	(500 - 900)
	Flood Prevention Projects	25,270	1	(400 - 4000)

Note: Figures in parentheses are order-of-magnitude estimates which are not supported by in-depth case studies.

*Source: ECON, Inc.

Table 1: Summary of Potential Benefits to Federal Agencies from an ERS Satellite System (con't)

Government Agency	Relevant Program Item	Program Budget $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit, This Program, $ thousands, 1973
U.S. Dept. of Agriculture, Soil Conservation Service	Soil and Water Science for Management Support	8,900	2	(80)
U.S. Dept. of Interior, Bureau of Land Management	Soil and Watershed Conservation	16,565	4	(160 - 480)
U.S. Dept. of Interior, Bureau of Reclamation	Water Resources, Planning and Engineering Research	2,630	1	(6)
	Plan Formulation Investigations	9,800	1	(390 - 3,100)
	Regional Planning Service	1,282	6	(180 - 540)
U.S. Dept. of Interior, Office of Water Resource Research	Additional Water Research	3,107	1	(10)
U.S. Geological Survey	Water Resources Investigations	84,880	13	(13,500 - 27,000)
Total				(25,822 - 61,948)

Note Figures in parentheses are order-of-magnitude estimates which are not supported by in-depth case studies.
Source: ECON, Inc.

Table 2: Magnitudes and Types of Potential Benefits of an ERS Satellite System by Resource Management Function-Inland Water Resources

Resource Management Function	Benefits, $ millions (1973)		
	Equal Capability	Increased Capability	New Capability
3.1 Cartography, Thematic Maps and Visual Displays			
3.1.1 Map and survey free water areas	(1.5-3.0)	(1.5-3.0)	
3.1.2 Map and survey snow, ice and glaciers	.2 (.4-.9)	.2 (.4-.9)	
3.1.4 Map watershed areas	.04 (2.0-3.9)	.04 (2.0-3.9)	
3.1.5 Map water pollution	(.2-.5)	(.1-.4)	
3.1.6 Map potential water impoundment areas	(1.5-3.4)	(1.5-3.4)	
3.2 Statistical Services			
3.2.1 Predict fresh water supplies & floods	.3 (2.0-4.6)	.3 (2.0-4.6)	
3.2.2 Inventory fresh water supplies & snow cover	.2 (2.1-4.2)	.2 (2.1-4.2)	
3.2.3 Gather information for hydrological models	2 (2.7-5.0)	.2 (2.3-4.4)	
3.2.4 Inspect water impoundment areas	(1.5-3.0)	(1.5-3.0)	
3.2.5 Monitor stream salinity & pollution	(.5-1.2)	(.4-1.0)	
3.2.6 Monitor thermal pollution of free water	(.3-.8)	(.3-.6)	
3.3 Calendars			
3.3.1 Monitor changes in free water areas	.2 (.6-1.2)	.2 (.6-1.2)	
3.3.2 Monitor changes in snow, ice and glaciers	.2 (.4-.9)	.2 (.4-.9)	
3.3.4 Monitor evapo-transpiration, soil moisture & drainage patterns	(.2)	(.2)	
3.3.5 Monitor cyclical pollution patterns	(.2-.6)	(.2-.5)	
3.4 Allocation			
3.4.1 Manage water impoundment systems-for power generation	.3 (.6-1.4)	.3 (.5-1.4)	42.0(e)
3.4.2 Manage water impoundment systems-for flood control	.3 (.6-1.4)	.3 (.5-1.4)	
3.4.3 Manage water impoundment systems-for urban water supply	.3 (.6-1.4)	.3 (.5-1.4)	.9(e)

Note: Figures in parenthes are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

(Table 2 continued on p. 1-16)

Table 2: Magnitudes and Types of Potential Benefits of an ERS Satellite System by Resource Management Function-Inland Water Resources (con't)

Resource Management Function	Benefits, $ millions (1973)		
	Equal Capability	Increased Capability	New Capability
3.4.4 Manage water impoundment systems-for agricultural water supply	.3 (.6-1.4)	.3 (.5-1.4)	7.7(e)
3.4.5 Manage water impoundment systems-for recreational purposes			
3.4.6 Manage water impoundment systems-for navigation	(a)	(a)	
3.4.7 Plan changes in drainage & water impoundment systems	(1.4-8.8)	(1.4-8.8)	
3.5 Conservation			
3.5.1 Conserve Fresh Water Supplies	(.04-.12)	(.04-.12)	
3.6 Damage Prevention and Assessment			
3.6.1 Assess & reduce flood damage	.3 (.5-1.5)	.3 (.5-1.5)	
3.6.3 Reduce pollution of free water	(.5-1.1)	(.4-.8)	
3.7 Unique Event Recognition and Early Warning			
3.7.1 Provide early warning of disastrous floods	.3 (1.0-2.1)	.3 (.6-1.6)	
3.7.2 Provide early warning of lake eutrophication	(.1-.4)	(.1-.3)	
3.7.3 Monitor changes in surface water supply due to geological changes	(a)	(a)	
3.8 Research			
3.8.1 Conduct hydrological research	(1.5-3.0)	(1.5-3.0)	

(a) ERTS capability in this area not established

(Table 2 continued on p. 1-17)

Table 2: Magnitudes and Types of Potential Benefits of an ERS Satellite System by Resource Management Function-Inland Water Resources (con't)

Resource Management Function	Benefits, $ millions (1973)		
	Equal Capability	Increased Capability	New Capability
3.8.2 Conduct flood control research	(1.5-3.0)	(1.5-3.0)	
3.8.3 Conduct water pollution research	(.1-.4)	(.1-.3)	
3.9 Administrative, Judicial and Legislative			
3.9.1 Design government programs to reduce flood damage	.04 (b) (.1-.6)	.04 (b) (.1-.6)	
3.9.2 Increase compliance with water pollution regulations	(.5-1.1)	(.4-.9)	
3.9.3 Aid in designing legislative controls for policy implementation	(.1-.4) (c)	(.1-.3) (c)	
3.9.4 Aid in planning government projects for future water supply	(.1-.2) (b)	(.1-.2) (b)	
(d) Total: Hard Benefits	3.3	3.3	50.6
Soft Benefits	(25.8-61.9)	(24.3-59.2)	

(b) For benefits to this RMF see also RMF 3.4.7
(c) For benefits to this RMF see also RMF's 3.2.5, 3.3.5, 3.4.7, 3.6.3, 3.9.2, 3.9.4
(d) Totals may not correspond exactly with sum of values given in table because of rounding of individual entries.
(e) Hard benefits documented in ECON Feather River Case Study

1.6 Cartography, Thematic Maps and Visual Displays

The six water management functions detailed under this heading include mapping and surveying of free water areas, snow and ice, ground water, watershed areas, water pollution and potential water impoundment areas. Mapping and surveying are essentially static operations which provide valuable information on the location, condition and state of water resources at a particular time. Of course, as water moves through the hydrological cycle through evaporation, precipitation, freezing and drainage, its location and condition will change. This area, therefore, is primarily useful as an input into functions such as monitoring for which it provides the base-line data.

An estimate of the equal capability and the increased capability benefit in this area can rely on the standard models discussed in the main report for measuring these benefits. To determine equal capability, an estimate of the current and projected requirements in the absence of new technology for maps and surveys in terms of current quality, technical characteristics, and frequency of coverage is necessary. Given these current and projected requirements, estimates of the total and incremental cost of meeting these requirements are needed. Once benefit results are obtained for the equal capability case, it is a straightforward procedure to determine the benefit in the increased capability or equal budget approach.

The potential for satellite mapping and surveying offers new possibilities. Location of water resources or potential water impoundment areas in remote regions is feasible using satellite imagery and often proves to be less expensive than conventional methods. Map and survey information on water resources is used by Federal, State and Local officials as inputs to monitoring systems as well as for purposes of land-use planning in flood plain areas, locating new sources of water supply and areas of recreational potential, and in legislation or adjudication relating to boundaries, water rights and water use.

The Federal agencies which collect or use mapping and surveying information on inland water resources and their statutory authority are detailed under each RMF heading. The principal Federal agencies involved are the Soil Conservation Service of USDA, various bureaus within the Department of the Interior and the Army Corps of Engineers (civil).

Since State governments are responsible for water rights and water use within their boundaries, there is a need at State and local levels for information on lake perimeters, river courses and unauthorized or accidental water diversions. Individual State governments also cooperate with the Federal government and other states in flood plain management, land-use planning, snow surveys and river basin management.

The principal investigators studying the application of ERTS to this function are detailed under each RMF and additional information on their results and progress is contained in Appendix E. Generally, they have found that ERTS imagery is extremely useful in mapping and surveying inland water resources. The advantages of remote sensing result from the ability to see features that would not otherwise be observed and the ability to cover a large geographic region.

Considerable economic benefits could result from the use of ERS imagery for this function. Large areas can be mapped and surveyed at a low incremental cost. This is particularly true for geographically remote or inaccessible areas. One major source of benefits results from lowered property damage during floods. Using ERS imagery it is possible to delineate flood plains and areas of potential flooding. The Army Corps of Engineers and other Federal agencies collect this kind of information in order to assist local officials in planning land-use. In many instances, simply avoiding construction in a flood plain area will eliminate the need to construct dams and water retainers to protect constructions from flood damage. Presently, large amounts are spent gathering mapping and surveying information Benefits will arise from using ERS data in that the same information can be obtained at less cost. In addition, information on remote areas which cannot be obtained with conventional methods will become available with an ERS and contribute to an improvement in decision making. This improvement will also give rise to economic benefits. Further details on the economic capabilities and benefits of ERS are contained under each RMF.

Table 3 summarizes potential equal capability benefits for remote sensing applied to cartography, thematic maps and visual displays by benefiting agency.

Table 3: Summary of Potential Equal Capability Benefits to Federal Agencies from Remote Sensing in Cartography, Thematic Maps, and Visual Displays

Government Agency	Relevant Program Item	FY Programs Budget $ thousands	Estimated Equal Capability Benefit, $ thousands (1973)
Alaska Power Administration	Resource Development Studies	190	(24)
Army Corps of Engineers	Flood Plain Information Reports	5,750	40 (140 - 600)
	Northeastern U.S. Water Study	1,950	(30 - 450)
	Lake Erie Waste Water Management Study	670	
Bonneville Power	Power Supply and Scheduling	1,260	(12)
Delaware River Basin Commission	Flood Loss Reduction	76	(8 - 20)
Environmental Protection Agency	Research and Development on Processes and Efforts	18,391	(50 - 100)
	Abatement and Control: Water Quality Ambient Trend Monitoring	5,274	(15 - 60)
	Abatement and Control: Water Quality Control Agency Support	40,000	(50 - 220)
Susquehanna River Basin Commission	Appriasal of Measures to Reduce Future Flood Damages	126	(2 - 6)
Tennessee Valley Authority	Flood Control Operations	425	(4)
	Regional Water Quality Management: Water Quality Inventory	718	(10)
U.S. Dept. of Agriculture	Technical Programming, Installation Services and Snow Surveys	165,713	220 (340 - 900)
U.S. Dept. of Agriculture, Forest Service	Water Pollution Abatement	16,733	(45 - 80)
U.S. Dept. of Agriculture, Soil Conservation Service	River Basin Surveys and Investigations	15,561	(240)
	Soil and Water Science for Management Support	8,900	(40)
U.S. Geological Survey	Water Resources Investigations	84,880	(4,500 - 9,000)
TOTALS			260 (5,510 - 11,766)

Note: Figures in parentheses are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

1.7 Statistical Services

Six RMF's are detailed under this heading. Statistical information is used in flood prediction, water supply inventories, inspection of water impoundment areas and monitoring salinity and pollution of streams and free water. The value of statistical inputs for water resource management and decision-making increases greatly as the statistical data become more comprehensive and current.

Much effort at all levels of government is devoted to the collection and compilation of basic hydrologic data. Details on Federal and non-Federal data collection activities are included under each RMF heading. In addition to USDA, USDI and the Army Corps of Engineers, such Federal agencies as HEW, HUD and EPA are involved in data collection. Many of these agencies have scientific research programs which aim at modeling relationships between various hydrologic phenomena. For example, the Bureau of Reclamation finances research studies on theoretical problems such as the determination of underground water movements. These models are used in setting standards and procedures in a variety of water resource management programs as well as for policy formulation. In order to test theoretical results, accurate statistical information is needed. If the theoretical results appear to be useful, application of the model to real-world problems is only beneficial to the extent that timely, reliable data are available.

Most State governments cooperate with Federal agencies in the collection of hydrologic data. In the Western states, snow cover inventories are used in forecasting run-off which, in turn, is a principle input into reservoir draw-down decisions. Further details on State and Local activities in the area of data collection are included under each RMF.

The principal investigators studying the applicability of remote sensing to the area of data collection are listed under each RMF and in Appendix G. Some of the progress reports indicate that ERTS imagery is opening new dimensions in measuring snow cover and providing data for run-off forecasting models. ERTS imagery is also proving useful in data collection on pollution and particularly for the theoretical study of lake sedimentation.

The value of remote sensing in the are of data collection rests with the frequent coverage of large areas. Hydrologic data are needed for decisions on power generation, irrigation, flood prevention and fresh-water supply. The frequent synoptic coverage and short lead times provided by remote sensing make possible significant improvements in real-time hydrologic models. In addition, remote data collection

systems using satellite relay allow geographically remote areas to be monitored more frequently and more efficiently. There could be substantial benefits from the use of an ERS in data collection, since a greater volume of statistical information covering conventional and geographically remote areas on a near real-time basis could be obtained. For example, a small improvement in run-off forecasting resulting from better statistical inputs, would lead to a very large increase in benefits resulting from improved reservoir management decisions.

Further details on the economic capabilities and benefits of remote sensing in the area of statistical data collection are included under each RMF. Table 4 summarizes potential equal capability benefits, due to remote sensing applied to statistical services, by benefiting agency.

Table 4. Summary of Potential Equal Capability Benefits to Federal Agencies from Remote Sensing Applied to Statistical Services

Government Agency	Relevant Program Item	FY Programs Budget $ thousands	Estimated Equal Capability Benefit, $ thousands (1973)
Army Corps of Engineers	Lake Erie Waste Water Management Study	670	
	Flood Plain Information Reports	5,750	50 (140 - 600)
	Stream Gaging	5,105	(500 - 600)
	General Hydrological Studies	100	
Bonneville Power Administration	Power Supply and Scheduling	1,260	(12)
Delaware River Basin Commission	Water Quality Management	632	(10 - 18)
	Flood Loss Reduction	76	(8 - 20)
Environmental Protection Agency	Water Quality Municipal Source Control	14,951	(90 - 180)
	Water Quality Enforcement	11,450	(250 - 500)
	Research and Development on Processes and Effects	18,391	(100 - 200)
	Abatement and Control: Water Quality Ambient Trend Monitoring	5,274	(30 - 120)
	Abatement and Control: Water Quality Control Agency Support	40,000	(100 - 440)
	Water Quality Technical Assistance and Planning	11,477	(100 - 260)

Table 4: Summary of Potnetial Equal Capability Benefits to Federal Agencies from Remote Sensing Applied to Statistical Services (con't)

Government Agency	Relevant Program Item	Program Budget ($ in thousands)	Estimated Equal Capability Benefit, this RMF $ thousands (1973)
Susquehanna River Basin Commission	Appraisal of Measures to reduce future flood damage	126	(2 - 6)
Tennessee Valley Authority	Flood Control Operations	425	(4)
	Regional Water Quality Management: Water Quality Inventory	718	(20)
	Water Control Operations	1,370	(40 - 50)
U.S. Dept. of Agriculture, Forest Service	Soil and Water Science for Management Report	8,900	(40)
	Water Pollution Abatement	16,733	(90 - 160)
U.S. Dept. of Agriculture, Soil Conservation Services	Technical Programming, Installation Services and Snow Surveys	165,713	660 (1020 - 2700)
	River Basin Surveys and Investigation	15,571	(480)
U.S. Dept. of Interior, Bureau of Land Management	Soil and Watershed Conservation	16,565	(40 - 120)
U. S. Dept. of Interior, Bureau of Reclamation	Regional Planning Service	1,282	(90 - 270)
U.S. Geological Survey	Water Resources Investigations	84,880	(6,000 - 12,000)
TOTALS			710 (9,166 - 18,800)

Note: Figures in parentheses are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

1.8 Calendars

Five RMF's are detailed under this heading. They include monitoring of free water areas, snow and ice, ground water, evaporation, soil moisture and drainage, and cyclical pollution patterns. Monitoring is closely related to statistical data collection and mapping and surveying. These three areas make up the basic hydrologic data needed by planners, policy makers and water resources managers. Remote sensing is particularly useful for the monitoring function.

Federal and non-Federal activities are detailed under each RMF. In the future, more and more Federal, State and local activities will have to be devoted to monitoring of streams and lakes for purposes of pollution control. This is particularly true of streams and rivers which cross state boundaries. Receiving standards have been established by all states in compliance with Federal legislation and EPA directions. Ambient pollution must be monitored by states to assure that waters delivered to neighboring states will meet the standards. This function is largely a responsibility of state and local environmental agencies.

One of the recurring activities of Federal agencies in cooperation with State agencies is the monitoring of changes in snow cover. As winter progresses, it is essential to know how much snow is being added to the snow pack since this will determine the spring runoff forecasts used in reservoir management. It is also necessary to monitor ground water and changes in free water in order to predict water supply. Advance warnings of water shortages allow the authorities to transfer or divert water and make other contingency decisions affecting water supply.

As with statistical services, the principal advantage of remote sensing in monitoring water resources is the greater frequency of update. In remote areas, satellite data relay of information collected from ground monitors provides the possibility for more frequent coverage than is presently practicable with conventional methods. Remote sensing also allows observation and monitoring of features which would not otherwise be observed.

The principal investigators studying the applicability of remote sensing to water resource monitoring are listed under RMF and in Appendix G. Progress reports received seem to indicate that remote sensing could be extremely useful in mapping and monitoring water pollution as well as providing frequent and accurate updates on important changes in snow cover, lake ice, drainage patterns, sedimentation and erosion, and the hydrologic conditions of watersheds.

Further details on economic capabilities and benefits of remote sensing for monitoring purposes are included in the discussion under each RMF. Table 5 summarizes potential equal capability benefits, due to remote sensing applied to establishing hydrological calendars, by benefiting agency.

Table 5: Summary of Potential Equal Capability Benefits to Federal Agencies from Remote Sensing Applied to Establish Hydrological Calendars

Government Agency	Relevant Program Item	FY 75 Program Budget, $ thousands	Estimated Equal Capability Benefit This Program, $ thousands (1973)
Bonneville Power Administration	Power Supply and Scheduling	1,260	(12)
Environmental Protection Agency	Research and Development on Processes and Effects	18,391	(50 - 100)
	Abatement and Control: Water Quality Ambient Trend Monitoring	5,274	(15 - 60)
	Abatement and Control: Water Quality Control Agency Support	40,000	(50 - 220)
	Water Quality Technical Assistance and Planning	11,477	(50 - 130)
Tennessee Valley Authority	Regional Water Quality Management: Water Quality Inventory	718	[illegible]
U.S. Dept. of Agriculture, Forest Service	Water Pollution Abatement	16,733	(45 - 80)
U.S. Dept. of Agriculture, Soil Conservation Service	River Basin Surveys and Investigations	15,561	(480)
	Technical Programming, Installation Services and Snow Surveys	165,713	440 (680 - 1800)
U.S. Dept. of Interior, Bureau of Reclamation	Regional Planning Service	1,282	(30 - 90)
TOTALS			440 (1,422 - 2,982)

Note: Figures in parentheses are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

1.9 Allocation

This area concerns the management of water impoundment systems for a variety of purposes, including power generation, flood control, urban water supply, commercial and agricultural water supply, recreation and navigation. It also involves planning changes in drainage and water impoundment systems. Primarily, the water impoundment systems subject to management and therefore relevant to this resource management area are reservoirs. However, some management functions exist for natural lakes and water impoundment systems as well as for the areas surrounding bodies of water. Influence on lake levels, lake sedimentation and watershed preservation can be exercised through planned changes in drainage patterns and erosion control. This is true whether the lake be man-made or natural.

The greatest potential for increased benefits arises from improved reservoir management. This function is a "final product" of water management. The functions of mapping, inventorying and monitoring (3.1, 3.2,3.3) all contribute to forecasts of runoff and future water supplies in watershed areas. These forecasts allow reservoir managers to make reasonable decisions concerning the amount of water storage space to reserve in controlling floods and the amount of hydroelectric power to produce. Another management decision involves the allocation of storage space to local agencies concerned with municipal, industrial, commercial or agricultural water supply. These agencies can frequently "rent" storage space in Federally owned reservoirs. Reservoir managers frequently must make decisions concerning transfer or diversion of water to other impoundment systems depending on relative water supplies in different areas.

The Federal government has built large numbers of reservoirs. These reservoirs may be built for one purpose, such as flood control, or they may be multi-purpose. Most of these constructions have been built by the Army Corps of Engineers, although the Soil Conservation Service owns and manages some. State and City governments often own or manage reservoirs designed to assure water supply. Further details on Federal and non-Federal activities in this area are included under each RMF.

The principal investigators studying the applicability of ERTS to the allocation function are listed under each RMF and in Appendix G. Generally, ERTS capabilities seem to be more relevant for other resource management functions which serve as inputs for water impoundment system management. Accurate forecasts of future water supply and runoff are necessary for efficient reservoir management. The accuracy of these forecasts depends on the frequency and comprehensiveness of monitoring and surveying relevant hydrolic conditions. A space-

based ERS system appears to be particularly beneficial in enhancing accuracy at a low incremental cost.

Discounted annual hard benefits (discount rate = 10%) of 42.6 million have been estimated for power generation (RMF 3.4.1). Explanations of the calculations used to arrive at this figure are included under RMF No. 3.4.1 and in Appendix F, the Feather River Case Study. No benefits should be allocated to the flood control function since these benefits would appear under other RMF's. A full discussion of ERTS economic capabilities and benefits is included under each RMF. A summary of potential equal capability benefits, due to remote sensing applied to allocating activities, by benefiting agency is given in Table 6.

Table 6: Summary of Potential Equal Capability Benefits to Federal Agencies from Remote Sensing Applied to Allocation Activities

Government Agency	Relevant Program Item	FY Programs Budget $ thousands	Estimated Equal Capability Benefit, $ thousands (1973)
Alaska Power Administration	Resource Development Studies	190	(8 - 70)
Army Corps of Engineers	Northeastern U.S. Water Study	1,950	(30 - 450)
Bonneville Power Administration	Power Supply and Scheduling	1,260	(72)
Southeastern Power Administration	System Operation and Maintenance	235	
Southwestern Power Administration	System Operation and Maintenance	2,747	
Tennessee Valley Authority	Water Control Operations	1,370	(240 - 300)
	Preliminary Investigations	90	(7 - 30)
U.S. Dept. of Agriculture, Soil Conservation Service	Technical Programming, Installation Services and Snow Surveys	105,713	1320 (2,000 - 5,400)
	Small Watershed Project Investigations and Planning	12,756	(500 - 900)
	Flood Prevention Projects	25,270	(400 - 4,000)
U.S. Dept. of Interior, Bureau of Land Management	Soil and Watershed Conservation	16,565	(40 - 120)
U.S. Dept. of Interior, Bureau of Reclamation	Operation and Maintenance	72,176	
	Regional Planning Service	1,282	(30 - 90)
	Plan Formulation Investigations	9,800	(390 - 3,100)
TOTAL			1320 (3,717 - 14,532)

Note: Figures in parentheses are order-of-magnitude estimates which are not supported by in-depth case studies
Source: ECON, Inc.

1.10 Conservation

This area includes one RMF: conservation of fresh water resources. No general discussion of the conservation function (3.5) is necessary since all details are provided under RMF 3.5.1.

1.11 Damage Prevention and Assessment

This area includes assessment and reduction of damage due to floods, silting and sedimentation in water impoundment systems and water pollution. Assessment of damage is particularly important for disaster relief, insurance, future planning, and water quality control. In the aftermath of flood disasters, information on the extent of flooding is crucial in the organization and coordination of relief efforts.

Disaster relief involves efforts by all levels of government as does water quality control. The Army Corps of Engineers and HUD assess flood damage for insurance purposes and future planning. EPA cooperates with State and local agencies in the enforcement of water quality standards. Silting and sedimentation of water impoundment systems is a problem which requires significant expenditure by Federal and State agencies involved in reservoir management. Further details of Federal and non-Federal activities in this area are included under each RMF.

The principal investigators studying the applicability of ERTS to these resource management functions are listed under each RMF and in Appendix G. A number of the studies address themselves to the problem of sedimentation. It appears that ERTS can be useful in monitoring sediment build-up as well as in providing basic information for the study of dynamic sediment processes. Other investigators have been able to determine the extent of flooding and flood plain areas from ERTS imagery. Finally, remote sensing appears to be a feasible method for monitoring water quality and locating certain kinds of pollution and sources of pollution in water.

Remote data collection systems with satellite data relay provide efficient means to monitor silting, sedimentation and pollution. Frequent synoptic monitoring provides a reliable data base for effective enforcement of pollution regulations and preventive maintenance for the protection of water impoundment systems. Remote sensing is also an efficient means of surveying an entire flood plain during and immediately after a flood when such information is most useful.

The Army Corps of Engineers has requested $11 million for flood plain information and planning assistance. ERTS imagery is effective in flood plain delineation. It is estimated that ERTS equal-capability benefits plus the increased

capability benefits could reach $20 million. Details of these calculations are included under RMF 3.6.1. The benefits of remote sensing for assessment and control of water pollution damage and sedimentation damage could be substantial (See RMF's 3.6.2, 3.6.3). Table 7 summarizes the potential equal capability benefits, due to remote sensing applied to damage prevention and assessment, by benefiting agency.

Table 7: Summary of Potential Equal Capability Benefits to Federal Agencies from Remote Sensing Applied to Damage Prevention and Assessment

Government Agency	Relevant Program Item	FY Programs Budget $ thousands	Estimated Equal Capability Benefit, $ thousands (1973)
Army Corps of Engineers	Lake Erie Waste Water Management Study	670	40
	Flood Plain Information Reports	5,750	(140 - 600)
Bonneville Power Administration	Power Supply and Scheduling	1,260	
Delaware River Basin Commission	Water Quality Management	632	(10 - 18)
	Flood Loss Reduction	76	(8 - 20)
Environmental Protection Agency	Abatement and Control: Water Quality Ambient Trend Monitoring	5,274	(15 - 60)
	Abatement and Control: Water Quality Control Agency Support	40,000	(50 - 220)
	Research and Development on Processes and Effects	18,391	(50 - 100)
	Water Quality Technical Assistance and Planning	11,477	(50 - 130)
	Water Quality Municipal Source Control	14,951	(90 - 180)
	Water Quality Enforcement	11,459	(150 - 300)
Southeastern Power Administration	System Operation and Maintenance	235	
Southwestern Power Administration	System Operation and Maintenance	2,747	
Tennessee Valley Authority	Flood Control Operations	425	(4)
U.S. Dept. of Agriculture, Forest Service	Water Pollution Abatement	16,733	(45 - 80)
U.S. Dept. of Agriculture, Soil Conservation Service	Technical Programming Installation Services and Snow Surveys	165,713	220 (340 - 900)
U.S. Dept. of Interior, Bureau of Reclamation	Operation and Maintenance of Water Impoundment Systems	72,176	
	Water Quantity Management and Control	121	
TOTAL			260 (952 - 2,612)

Note: Figures in parentheses are order-of-magnitude estimates which are not supported by in-depth case studies.
Source: ECON, Inc.

1.12 Unique Event Recognition and Early Warning

This area includes the provision of early warning of floods and lake eutrophication, and the recognition of changes in surface water supply due to geological change. Early warning of disastrous floods may reduce losses of life and property and lead to better preventive measures. However, the value of this function depends on the preparedness of communities, the amount of movable property and the degree of advance warning. One community in South Dakota suffered extensive damage despite early warning (about 6 - 8 hours) because no community emergency plans had been formulated. (Source: Commission on Water Resources Management, Report to the President, 1973). On the other hand, early warning of lake eutrophication and monitoring of geological changes affecting surface water supplies could provide large benefits since these processes are either irreversible or extremely costly to correct.

Most flood warning is done by the National Weather Service. Other Federal as well as State and local agencies cooperate with the NWS in collecting information needed for early flood warnings. Very little is presently done to provide early warning of lake eutrophication. Geological changes are monitored and studied by the Geological Survey and other Federal agencies for a variety of purposes. Further details on Federal and non-Federal activities are included under the appropriate RMF's.

The principal investigators studying the applicability of remote sensing to advance warning and unique event recognition are listed under the RMF's and in Appendix G. Interesting results have been obtained in monitoring and recognizing algae growth in lakes. It appears that remote sensing may be very useful in providing warning of lake eutrophication. Early warning of disastrous floods is dependent on frequent monitoring of watershed moisture, runoff and snow cover. Several investigators have reported significant results in measuring these factors with remote sensing. Advance flood warning is related to activities discussed in the sections on mapping and surveying, data collection and monitoring. ERTS may provide substantial benefits in flood warnings since the relevant flood indicators can be monitored frequently. Early warning of floods requires extremely current information since flooding may develop very rapidly.

Advance warning of lake eutrophication may have substantial benefit in preserving recreational values and preventing damage to fish and wildlife. Remote sensing is also an efficient way to monitor geological changes and their effects on water supply. Federal, State and local agencies involved in land-use planning, disaster relief, water supply management

and recreation all stand to benefit from improved information in this area. Further discussion of ERTS economic capabilities and benefits is included under each RMF. Table 8 summarizes potential equal capability benefits, due to remote sensing applied to unique event recognition and early warning by benefiting agency.

Table 8: Summary of Potential Equal Capability Benefits to Federal Agencies from Remote Sensing Applied to Unique Event Recognition and Early Warning

Government Agency	Relevant Program Item	FY 75 Program Budget, $ thousands	Estimated Equal Capability Benefit, $ thousands
Army Corps of Engineers	Flood Plain Information Reports	5,750	40 (140 - 600)
Army Corps of Engineers	Stream Gaging	5,105	(500 - 600)
Environmental Protection Agency	Research and Development on Process and Effects	18,391	(50 - 100)
	Abatement and Control: Water Quality Ambient Trend Monitoring	5,274	(10 - 40)
	Abatement and Control: Water Quality Control Agency Support	40,000	(50 - 220)
Tennessee Valley Authority	Regional Water Quality Management: Water Quality Inventory	718	(10)
U.S. Dept. of Agriculture, Soil Conservation Service	Technical Programming Installation Services and Snow Surveys	165,713	220 (340 - 900)
TOTAL			260 (1,100 - 2,470)

Note: Figures in parentheses are order- of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

1.13 Research

This area includes general hydrologic research as well as research aimed at the specific problem areas of flood control and water pollution. Research is valuable in increasing knowledge and understanding of hydrologic phenomena and their relationships. The increased understanding is a major input for developing methods and policies to manage water resources more effectively. The nature of water resource research carried on in the U.S. ranges from purely theoretical studies on the intricacies of hydrologic relationships to highly practical and technical models designed to improve decision making and policy formulation and implementation.

The Federal government supplies substantial amounts of money for hydrologic research carried out by private corporations, universities and state water agencies. The Water Resources Council, for example, provides grants to river basin commissions and states to carry out framework studies and other water related research. Many Federal agencies have their own research and development programs in hydrology, flood control and pollution control. In addition, Federal agencies concerned with construction and reclamation have need of substantial data inputs for the purpose of general investigations of feasibility and project location.

Increased theoretical and empirical knowledge of hydrologic relationships leads to benefits through improved design of water impoundment systems, flood control facilities and water pollution control measures. In addition to improved design, research can lead to the development of better water management, flood control and pollution control practices. Much research in recent years has been carried out by EPA in order to better understand the nature and movement of water pollution. This research has been necessary for the development of methods and policies to protect water quality. There is need for further research if economic growth is to continue without adversely affecting environmental quality. On the Colorado River system, serious problems of water loss, due to evaporation and seepage from certain reservoirs, and of salinity, due to irrigation projects, have been encountered. Research on the nature of these problems could lead to better future planning and avoidance of similar situations.

The value of remote sensing in hydrologic research is that it provides large amounts of current, accurate information covering wide areas. This information is necessary for empirical verification of theoretical work. The advantage of wide geographic coverage is that it allows the researcher to observe relationships and effects which develop outside the specific

geographic area of study. There is also great potential for benefits resulting from the possibility to observe features which cannot otherwise be seen. Due to the frequency of coverage, hydrologic information can be incorporated into flood control and pollution control models on a near real-time basis.

The principle investigators studying the applicability of ERTS to research are listed under the appropriate RMF's and in Appendix G. The reports seem to indicate that remote sensing is an extremely valuable tool in hydrologic, flood control and water quality research. The economic capabilities and benefits are detailed under the appropriate RMF's. Table 9 summarizes potential equal capability benefits, due to remote sensing applied to research, by benefiting agency.

Table 9: Summary of Potential Equal Capability Benefits to Federal Agencies from Remote Sensing Applied to Research

Government Agency	Relevant Program Item	FY 75 Program Budget $ thousands	Estimated Equal Capability Benefit, $ thousands
Army Corps of Engineers	General hydrological Studies	100	
Environmental Protection Agency	Research and Development on processes and effects	18,391	(50 - 100)
	Abatement and Control: water quality ambient trend monitoring	5,274	(15 - 60)
	Abatement and control: water quality control agency support	40,000	(50 - 220)
Susquehanna River Basin Commission	Appraisal of measures to reduce future flood damages	126	(2 - 6)
Tennessee Valley Authority	Preliminary research and Engineering	309	
U.S. Dept. of Interior, Bureau of Reclamation	Water resources planning and engineering research	2,630	(6)
U.S. Dept. of Interior, Office of Water Resource Research	Additional water research	3,107	(10)
U.S. Geological Survey	Water resources investigations	84,880	(3000 - 6000)
TOTAL			(3,133 - 6,402)

Note: Figures in parenthesis are order-of-magnitude estimates which are not supported by in-depth case studies

Source: ECON, Inc.

1.14 Administrative, Judicial and Legislative

This area includes design of government programs to reduce flood damage, compliance with water pollution regulations, design of legislative controls for policy implementation and aid in planning government projects for future water supply. Increasing government effort is being devoted to land-use and water resource planning. As a result of the energy crisis, great attention is being paid to programs and policies which would encourage the production of hydroelectric power. In the area of flood control programs, environmental interests have led to greater emphasis on land-use planning to reduce damage in flood plain regions. Assuring that adequate water supplies exist is the responsibility of Federal, State, City and local governments. It appears that, if present trends continue, certain regions (particularly the East Coast of the U.S.) could face serious water shortages in the future.

Federal and non-Federal activities in administration, legislation and adjudication of water resources and problems are, clearly, substantial. State legislatures are responsible for water use regulations and water rights within state boundaries. State governments are involved in setting water resource conservation policy and water quality standards, and for implementing policies and enforcing standards. A Federal commission on water resource management has studied water needs and problems and supplied the President with detailed recommendations on water policy and legislation.

Remote sensing is an efficient means of obtaining information on water supplies, flood plains, water pollution and other areas affected by legislation and administrative policy. The knowledge provided by remote sensing is useful in ascertaining the need for flood control or reclamation programs as well as in determining the most appropriate methods for implementing such programs. In addition to helping design flood control and water pollution programs, remote sensing can also be useful in such areas as shipping regulation, hydroelectric power generation, irrigation, and wildlife management. The benefits from improved program design, planning, legislation and policy implementation are great. Various government agencies presently spend substantial amounts for surveying of flood plains. Remote sensing would lead to a reduction in surveying costs and may be more effective in locating flood-prone areas than conventional methods. Remote sensing leads to a reduction in the administrative costs of pollution control monitoring and water supply inventorying. Further discussion of the economic capabilities and benefits of remote sensing in this area are included under the appropriate RMF's.

Figure 2 shows an ERTS-1 image of Lake Champlain. This image was instrumental in detecting a source of water pollution

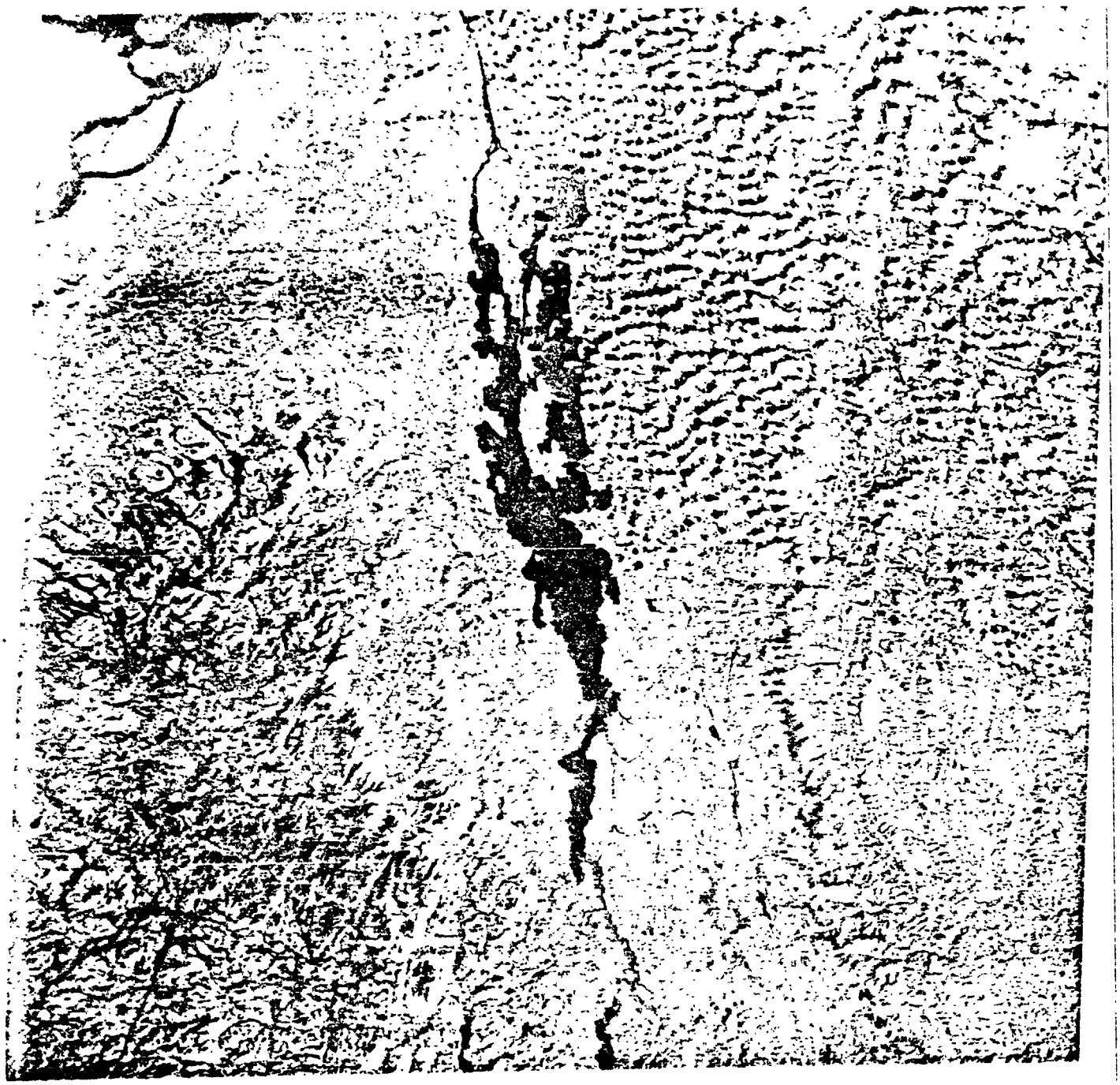

Figure 2 ERTS-1 Image of Lake Champlain Showing Water Pollution Caused by the New International Paper Company Mill North of Fort Ticonderoga, New York

and, with other images of Lake Champlain, is the first data obtained in space to be used in a legal action against the polluter, in this case a papaer mill in Fort Ticonderoga, New York.

The principal investigators studying the applicability of remote sensing to the area are listed under each RMF and in Appendix G. In one study, the investigator is evaluating the water budget of the Texas High Plains Plaza Lakes Region using information gathered by ERTS-1. Since states have water resources management and development plans that depend on reliable information, the potential for use of information gathered by remote sensing in designing, evaluating and planning government action is quite large. Table 10 summarizes potential equal capability benefits, due to remote sensing applied to administration, judicial and legislative activities, by benefiting agency.

Table 10: Summary of Equal Capability Benefits to Federal Agencies from Remote Sensing in Administrative, Judicial, and Legislative Activities

Government Agency	Relevant Program Item	Program Budget ($ in thousands)	Number of Relevant RMF's	Estimated Equal Capability Benefits, this RMF ($ in thousands)
Army Corps of Engineers	Lake Erie Waste Water Management Study	670	4	
	Flood Plain Information Reports	5,750	5	40 (140 - 600)
Delaware River Basin Commission	Water Quality Management	632	3	(10 - 18)
Environmental Protection Agency	Research and Development on Processes and Effects	18,391	8	(50 - 100)
	Abatement and Control: Water Quality Ambient Trend Monitoring	5,274	7	(15 - 60)
	Abatement and Control: Water Quality Control Agency Support	40,000	9	(50 - 220)
	Water Quality Technical Assistance and Planning	11,477	6	(100 - 260)
	Water Quality Municipal Source Control	14,951	3	(90 - 180)
	Water Quality Enforcement	11,450	3	(150 - 300)
Susquehana River Basin Commission	Appraisal of Measures to Reduce Future Flood Damages	126	4	(2 - 6)
Tennessee Valley Authority	Regional Water Quality Management: Water Quality Inventory	718	6	(10)
U.S. Dept. of Agriculture, Forest Service	Water Pollution Abatement	16,733	6	(45 - 80)
U.S. Dept. of Interior, Bureau of Land Management	Soil and Watershed	16,565	4	(40 - 120)
U.S. Dept. of Interior, Bureau of Reclamation	Regional Planning Service	1,282	6	(30 - 90)
TOTAL				40 (782 - 2,264)

Note: Figures in parentheses are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

APPENDIX A:

DETAILED EXAMINATION OF BENEFITS BY RESOURCE MANAGEMENT FUNCTION

This appendix contains a detailed documentation of benefits by resource management function.

RMF No. 3.1.1

MAP AND SURVEY FREE WATER AREAS

Rationale for Benefits

This function provides essential data for government planners, private land developers, industrial firms, farmers, fishermen, shipping companies, the public, etc. These data are necessary in order to make proper decisions on government and private water resource projects, decisions on recreation facilities, etc. This activity also provides data to government officials to be used as input for the higher order RMF's. For example, the output of this function is a necessary input in:

RMF 3.3.1 - Monitor Changes in Free Water

RMF 3.4 - Manage Water Impoundment Systems

RMF 3.7.2 - Provide Early Warning of Lake Eutrophication

RMF 3.8.1 - Conduct Hydrological Research, etc.

Federal Government Activities and Responsibilities

Table 11 gives those Federal statutes which mandate, authorize, or imply activity in RMF 3.1.1 map and survey free water areas. A description of these statutes is given in Appendix C.

General federal budgeting data and programs that impact this RMF are given in Appendix B.

The Corps of Engineers has the following remote sensing research projects initiated in FY 1973 in RMF 3.1.1.

Work Unit Title	Work Unit No.
Missouri River	030201
Fishtrap Reservoir	030501
Data Collection - ERTS	030401

A list of Corps of Engineers remote sensing research projects for FY 73, FY 74, and FY 75 relevant to RMF 3.1.1 is given in Appendix B.

Table 11: List of Federal Statutes Relevant to RMF 3.1.1

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Data Requirement Related to Inland Water
1.	Bankhead-Jones	7 USC 1010	DA	land inventory and monitoring of erosion, sediment, flood plains
2.	Watershed Protection and Flood Protection Act	16 USC 1001-1009	DA ACE	investigations and surveys for flood prevention and watershed program development
3.	Flood Control Act of 1960	P.L.86-645; 33USC709a	ACE	identification of flood plain areas, damage assessment
4.	Taylor Grazing Act	43 USC 315a	DI	studies of erosion and flood control
5.	Federal Reclamation Law	43 USC 485g	DI	inventory of irrigated land
6.	Admission of New States	43 USC 857	DI	survey of public lands in a state prior to its admission to the union
7.	Outdoor Recreation Act	P.L.88-29; 77-Sat.49	DI	inventory of outdoor recreation resources
10.	Dam Safety Act of 1972	P.L.92-367	ACE	inspection of dams; ERTS data used to locate them
11.	Federal Water Pollution Control Act of 1972	P.L.92-500; 33 USC 1151	EPA DC	oil spill surveillance, violation detection, pollution surveys and research
12.	Federal Disaster Protection Act of 1973	P.L.93-234	HUD	flood plain mapping
13.	Colorado River Basin Project Act	43 USC 1511	DI	water resources
14.	Agricultural Research Act	7 USC 427, 427i	DA	inventory of land and water resources
15.	Cooperative Agreements for Surveys and Investigations	33 USC 883E	ACE	surveying and mapping activities

RMF No. 3.1.1

The following activities, methods and products of the Soil Conservation Service (SCS) are relevant to this RMF. The classification system used is that of the SCS.

Data Categories	Activities	Methods	Products
7. Water (surface and ground water	7.2 Inventorying	7.22 Develop graphics	7.221 Map overlays of water areas, snow cover, aquifers, recharge areas, etc.
9. Flood	9.1 Surveying	9.11 Enumerators record flood heights and years of flood; use existing flood routing data available on flood plains, soil surveys, photo interpretation, etc.	9.111 Flood-prone area maps showing 100-year frequency flood hazard.
			9.112 Map showing flood-prone areas frequency described in general terms only.

Non-Federal Activities

State governments control water rights and access to free water areas. Many state authorities for water resources must carry out free water surveys for purposes of regulation and adjudication.

Functions of Remote Sensing

Remote sensing has considerable potential importance in mapping and surveying of free water. With an earth resources satellite remote sensing permits large areas to be mapped and surveyed at a low incremental cost. This low incremental cost advantage of ERS over other means of collecting data is particularly high in geographically remote areas. Several advantages result from the synoptic view given by

remote sensing. Two major advantages are: (1) the ability to see features that would not otherwise be observed, and (2) the ability to take a "snapshot" of a large geographic region.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

Baumgardner:	Purdue/Lars Crop & Soil Characterization & Mapping Using ERTS ccts
Chase:	(lake mapping)
Drew:	Mapping & Managing Soil & Range Resources in Sand Hills Region
Erb:	Utilization of ERTS Data at Test Site 175
Knepper:	Geologic & Mineral & Water Resources Investigation in Western Colorado Using ERTS-A Data
Polcyn:	To Use Space Acquired Imagery for Measurement of Water Depth
Wiegand:	Reflectance of Vegetation, Soil and Water

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

RMF No. 3.1.1

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 12 are based on Federal budgetary information, Congressional appropriations hearings, and estimated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for the program listed in Table 12.

Table 12: Summary of Potential Benefits to Federal Agencies from Remote Sensing for RMF 3.1.1

Government Agency	Relevant Program Item	FY 75 Program Budget, $ Thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
U.S. Geological Survey	Water Resources Investigations	84,880	13	(1,500 - 3,000)

Note: Figures in parenthesis are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

Increased capability benefits are approximately the same as equal capability benefits.

RMF No. 3.1.2

MAP AND SURVEY SNOW, ICE AND GLACIERS

Rationale for Benefits

This function provides basic data that are used by government planners, hydrologists, recreation land developers, etc. These data are used by government officials as inputs to higher order RMF's. For example the output of this activity is a necessary input in RMF 3.3.2 - monitor changes in snow, ice, and glaciers, in RMF 3.4 - manage water impoundment systems, in RMF 3.7.1 - provide early warning of disasterous floods, in RMF 3.8.1 - conduct hydrological research etc.

Federal Government Activities and Responsibilities

Table 13 gives those Federal statutes which mandate, authorize, or imply activity in RMF 3.1.2 map and survey snow, ice and glaciers. A description of these statutes is given in Appendix C.

General federal budgeting data and programs that impact this RMF are given in Appendix B.

The Corps of Engineers has the following remote sensing research projects initiated in FY 1973 in RMF 3.1.2

Work Unit Title	Work Unit No.
Missouri River	030201
Fishtrap Reservoir	030501
Data Collection - ERTS	030401

A list of Corps of Engineers remote sensing research projects for FY 1973, FY 1974, and FY 1975 relevant to RMF 3.1.2 is given in Appendix D.

Non-Federal Activities

One of the stated responsibilities of the California Dept. of Water Resources is to cooperate with other agencies to forecast snow melt and runoff. (Calif. State Controllers Report 71/72.) The responsible agencies in most Western States cooperate in mapping snow for runoff forecasting.

Table 13: List of Federal Statutes Relevant to RMF 3.1.2

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Date Requirement Related to Inland Water
1.	Bankhead-Jones	7 USC 1010	DA	land inventory and monitoring of erosion, sediment, flood plains
2.	Watershed Protection and Flood Protection Act	16 USC 1001-1009	DA ACE	investigations and surveys for flood prevention and watershed program development
3.	Flood Control Act of 1960	P.L.86-645; 33USC709a	ACE	identification of flood plain areas, damage assessment
4.	Taylor Grazing Act	43 USC 315a	DI	studies of erosion and flood control
6.	Admission of New States	43 USC 857	DI	survey of public lands in a state prior to its admission to the union
7.	Outdoor Recreation Act	P.L.88-29; 77-Sat.49	DI	inventory of outdoor recreation resources
9.	Act of June 17, 1902	32 STA 388	DI	planning, construction and operation of irrigation and water management facilities
12.	Federal Disaster protection Act of 1973	P.L.93-234	HUD	flood plain mapping
13.	Colorado River Basin Project Act	43 USC 1511	DI	water resources
14.	Agricultural Research Act	7 USC 427, 427i	DA	inventory of land and water resources
15.	Cooperative Agreements for Surveys and Investigations	33 USC 883E	ACE	surveying and mapping activities

RMF No. 3.1.2

The following activities, methods, and products of the Soil Conservation Service (SCS) are relevant to RMF 3.1.2. The classification system used is that of the SCS.

Data Categories	Activities	Methods	Products
7. Water (surface and ground water)	7.1 Surveying	7.11 Snow survey	7.111 Map of location and extent, depth water content of snow cover
7. Water (surface and ground water	7.2 Inventorying	7.22 Develop graphics	7.221 Map overlays of water areas, snow cover, aquifers, recharge areas, etc.
9. Flood	9.1 Surveying	9.11 Enumerators record flood heights and years of flood; use existing flood routing data available on flood plains, soil surveys, photo interpretation, etc.	9.111 Flood-prone area maps showing 100-year frequency flood hazard.
			9.112 Map showing flood-prone areas frequency described in general terms only.

The Function of Remote Sensing

Remote sensing has considerable potential importance in mapping and surveying of snow, ice and glaciers. With an earth resources satellite remote sensing permits large areas to be mapped and surveyed at a low incremental cost. This low incremental cost advantage of ERS over other means of collecting data is particularly large in geographically remote areas. Several advantages result from the synoptic view given by remote sensing. Two major advantages are: (1) the ability to "see" features that would not otherwise be observed, and (2) the ability to take a "snapshot" of a large geographic region.

RMF No. 3.1.2

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

Barnes:	To evaluate the Application of ERTS-A Data for Detecting & Mapping Snow Covers
Belon:	Grant from Office of University Affairs (Alaska)
Bryan:	Application of ERTS Imagery to Lake Ice Surveys
Carlson:	Break-up Characteristics of China River Basin
Hoffer:	Interdisciplinary Evaluation of ERTS for Colorado Mountain Environments Using ADP Techniques
Jelacic:	The Interdependence of Lake Ice and Climate in Central North America
MacDonald:	Cartographic Application of ERTS/RBV Imagery in Polar Regions
Meier:	Evaluation of ERTS Imagery for Mapping and Detection of Change of Snow Cover on Land & on Glaciers
Weller:	Survey of the Seasonal Snow Cover of Alaska
Wiesnet:	Evaluation of ERTS Data for Certain Hydrological Uses
Wobber:	Exploitation of ERTS Imagery Using Snow Enhancement Techniques

RMF No. 3.1.2

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 14 are based on Federal budgetary information, Congressional appropriations hearings and estimated ERTS technical capabilities. See Appendix B for additional federal budget and program information for agencies and programs listed in Table 14.

Table 14: Summary of Potential Benefits to Federal Agencies from Remote Sensing for RMF 3.1.2

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
Bonneville Power Administration	Power Supply and Scheduling	1,260	9	(12)
U.S. Dept. of Agriculture	Technical Programming, installation services and snow surveys	165,713	14	220 (340-900)
TOTALS				220 (352-912)

Note: Figures in parenthesis are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

Increased capability benefits are approximately the same size as equal capability benefits.

RMF No. 3.1.3

MAP AND SURVEY GROUND WATER AND AQUIFERS

Rationale for Benefits

This function provides basic data that are used by government planners, hydrologists, town planners and architects, etc. These data are used by government officials as inputs to higher order RMF's. For example, the output of this RMF is a necessary input in RMF 3.3.3 - monitor changes in ground water and aquifers, in RMF 3.4 - manage water impoundment systems, in RMF 3.7.3 - monitor changes in surface water supply due to geological changes, in RMF 3.8.1 - conduct hydrological research, etc.

Federal Government Activities and Responsibilities

Table 15 gives those Federal statutes which mandate, authorize, or imply activity in RMF 3.1.3 map and survey of ground water and aquifers. A description of these statutes is given in Appendix C.

General federal budgeting data and programs that impact this RMF are given in Appendix B.

The Corps of Engineers has the following remote sensing research projects initiated in FY 1973 in RMF 3.1.3.

Work Unit Title	Work Unit No.
Missouri River	030201
Fish Trap Reservoir	030501
Data Collection - ERTS	030401

A list of Corps of Engineers remote sensing research projects for FY 1973, FY 1974, and FY 1975 relevant to RMF 3.1.3 is given in Appendix D.

Table 15: List of Federal Statutes Relevant to RMF 3.1.3

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Date Requirement Related to Inland Water
1.	Bankhead-Jones	7 USC 1010	DA	land inventory and monitoring of erosion, sediment, flood plains
2.	Watershed Protection and Flood Protection Act	16 USC 1001-1009	DA ACE	investigations and surveys for flood prevention and watershed program development
3.	Flood Control Act of 1960	P.L.86-645; 33USC709a	ACE	identification of flood plain areas, damage assessment
4.	Taylor Grazing Act	43 USC 315a	DI	studies of erosion and flood control
5.	Federal Reclamation Law	43 USC 485g	DI	inventory of irrigated land
6.	Admission of New States	43 USC 857	DI	survey of public lands in a state prior to its admission to the union
12.	Federal Disaster protection Act of 1973	P.L.93-234	HUD	flood plain mapping
13.	Colorado River Basin Project Act	43 USC 1511	DI	water resources
14.	Agricultural Research Act	7 USC 427, 427i	DA	inventory of land and water resources
15.	Cooperative Agreements for Surveys and Investigations	33 USC 883E	ACE	surveying and mapping activities

RMF No. 3.1.3

The following activities, methods and products of the Soil Conservation Service (SCS) are relevant to this RMF. The classification system used is that of the SCS.

Data Categories	Activities	Methods	Products
7. Water (surface and ground water	7.2 Inventorying	7.22 Develop graphics	7.221 Map overlays of water areas, snow cover, aquifers, recharge areas, etc.
9. Flood	9.1 Surveying	9.11 Enumerators record flood heights and years of flood; use existing flood routing data available on flood plains, soil surveys, photo interpretation, etc.	9.111 Flood-prone area maps showing 100-year frequency flood hazard.
			9.112 Map showing flood-prone areas frequency described in general terms only.

Non-Federal Activities

One of the stated responsibilities of the California Water Resources Department is to investigate surface and underground water supplies. (Controllers report 71/72.) This is true of the responsible agency in most states.

The Function of Remote Sensing

Remote sensing has considerable potential importance in mapping and surveying of vegetation patterns and geologic features that indicate ground water and aquifers. With an earth resources satellite, remote sensing permits large areas to be mapped and surveyed at a low incremental cost. This low incremental cost advantage of ERS over other means of collecting data is particularly large in geographically remote areas.

RMF No. 3.1.3

Several advantages result from the synoptic view given by remote sensing. Two major advantages are: (1) the ability to see features that would not otherwise be observed, and (2) the ability to take a "snapshot" of a large geographic region.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF have followed the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

Collins:	(ground water surveys)
Goetz:	Application of ERTS & EREP Images to Geologic Investigation of Basin & Range - Colorado Plateau Boundary in Arizona

Appendix G contains further information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

No demonstrated benefits from remote sensing have been located for this RMF.

RMF No. 3.1.4

MAP WATERSHED AREAS

Rationale for Benefits

This function provides basic data for government planners, power company officials, hydrologists, etc. These data are used by government officials as inputs to higher order RMF's. For example, the output of this RMF is a necessary input in RMF 3.3 - inspect water impoundment areas, in RMF 3.4 - manage water impoundment systems, in RMF 3.7.1 - provide early warning of disasterous floods, in RMF 3.6.1 - conduct hydrological research, etc.

Federal Government Activities and Responsibilities

Table 16 gives those Federal statutes which mandat , authorize, or imply activity in RMF 3.1.4 map watershed areas. A description of these statutes is given in Appendix C.

General federal budgeting data and programs that impact this RMF are given in Appendix B.

The Corps of Engineers has the following remote sensing research projects initiated in FY 1973 in RMF 3.1.4.

Work Unit Title	Work Unit No.
Missouri River	030201
Fishtrap Reservoir	030501
Data Collection - ERTS	030401

A list of Corps of Engineers remote sensing research projects for FY 1973, FY 1974, FY 1975 relevant to RMF 3.1.4 is given in Appendix D.

Table 16: List of Federal Statutes Relevant to RMP 3.1.4				
No.	Name of Statute	USC or P.L. Reference	Federal Agency	Date Requirement Related to Inland Water
1.	Bankhead-Jones	7 USC 1010	DA	land inventory and monitoring of erosion, sediment, flood plains
2.	Watershed Protection and Flood Protection Act	16 USC 1001-1009	DA ACE	investigations and surveys for flood prevention and watershed program development
3.	Flood Control Act of 1960	P.L.86-645; 33USC709a	ACE	identification of flood plain areas, damage assessment
4.	Taylor Grazing Act	43 USC 315a	DI	studies of erosion and flood control
5.	Federal Reclamation Law	43 USC 485g	DI	inventory of irrigated land
6.	Admission of New States	43 USC 857	DI	survey of public lands in a state prior to its admission to the union
9.	Act of June 17, 1902	32 STA 388	DI	planning, construction and operation of irrigation and water management facilities
10.	Dam Safety Act of 1972	P.L.92-367	ACE	inspection of dams; ERTS data used to locate them
12.	Federal Disaster protection Act of 1973	P.L.93-234	HUD	flood plain mapping
13.	Colorado River Basin Project Act	43 USC 1511	DI	water resources
14.	Agricultural Research Act	7 USC 427, 427i	DA	inventory of land and water resources
15.	Cooperative Agreements for Surveys and Investigations	33 USC 883E	ACE	surveying and mapping activities
18.	Tennessee Valley Authority Act of 1933	16 USC 12a	TVA	water management of TVA system

RMF No. 3.1.4

The following activities, methods and products of the Soil Conservation Service (SCS) are relevant to this RMF. The classification system used is that of the SCS.

Data Categories	Activities	Methods	Products
7. Water (surface and ground water	7.2 Inventorying	7.22 Develop graphics	7.221 Map overlays of water areas, snow cover, aquifers, recharge areas, etc.
9. Flood	9.. Surveying	9.11 Enumerators record flood heights and years of flood; use existing flood routing data available on flood plains, soil surveys, photo interpretation, etc.	9.111 Flood-prone area maps showing 100-year frequency flood hazard.
			9.112 Map showing flood-prone areas frequency described in general terms only.

The Function of Remote Sensing

Remote sensing has considerable potential importance in mapping and surveying of watershed. With an earth resources satellite, large areas can be mapped and surveyed at a low incremental cost. This low incremental cost advantage of ERS over other means of collecting data is particularly large in geographically remote areas. Several advantages result from the synoptic view given by remote sensing. Two major advantages are: (1) the ability to see features that would not otherwise be observed, and (2) the ability to take a "snapshot" of a large geographic region.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of

these models to water resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

Blanchard:	Use of Space Data in Watershed Hydrology
Burgey:	(watershed survey)
Hoffer:	Interdisciplinary Evaluation of ERTS for Colorado Mountain Environments Using ADP Techniques
Hollyday:	Basin Characteristics Extracted from ERTS Data for Improving Regression Estimates of Streamflow
Schumann:	Application of ERTS Data Collection Systems in ARETS
Shown:	Determine Utility of Imagery in Preparation of Hydrologic Atlases of Aridland Watersheds
Stoeckeler:	Develop Land Use - Peak Runoff Classification System for Highway Engineering Purposes
Thorley:	(watershed survey)

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 17 are based on Federal budgetary information, Congressional appropriations hearings, and estimated ERTS technical capabilties. See Appendix B for additional Federal budget and program information for agencies and programs listed in Table 17.

Table 17: Summary of Potential Benefits to Federal Agencies from Remote Sensing for RMF 3.1.4

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
Alaska Power Administration	Resource Development Studies	190	3	(16)
Tennessee Valley Authority	Flood Control Operations	425	4	(4)
U.S. Dept. of Agriculture, Soil Conservation Service	River Basin Surveys and Investigations	15,561	5	(260)
U.S. Geological Survey	Water Resources Investigations	84,880	13	(1,500-3,000)
Delaware River Basin Commission	Flood Loss Reduction	76	3	(8-20)
Susquehanna River Basin Commission	Appraisal of Measures to Reduce Future Flood Damages	126	4	(2-6)
Army Corps of Engineers	Flood Plain Information Reports	5,750	5	40 (140-600)
U.S. Dept. of Agriculture	Soil and Water Science	8,900	2	(40)
TOTAL				40 (1950-3926)

Note: Figures in parenthesis are order-of-magnitude estimates which are not supported by in-depth studies.

Source: ECON, Inc.

Increased capability benefits are approximately the same size as equal capability benefits.

RMF No. 3.1.5

MAP WATER POLLUTION

Rationale for Benefits

This function provides essential data for government planners, recreation developers, industrial firms, fishermen, the general public, etc. These data are necessary in order to make proper decisions on government and private water resource projects, decisions on the location of industrial plants, decisions on recreation facilities, etc. This activity also provides data to government officials to be used as inputs for the higher order RMF's. For example, the output of this function is a necessary input in RMF 3.2.6 - monitor stream salinity and pollution, in RMF 3.4.5 - manage water impoundment systems - for recreational purposes, in RMF 3.6.3 - reduce and monitor pollution damage, in RMF 3.7.2 - provide early warning of lake eutrophication, etc.

Federal Government Activities and Responsibilities

The following table gives those Federal statutes which mandate, authorize, or imply activity in RMF 3.1.5 Map water pollution. A description of these statutes is given in Appendix C.

Table 18: List of Federal Statutes Relevant to RMF 3.1.5

	Name of Statute	USC or P.L. Reference	Federal Agency	Data Requirement Related to Inland Water
1.	Bankhead-Jones	7 USC 1010	DA	land inventory and monitoring of erosion, sediment, flood plains
6.	Admission of New States	43 USC 857	DI	survey of public lands in a state prior to its admission to the union
7.	Outdoor Recreation Act	P.L. 88-29; 77-Stat. 49	DI	inventory of outdoor recreation resources
11.	Federal Water Pollution Control Act of 1972	P.L. 92-500; 33 USC 1151	EPA DC	oil spill surveillance, violation detection, pollution surveys and research
15.	Cooperative Agreements for Surveys and Investigations	33 USC 883 E	ACE	surveying and mapping activities
16.	Toxic Substance Control Act of 1973	NYP	DI	research and monitoring of extent of toxic substances
17.	Land Use Policy and Planning Assistance Act	NYP	DI	comprehensive land use planning

RMF No. 3.1.5

General Federal budgeting data and programs that impact this RMF are given in Appendix B.

The Corps of Engineers has the following remote sensing research projects initiated in FY 1973 in RMF 3.1.5.

Work Unit Title	Work Unit No.
Data Collection	030401
Project Impact	040101
Land Use and Pollution	040102
Tennessee-Tombigbee	040103

A list of Corps of Engineers remote sensing research projects for FY 1973, FY 1974, and FY 1975 relevant to RMF 3.1.5 is given in Appendix D.

Non-Federal Activities

State environmental agencies are responsible for the execution of environmental protection programs and for meeting water quality standards set by E.P.A. State information collection on water pollution exists in only a few states. The need for water pollution mapping for State agencies will probably be met through joint Federal-State programs for information and data gathering.

There are 11 interstate compacts which aim at water pollution control. There are also some comprehensive river basin compacts between States and the Federal government which have water pollution control objectives (e.g., Delaware R.B.C.). None of these have specific water pollution mapping functions but all have responsibility for pollution information and, therefore, need mapping data. (Source: Commission on Water Resource Mgt. Report to the President - 1973.)

The Function of Remote Sensing

Remote sensing has considerable potential importance in mapping and surveying of water pollution. With an earth resources satellite, remote sensing permits large areas to be mapped and surveyed at a low incremental cost. This low incremental cost advantage of ERS over other means of collecting data is particularly large in geographically remote areas. Several advantages result from the synoptic view given by remote sensing. Two major advantages are: (1) the ability to see features that would not otherwise be observed, and (2) the ability to take a "snapshot" of a large geographic region.

RMF No. 3.1.5

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

Wezernak: Application of Remote Sensing to Water Quality Monitoring

Wells: (lake and river pollution surveys)

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

The estimated benefits shown on Table 19 are based on Federal budgetary information, Congressional appropriations hearings and estimated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for agencies and programs listed in Table 19.

RMF No. 3.1.5

Table 19: Summary of Potential Benefits to Federal Agencies from ERTS for RMF 3.1.5

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
U.S. Dept. of Agriculture. Forest Service	Water pollution abatenent	16,733	6	($45 - 80) (a)
Army Corps of Engineers	Lake Erie waste water management study	670	4	*
Environmental Protection Agency	Research and development on processes and efforts	18,391	8	(50 - 100) (a)
Environmental Protection Agency	Abatement and control: water quality ambient trend monitoring	5,274	7	(15 - 60) (a)
Environmental Protection Agency	Abatement and control: water quality control agency support	40,000	9	(50 - 220) (a)
Tennessee Valley Authority	Regional water quality management: water quality inventory	718	6	(10) (a)
U.S. Geological Survey	Water resources investigations	84,980	13	*
TOTAL				(170 - 470)

(a) Increased capability benefits are approximately 20% less than equal capability benefit.

Note: Figures in parenthesis are order-of-magnitude estimates which are not supported by in-depth case studies.

* Benefit significant but not quantifiable

Source: ECON, Inc.

RMF No. 3.1.6

MAP POTENTIAL WATER IMPOUNDMENT AREAS

Rationale for Benefits

This function provides basic data for government planners, power company officials, hydrologists, etc. These data are used by government officials as inputs in higher order RMF's. For example, the output of this RMF is a necessary input in RMF 3.4.7 - plan changes in drainage and water impoundment systems, in RMF 3.8.1 - conduct hydrological research, in RMF 3.9.4 - aid in planning government projects for future water supply, etc.

Federal Government Activities and Responsibilities

Table 20 gives those Federal statutes which mandate, authorize, or imply activity in RMF 3.1.6 map potential water impoundment areas. A description of these statutes is given in Appendix C.

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

The Corps of Engineers has the following remote sensing research projects initiated in FY 1973 in RMF 3.1.6.

Work Unit Title	Work Unit No.
Data Collection - ERTS	030401

A list of Corps of Engineers remote sensing research projects for FY 1973, FY 1974, and FY 1975 relevant to RMF 3.1.6 is given in Appendix D.

Table 20: List of Federal Statutes Relevant to RMF 3.1.6

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Data Requirement Related to Inland Water
1.	Bankhead-Jones	7 USC 1010	DA	land inventory and monitoring of erosion, sediment, flood plains
2.	Watershed Protection and Flood Protection Act	16 USC 1001-1009	DA ACE	investigations and surveys for flood prevention and watershed program development
3.	Flood Control Act of 1960	P.L. 86-645; 33 USC 709a	ACE	identification of flood plain areas, damage assessment
4.	Taylor Grazing Act	43 USC 315a	DI	studies or erosion and flood control
5.	Federal Reclamation Law	43 USC 485g	DI	inventory of irrigated land
6.	Admission of New States	43 USC 857	DI	survey of public lands in a state prior to its admission to the union
10.	Dam Safety Act of 1972	P.L. 92-367	ACE	inspection of dams; ERTS data used to locate them
12.	Federal Disaster Protection Act of 1973	P.L. 93-234	HUD	flood plain mapping
13.	Colorado River Basin Project Act	43 USC 1511	DI	water resources
14.	Agricultural Research Act	7 USC 427, 427i	DA	inventory of land and water resources
15.	Cooperative Agreements for Surveys and Investigations	33 USC 883E	ACE	surveying and mapping activities

RMF No. 3.1.6

The following activities, methods and products of the Soil Conservation Service (SCS) are relevant to this RMF. The classification system is that of the SCS.

Data Categories	Activities	Methods	Products
7. Water (surface and ground water)	7.2 Inventorying	7.22 Develop Graphics	7.221 Map overlays of water areas, snow cover, aquifers, recharge areas, etc.
9. Flood	9.1 Surveying	9.11 Enumerators record flood heights and years of flood; use existing flood routing data available on flood plains; soil surveys, photo interpretation, etc.	9.111 Flood prone area maps showing 100-year frequency flood hazard
			9.112 Map showing flood prone areas frequency described in general terms only

Non-Federal Activities

In all states, there are one or more agencies responsible for collection of basic data and water resources investigations. No specific mention is made of this RMF but it forms part of the basic data needed for water resource development.

The Function of Remote Sensing

Remote sensing has considerable potential importance in mapping and surveying of potential water impoundment. With an earth resources satellite, remote sensing permits large areas to be mapped and surveyed at a low incremental cost. This low incremental cost advantage of ERS over other means of collecting data is particularly large in geographically remote areas. Several advantages result from the synoptic view given by remote sensing. Two major advantages are: (1) the ability to see features that would not otherwise be observed, and (2) the ability to take a "snapshot" of a large geographic region.

RMF No. 3.1.6

Economic and Tecnical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

Dethier:	Phenology Satellite Experiment
Lind:	Environmental Study of ERTS Imagery, Lake Champlain Basin
Reeves:	Water Budget of Texas High Plains Plaza Lakes
Woodman:	To Map the Distribution of Glacio-Aluvial Deposits and Associated Glacial Land Flows

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 21 are based on Federal budgetary information, Congressional appropriations hearings, and estimated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for agencies and programs listed in Table 21.

RMF No. 3.1.6

Table 21: Summary of Potential Benefits to Federal Agencies from Remote Sensing for RMF 3.1.6

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
Army Corps of Engineers	Northeastern U.S. Water Study	$ 1,950	3	(30-450)
Alaska Power Administration	Resource Development Studies	190	3	(8)
U.S. Geological Survey	Water Resources Investigations	84,880	13	(1,500-3,000)
TOTAL				(1,538-3,458)

Note: Figures in parenthesis are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

Increased capability benefits are approximately the same size as equal capability benefits.

RMF No. 3.2.1

PREDICT FRESH WATER SUPPLIES AND FLOODS

Rationale for Benefits

This prediction function is necessary in order to take action that insures an adequate supply of fresh water in the future and in order to take preventive action in minimizing the effects of floods. The output of this RMF, for example, is an input to RMF 3.4.2 - manage water impoundment systems for flood control, to RMF 3.6.1 - assess and reduce flood damage, RMF 3.7.1 provide early warning of disasterous floods, to RMF 3.4.3 - manage water impoundment systems for urban water supply, etc.

Federal Government Activities and Responsibilities

Table 22 gives those Federal statutes which mandate, authorize, or imply activity in RMF 3.2.1, Predict Fresh Water Supplies and Floods.

Table 22: List of Federal Statutes Relevant to RMF 3.2.1

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Data Requirement Related to Inland Water
2.	Watershed Protection and Flood Protection Act	16 USC 1001-1009	DA ACE	investigations and surveys for flood prevention and watershed program development
8.	Water Resources Planning Act	P.L. 89-80; 42 USC 1962D-12	DI, DA HEW FPC	studies of water supply supply adequacy
9.	Act of June 17, 1902	32 STA 388	DI	planning, construction and operation of irrigation and water management facilities
18.	Tennessee Valley Authority Act of 1933	16 USC 12 a	TVA	water management of TVA system

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

RMF No. 3.2.1

The Corps of Engineers has the following remote sensing research projects initiated in FY 1973 in RMF 3.2.1.

Work Unit Title	Work Unit No.
Missouri River	030201
Fishtrap Reservoir	030501
Data Collection - ERTS	030401

A list of Corps of Engineers remote sensing research projects for FY 1973, FY 1974, and FY 1975 relevant to RMF 3.2.1 is given in Appendix D.

Non-Federal Activities

The California Department of Water Resources is responsible for compiling data [illegible] water supplies and uses, and for cooperating in forecasting snowmelt and runoff. (Controllers Report 71/72). These responsibilities are carried out by various State and local agencies in each state.

The Function of Remote Sensing

Remote sensing provides data that can significantly improve prediction of fresh water supplies and floods. Frequent synoptic coverage of large watershed areas makes possible an assessment of snow-cover, moisture, and runoff conditions that cannot be achieved as efficiently using other means. These data, together with the advance information on weather conditions also supplied by remote sensing, reduce error margins in predictive models and lengthen flood warning times.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

RMF No. 3.2.1

Current ERTS Activities

Colwell:	Analysis of River Meanders From ERTS-A Imagery
Higer:	Develop Data Relay System for Monitoring Hydrologic Conditions in Florida
Schumann:	Application of ERTS Data Collection System in ARETS
Serebreny:	Time-Lapse Data Processing for Dynamic Hydrologic Conditions

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 23 are based on Federal budgetary information, Congressional hearings, and estimated ERTS technical capabilities. See Appendix B additional Federal budget and program information for agencies and programs listed on Table 23.

Table 23: Summary of Potential Benefits to Federal Agencies from Remote Sensing for RMF 3.2.1

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
Susquehanna River Basin Commission	Appraisal of Measures to Reduce Future Flood Damages	126	4	(2 - 6)
Delaware River Commission	Flood Loss Reduction	76	3	(8 - 20)
U.S. Dept. of Interior, Bureau of Reclamation	Regional Planning Service	1,282	6	(30 - 90)
U.S. Geological Survey	Water Resources Investigations	84,880	13	(1,500 - 3,000)
Tennessee Valley Authority	Flood Control Operations	425	4	(4)
Army Corps of Engineers	Flood Plain Information Reports	5,750	5	50 (140 - 600)
U.S. Dept. of Agriculture, Soil Conservation Service	Technical Programming, Installation Services and Snow Surveys	165,713	14	220 (340 - 900)
TOTALS				270 (2,074 - 4,620)

Note: Figures in parenthesis are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

Increased capability benefits are approximately the same size as equal capability benefits.

RMF No. 3.2.2

INVENTORY FRESH WATER SUPPLIES AND SNOW COVER

Rationale for Benefits

This inventoring function is required in order to be able to determine if current fresh water supply will be adequate to meet current fresh water needs. If it is known that the current fresh water supply is at an inadequate level, then action can be taken to increase this level. The output of this RMF, for example, is an input into RMF 3.3.1 - monitor changes in free water areas, into RMF 3.3.2 - monitor changes in snow, ice and glaciers, into RMF 3.4 - manage water inpoundment systesm, into RMF 3.5.1 - conserve fresh water resoureces, etc. An example of the potential usefulness of ERS in monitoring snow cover is shown in Figure 1.4a in Volume I.

Federal Government Activities and Responsibilities

Table 24 gives those Federal statutes which mandate, authorize, or imply activity in RMF 3.2.2 Inventory fresh water supplies and snow cover. A description of these statues is given in Appendix C.

Table 24 List of Federal Statutes Relevant to RMF 3.2.2

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Data Requirement Related to Inland Water
2.	Watershed Protection and Flood Protection Act	16 USC 1001-1009	DA ACE	investigations and surveys for flood prevention and watershed program development
5.	Federal Reclamation Act	43 USC 485g	DI	inventory of irrigated land
7.	Outdoor Recreation Act	P.L. 88-29; 77-Stat. 49	DI	inventory of outdoor recreation resources
8.	Water Resources Planning Act	P.L. 89-80 42 USC 1962D-12	DI, DA HEW, FPC	studies of water supply supply adequacy
9.	Act of June 17, 1902	32 STA 388	DI	planning, construction and operation of irrigation and water management facilities
14.	Agricultural Research Act	7 USC 427, 427i	DA	inventory of land and water resources
18.	Tennessee Valley Authority Act of 1933	16 USC 12a	TVA	water management of TVA System

RMF No. 3.2.2

General federal budgetary data and programs that impact this RMF are given in Appendix B.

The Corps of Engineers has the following remote sensing research projects initiated in FY 1973 in RMF 3.2.2.

Work Unit Title	Work Unit No.
Data Collection - ERTS	030401
Permafrost Mapping	030505

A list of Corps of Engineers remote sensing research projects for FY 1973, FY 1974, and FY 1975 relevant to RMF 3.2.2 is given in Appendix 3D.

The following activities, methods and products of the Soil Conservation Service (SCS) are relevant to this RMF. The classification system used is that of the SCS.

Data Categories	Activities	Methods	Products
7. Water (surface and ground water)	7.2 Inventorying	7.21 Use Enumerators to collect data from all available sources.	7.211 Complete data showing acrefeet of water, water quality, irrigation water use, water use, hydrograph fore casts, peak and low values water yield from snow, etc.
9. Flood	9.2 Inventorying	9.21 Use ADP tapes developed from 9.11 methods	9.211 -----
		9.22 Tabulate	9.221 Acres of land with 100-year frequency flood hazard.
			9.222 Acres of land with flood hazard of unknow frequency.
			9.223 Acres with flood hazard in urban and built-up.
			9.224 Acres with flood hazard in other areas.
		9.23 Develop graphics	9.231 Flood-prone area maps

RMF No. 3.2.2

Non-Federal Activities

In most western states, an appropriate agency (for example, the California Department of Water Resources) cooperates with the Federal snow cover survey. Cities and rural water districts maintain inventories of water supplies in city and rural storage systems. States maintain inventories of supply in state reservoirs and cooperate with the Federal government in the use of water storage space in federally managed reservoirs. Municipal and Industrial Water Supply programs receive financial and planning assistance from HUD, FHA and other Federal agencies.

The Function of Remote Sensing

The frequent synoptic coverage of large areas provided by remote sensing is well suited to inventorying parameters that are subject to rapid change. This is especially true of the water-resources area, in which a broad range of decisions on power generation, irrigation, flood prevention, and fresh-water supply must be made based on information which should have as short a lead time as possible. Accurate current information both reduces error margins and makes possible full use of available resources. The low incremental cost of information from earth resources satellites makes them especially appropriate for this function.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

Barnes:	To Evaluate the Application of ERTS (A) Data for Detecting and Mapping Snow Cover
Colwell:	Use of ERTS-A to Aid in Solving Water Resource Management Problems in North California
Knepper:	Geologic and Mineral and Water Resources Investigation in Western Colorado Using ERTS-A Data

RMF No. 3.2.2

Schumann	Application of ERTS Data Collection System in ARETS
Weaver:	Research and Investigation of Geology, Mineral and Water Resources in Maryland
Weller:	Survey of the Seasonal Snow Cover of Alaska
Wiesnet:	Evaluation of ERTS Data for Certain Hydrolcgical Uses
Webber:	Exploitation of ERTS Imagery Using Snow Enhancement Techniques

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

Th estimated benefits shown in Table 25 are based on Federal budgetary information, Congressional Appropriations hearings, and estimated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for agencies and programs listed in Table 25.

In Table 25 increased capability benefits are approximately the same size as equal capability benefits.

Table 25: Summary of Potential Benefits to Federal Agencies from Remote Sensing for RMF 3.2.2

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF $ thous. (1973)
U.S. Dept. of Agriculture, Forest Service	Soil and Water Science for Management Support	8,900	2	(40)
Bonneville Power Administration	Power Supply and Scheduling	1,260	9	(12)
U.S. Dept. of Agriculture, Soil Conservation Service	Technical Programming, Installation Services and Snow Surveys	165,713	14	220 (340 - 9000
U.S. Dept. of Agriculture, Soil Conservation Service	River Basin Surveys and Investigations	15,561	5	(240)
U.S. Geological Survey	Water Resources Investigations	84,880	13	(1,500 - 3,000)
TOTALS				220 (2,132 - 4,192)

Note: Figures in parenthesis are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

RMF No. 3.2.3

GATHER INFORMATION FOR HYDROLOGICAL MODELS

Rationale of Benefits

The output of this information function is needed as an input for several higher order RMF's. Examples of such RMF's are RMF 3.4 - manage water impoundment systems, RMF 3.6.2 - reduce damage to water impoundment systems from silting and sedimentation, RMF 3.8.1 - conduct hydrological research, RMF 3.9.1 - design government programs to reduce flood damage.

Federal Government Activities and Responsibilities

Table 26 gives those Federal statutes which mandate, authorize, or imply activity in RMF 3.2.3 gather information for hydrological models. A description of these statutes is given in Appendix C.

Table 26: List of Federal Statutes Relevant to RMF 3.2.3

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Data Requirement Related to Inland Water
2.	Watershed Protection and Flood Protection Act	16 USC 1001-1009	DA ACE	investigations and surveys for flood prevention and watershed program development
5.	Federal Reclamation Law	43 USC 485g	DI	inventory of irrigated land
8.	Water Resources Planning Act	P.L. 89-80; 42 USC 1962D-12	DI,DA HEW, FPC	studies of water supply supply adequacy
9.	Act of June 1902	32 STA 388	DI	planning, construction and operation of irrigation and water management facilities
18.	Tennessee Valley Authority	16 USC 12a	TVA	water management of TVA system

RMF No. 3.2.3

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

The Corps of Engineers has the following remote sensing research projects initiated in FY 1973 in RMF 3.2.3.

Work Unit Title	Work Unit No.
Data Collection - ERTS	030401

A list of Corps of Engineers remote sensing research projects for FY 1973, FY 1974, and FY 1975 relevant to RMF 3.2.3 is given in Appendix D.

The Function of Remote Sensing

This RMF covers not only inputs from 3.2.2, the inventorying of fresh water supplies and snow cover, but also the surveying of moisture and runoff conditions, ground temperatures and weather conditions. Accurate data in these areas are essential to operational hydrological models. The frequent synoptic coverage and short lead times provided by remote sensing make possible especially significant improvements in real-time models. The resulting output has a direct impact on decisions affecting irrigation, power generation, flood control and fresh water supply. The low incremental cost of information from earth resources satellites makes them especially appropriate for this function.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

Mark: ERTS Data for Lewis Resource Center

Serebreny: Time-Lapse Data Processing for Dynamic Hydrologic Conditions

Appendix G contains further information on ERTS prin-

ciple investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 27 are based on Federal budgetary information, Congressional appropriations hearings, and estimated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for agencies and programs listed in Table 27.

Table 27: Summary of Potential Benefits to Federal Agencies from Remote Sensing for RMF 3.2.3

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
U.S. Dept. of Interior, Bureau of Land Management	Soil and Watershed Conservation	16,565	4	(40 - 120)
U.S. Dept. of Interior, Bureau of Reclamation	Regional Planning Service	1,282	6	(30 - 90)
Tennessee Valley Authority	Water Control Operations	1,370	7	(40 - 50)a
Army Corps of Engineers	Stream Gaging	5,105	2	(500 - 600)b
U.S. Dept. of Agriculture, Soil Conservation Service	Technical Programming Installation Services and Snow Surveys	165,713	14	220 (340 - 900)
U.S. Dept. of Agriculture, Soil Conservation Service	River Basin Surveys and Investigations	15,571	5	(240)
Army Corps of Engineers	General Hydrological Studies	100	2	*
U.S. Geological Survey	Water Resources Investigations	84,880	13	(1,500 - 3,000)
TOTALS				220 (2,690 - 5,000)

(a) Increased capability benefits = $(6-8) thousand
(b) Increased capability benefits = $(75-90) thousand
* Benefit significant but not quantifiable

Note: Figures in parenthesis are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

Increased capability benefits are approximately the same size as equal capability benefits, except where otherwise indicated in Table 27.

RMF No. 3.2.4

INSPECT WATER IMPOUNDMENT AREAS

Rationale for Benefits

This inspection function is necessary in order to determine the degree of vario s types of water pollution and to determine the structural and mechanical soundness of water resource facilities in water impoundment areas. The output of this inspection activity are inputs into several RMF's such as, for example, RMF 3.3.5 - monitor drainage patterns, RMF 3.3.6 - monitor cyclical pollution patterns, RMF 3.4.7 - plan changes in drainage and water impoundment systems, RMF 3.7.2 - provide early warning of lake eutrophications, etc.

Federal Government Activities and Responsibilities

The following table gives those Federal statutes which mandate, authorize, or imply activity in RMF 3.2.4, inspect water impoundment areas. A description of these statutes is given in Appendix C.

Table 28: List of Federal Statutes Relevant to RMF 3.2.4

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Data Requirement Related to Inland Water
2.	Watershed Protection and Flood Protection Act	16 USC 1001-1009	DA ACE	investigations and surveys for flood prevention and watershed program development
10.	Dam Safety Act	P.L. 92-367	ACE	inspection of dams; ERTS data used to locate them
11.	Federal Water Pollution Control Act of 1972	P.L. 92-500; 33 USC 1151	EPA DC	oil spill surveillance, violation detection, pollution surveys and research
16.	Toxic Substance Control Act	NYP	DI	research and monitoring of toxic substances

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

The Corps of Engineers has the following remote sensing research project initiated in FY 1973 in RMF 3.2.4.

Work Unit Title	Work Unit No.
Data Collection - ERTS	030401

A list of Corps of Engineers remote sensing research projects for FY 1973, FY 1974 and FY 1975 relevant to RMF 3.2.4 is given in Appendix D.

Non-Federal Activities

In Florida, the Water Resources Act of 1972, among other responsibilities, calls on the Department of Natural Resources to regulate the construction and operation of surface water reservoirs. (Source: Commission on Water Resource Management Report to President - 1973). The Washington (state) Department of Water Resources established minimum levels for lakes. All states have some state-owned and operated dams and reservoirs. All of these impoundment areas are inspected by appropriate state agencies as part of the management of state-owned dams and public lakes.

The Function of Remote Sensing

Remote sensing can be used to survey water impoundment areas to determine water levels, water volumes (especially when used in conjunction with a remote data collection system), types and concentration of pollutants, and the presence and condition of unregistered dams and impoundments. This information can be used to take timely corrective action when this is indicated and to fulfill statutory survey requirements. The synoptic capabilities of remote sensing make it especially usedful for watershed survey activities such as those which must be repeated on a regular basis.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

RMF No. 3.2.4

Current ERTS Activities

Carlson:	Break-up Characteristics of the Chena Fiver Basin
Cast:	Remote Sensing of Reclamation Projects
Chase:	(watershed, lake survey)
Hidalgo:	Preliminary Study of Lake Pontchartrain and Vicinity Using Remotely Sensed Data From ERTS
Lind:	Environmental Study of ERTS Imagery, Lake Champlain Basin
Mark:	ERTS Data for Lewis Resource Center
Myers:	Effective Use of ERTS Multisensor Data in Great Plains Corridor
Polcyn:	Hydrologic Problems of Lake Ontario Basin for IFYGL
Reeves:	Water Budget of Texas High Plains Plaza Lakes
Sattinger:	Planning of Land Use in the Detroit Metro Area
Yarger:	Study of Monitoring Fresh Water Resources

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 29 are based on Federal budgetary information, Congressional appropriations hearings, and estimated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for the program listed in Table 29.

RMF No. 3.2.4

Table 29: Summary of Potential Benefits to Federal Agencies from ERTS for RMF 3.2.4

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit, this RMF, $ thous. (1973)
U.S. Geological Survey	Water Resources Investigations	84,880	13	(1,500 - 3,000)

Note: Figures in parenthesis are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

Increased capability benefits are approximately the same size as equal capability benefits.

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RMF No. 3.2.5

MONITOR STREAM SALINITY AND POLLUTION

Rationale for Benefits

This monitoring function is necessary in order to be able to take corrective action when levels of salinity or various types of chemical or bacteriological pollution approach unacceptable levels. The outputs of this monitoring function are inputs into several RMF's such as, for example, RMF 3.4.1 - manage water impoundment systems for urban water supply, RMF 3.8.3 - conduct water pollution research, FMF 3.9.2 - increase compliance with water pollution regulations, RMF 3.9.3 - aid in designing legislative controls for policy implementation, etc.

Federal Government Activities and Responsibilities

The following table gives those federal statutes which mandate, authorize, or imply activity in RMF 3.2.5, monitor stream salinity and pollution. A description of these statutes is given in Appendix C.

Table 30: List of Federal Statutes Relevant to RMF 3.2.5

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Data Requirement Related to Inland Water
1.	Bankhead-Jones	7 USC 1010	DA	land inventory and monitoring of erosion, sediment, flood plains
5.	Federal Reclamation Law	43 USC 485g	DI	inventory of irrigated land
7.	Outdoor Recreation Act	P.L. 88-29; 77-Stat.49	DI	inventory of outdoor recreation resources
11.	Federal Water Pollution Control Act of 1972	P.L. 92-500; 33 USC 1151	EPA DC	oil spill surveillance, violation detection, pollution surveys and research

RMF No. 3.2.5

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

The Corps of Engineers has the following remote sensing research projects initiated in FY 1973 in RMF 3.2.5

Work Unit Title	Work Unit No.
Data Collection - ERTS	030401
Project Impact	040101
Land Use and Pollution	040102
Tennessee-Tombigbee	040103

A list of Corps of Engineers remote sensing research projects for FY 1973, FY 1974, and FY 1975 relevant of RMF 3.2.5 is given in Appendix D.

Non-Federal Activities

All states have established receiving water standards for interstate waters and nearly all states apply comparable standards to the rest of their surface waters. In order to control pollution, the states need to monitor salinity and pollution to determine if the standards are being met.

The Function of Remote Sensing

Stream salinity and pollution in remote areas can be monitored more efficiently and with greater frequency using a remote data collection system with satellite data relay than with solely ground-based means. This information constitutes a significant source of data for agencies concerned with fish and wildlife as well as water-resource management.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

RMF No. 3.2.5

Current ERTS Activities

Higer:	Develop Data Relay System for Monitoring Hydrologic Conditions in Florida
Paulson:	Near Real-Time Water Resources Data for River Basin Management
Wells:	(lake & river pollution surveys)
Wezernak:	Application of Remote Sensing to Water Quality Monitoring

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 31 are based on Federal budgetary information, Congressional appropriations hearings, and estimated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for agencies and programs listed in Table 31.

RMF No. 3.2.5

Table 31: Summary of Potential Benefits to Federal Agencies from ERTS for RMF 3.2.5

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
Delaware River Basin Commission	Water quality management	632	3	(10 - 18) (a)
Environmental Protection Agency	Water quality technical assistance and planning	11,477	6	(50 - 130) (a)
Environmental Protection Agency	Water quality municipal source control	14,951	3	(90 - 180) (a)
Environmental Protection Agency	Water quality enforcement	11,450	3	(150 - 300) (a)
U.S. Geological Survey	Water resources investigations	84,880	13	*
Army Corps of Engineers	Lake Erie waste water management study	670	4	*
U.S. Dept. of Agriculture, Forest Service	Water pollution abatement	16,733	6	(45 - 80) (a)
Tennessee Valley Authority	Regional water quality management: water quality inventory	718	6	(10) (a)
Environmental Protection Agency	Research and development on processes and effects	18,391	8	(50 - 100) (a)
Environmental Protection Agency	Abatement and control: water quality ambient trend monitoring	5,274	7	(15 - 60) (a)
Environmental Protection Agency	Abatement and control: water quality control agency support	40,000	9	(50 -220) (a)
U.S. Dept. of Interior, Bureau of Reclamation	Regional planning service	1,282	3	(30 - 90)
TOTAL				(500 - 1188)

(a) Increased capability benefits are approximately 20% less.

Note: Figures in parenthesis are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

RMF No. 3.2.6

MONITOR THERMAL POLLUTION OF FREE WATER

Rationale for Benefits

This monitoring function is necessary in order to be able to take corrective action when levels of thermal pollution approach unacceptable levels. The output of this monitoring function is an input into several RMF's such as, for example, RMF 3.6.3 - reduce and monitor pollution damage, RMF 3.6.4 - reduce pollution of free water by industry and municipalities, RMF 3.8.3 - conduct water pollution research, RMF 3.9.2 - increase compliance with water pollution regulations, etc.

Federal Government Activities and Responsibilities

General Federal budgetary data and programs that may impact this RMF are given in Appendix B.

The Corps of Engineers has the following remote sensing research projects initiated in FY 1973 in RMF 3.2.6.

Work Unit Title	Work Unit No.
Project Impact	040101
Land Use and Pollution	040102
Tennessee-Tombigbee	040103

A list of Corps of Engineers remote sensing research projects for FY 1973, FY 1974 and FY 1975 relevant to RMF 3.2.6 is given in Appendix D.

Non-Federal Activities

All states have standards of water quality and must meet national standards set by EPA. Local environmental agencies monitor many forms of water pollution to determine if the standards are being met.

The Function of Remote Sensing

Thermal pollution of free water can be most effectively monitored with techniques which provide a simultaneous thermal overview, or "snapshot", of the affected area. Such overviews are either inefficient or impossible with ground-based means alone. Remote sensing using infrared techniques can provide

synoptic information on the degree and extent of such pollution at relatively low cost. This information is useful in the implementation of statutory controls and in the monitoring of fish and wildlife management areas.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

None Found

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 32 are based on Federal budgetary information, Congressional appropriations hearings, and estimated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for agencies and programs listed in Table 32.

Table 32: Summary of Potential Benefits to Federal Agencies from ERTS for RMF 3.2.6

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit, this RMF, $ thous. (1973)
U.S. Dept. of Agriculture, Forest Service	Water pollution abatement	16,733	6	(45 - 80) (a)
Environmental Protection Agency	Water quality enforcement	11,450	3	(100 - 200) (a)
Environmental Protection Agency	Research and Development on processes and effects	18,391	8	(50 - 100) (a)
Environmental Protection Agency	Abatement and control: water quality ambient trend monitoring	5,274	7	(15 - 60) (a)
Environmental Protection Agency	Abatement and control: water quality control agency support	40,000	9	(50 - 220) (a)
Environmental Protection Agency	Water quality technical assistance and planning	11,477	6	(50 - 130) (a)
Tennessee Valley Authority	Regional water quality management: water quality inventory	718	6	(10) (a)
TOTAL				(320 - 800)

(a) Increased capability benefits are approximately 20% less than equal capability benefits.

Note: Figures in parenthesis are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

RMF No. 3.3.1

MONITOR CHANGES IN FREE AREAS

Rationale for Benefits

This function provides essential data for government planners, private land developers, industrial firms, farmers, fisherman, shipping companies, the general public, etc. These data are necessary in order to make proper decisions on government and private water resource projects, decisions on the location of industrial plants, decisions on recreation facilities, etc. This activity also provides data to government officials to be used as input for the higher order RMF's. For example, the output of this function is a necessary input in:

RMF 3.4 - Manage Water Impoundment Systems

RMF 3.7.2 - Provide Early Warning of Lake Eutrophication

RMF 3.8.1 - Conduct Hydrological Research, etc.

Federal Government Activities and Responsibilities

The following table gives those Federal statutes which mandate, authorize, or imply activity in RMF 3.3.1 Monitor changes in free water areas. A description of these statutes is given in Appendix C.

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

The Corps of Engineers has the following remote sensing research projects initiated in FY 1973 in RMF 3.3.1.

Work Unit Title	Work Unit No.
Missouri River	030201
Fishtrap Reservoir	030501
Data Collection - ERTS	030401

RMF No. 3.3.1

Table 33: List of Federal Statutes Relevant to RMF 3.3.1				
No.	Name of Statute	USC or P.L. Reference	Federal Agency	Date Requirement Related to Inland Water
2.	Watershed Protection and Flood Protection Act	16 USC 1001-1009	DA ACE	investigations and surveys for flood prevention and watershed program development
5.	Federal Reclamation Law	43 USC 485g	DI	inventory of irrigated land
7.	Outdoor Recreation Act	P.L. 88-29 77-Stat.49	DI	inventory of outdoor recreation resources
9.	Act of June 17, 1902	32 STA 388	DI	planning, construction and operation of irrigation and water management facilities
18.	Tennessee Valley Authority Act of 1933	16 USC 12a	TVA	water management of TVA system

A list of Corps of Engineers remote sensing research projects for FY 1973, FY 1974, and FY 1975 relevant to RMF 3.3.1 is given in Appendix D.

Non-Federal Activities

State Agencies involved in environmental, recreational and water supply questions are all interested in changes in free water areas. Examples include: state environmental agencies which monitor water pollution; the Montana Fish & Game Department which monitors streams to control changes which would have an adverse effect on fishing and recreation; Washington (state) Department of Water Resources which sets minimum stream flow and lake levels; state, municipal and rural authorities concerned with insuring an adequate supply of water.

RMF No. 3.3.1

The Function of Remote Sensing

Remote sensing has considerable potential importance in monitoring changes in free water areas. It permits large areas to be monitored with a much greater frequency of update than is practical with other means. This advantage of area of coverage and frequency of update is particularly great in geographically remote areas. Several advantages result from the synoptic view given by remote sensing. Two of these advantages are: (1) the ability to see features that would not otherwise be observed, and (2) the ability to take a "snapshot" of a large geographic area. A major advantage of remote sensing from an earth resources satellite is that the incremental cost is low.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

Baumgardner:	Purdue/Larsys Crop & Soil Characterization & Mapping Using ERTS CCTS
Cast:	Remote Sensing of Reclamation Projects
Chase:	(Lake, Watershed Surveys)
Landgrebe:	Study of the Utilization of ERTS-A Data From Wabash River Basin
Paulson:	Near Real-Time Water Resources Data for River Basin Management
Perrier:	Use of DCS to Operate Network of Remote Hydrological & Climatological Stations

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

RMF No. 3.3.1

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 34 are based on Federal budgetary information, Congressional appropriation hearings, and estimated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for agencies and programs listed in Table 34.

Table 34: Summary of Potential Benefits to Federal Agencies from Remote Sensing for RMF 3.3.1

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
U.S. Dept. of Agriculture Soil Conservation Service	Technical Programming, Installation Services and Snow Surveys	165,713	14	220 (340 - 900)
	River Basin Surveys and Investigations	15,561	5	(240)
U.S. Dept. of Interior, Bureau of Reclamation	Regional Planning Service	1,282	6	(30 - 90)
TOTAL				220 (610 - 1,230)

Note: Figures in parentheses are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

Increased capability benefits are approximately the same size as equal capability benefits.

RMF No. 3.3.2

MONITOR CHANGES IN SNOW, ICE AND GLACIERS

Rationale for Benefits

This function provides basic data that are used by government planners, hydrologists, recreation land developers, etc. These data are used by government officials as inputs to higher order RMF's. For example, the output of this activity is a necessary input in RMF 3.4 - Manage Water Impoundment Systems, in RMF 3.7.1 - Provide Early Warning of Disasterous Floods, in RMF 3.8.1 - Conduct Hydrological Research, etc.

Federal Government Activities and Responsibilities

The following table gives those Federal statutes which mandate, authorize, or imply activity in RMF 3.3.2, monitor Changes in Snow, Ice and Glaciers. A description of these statutes is given in Appendix C.

Table 35: List of Federal Statutes Relevant to 3.3.2

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Date Requirement Related to Inland Water
7.	Outdoor Recreation Act	P.L. 88-29; 77-Stat.49	DI	inventory of outdoor recreation resources
9.	Act of June 17, 1902	32 STA 388	DI	planning, construction and operation of irrigation and water management facilities

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

RMF No. 3.3.2

A list of Corps of Engineers remote sensing research projects for FY 1973, FY 1974, and FY 1975 relevant to RMF 3.3.2 is given in Appendix D.

The following activities, methods and products of the Soil Conservation Service (SCS) are relevant to this RMF. The classification system used is that of the SCS.

Data Categories	Activities	Methods	Products
7. Water (surface and ground water)	7.3 Monitoring	7.31 Survey and inventory changes in water by survey and inventory methods	7.311 Revised data 7.312 Revised map overlays to show changes 7.313 Sequential water data for developing prediction models
9. Flood	9.3 Monitoring	9.31 Survey and inventory flood and tide heights heights and year of occurrence.	9.311 Revised data showing acres flooded. 9.312 Revise map overlays to show changing flood hazard

Non-Federal Activities

In most Western States the state engineer or Water Resources Department is charged with cooperating with Federal and other State agencies to monitor snow cover and forecast runoff.

RMF No. 3.3.2

The Function of Remote Sensing

Remote sensing has considerable potential importance in monitoring changes in snow, ice and glaciers. It permits large areas to be monitored with a much greater frequency of update than is practical with other means. This advantage of area of coverage and frequency of update is particularly great in geographically remote areas. Several advantages result from the synoptic view given by remote sensing. Two of these advantages are: (1) the ability to see features that would not otherwise be observed, and (2) the ability to take a "snapshot" of a large geographic area. A major advantage of remote sensing from an ERS-type satellite is that the incremental cost is low.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF have followed the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

Barnes:	To Evaluate the Application of ERTS-A Data for Detecting and Mapping Snow Cover
Belon:	Grant from Office of University Affairs, Alaska
Bryan:	Application of ERTS Imagery to Lake Ice Surveys
Carlson:	Break-up Characteristics of Chena River Basin
Holmgren:	(drainage patterns and snow cover in tundra regions)
Jelacic:	Interdependence of Lake Ice and Climate in Central North America
MacDonald:	Cartographic Application of ERTS/RBV Imagery in Polar Regions

RMF No. 3.3.2

Meier:	Evaluation of ERTS Imagery for Mapping and Detection of Change of Snow Cover on Land and on Glaciers
Weller:	Survey of the Seasonal Snow Cover of Alaska
Wiesnet:	Evaluation of ERTS Data for Certain Hydrological Uses
Wobber:	Exploitation of ERTS Imagery Using Snow Enhancement Techniques

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 36 are based on Federal budgetary information, Congressional appropriation hearings, and estimated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for agencies and programs listed in Table 36.

Table 36: Summary of Potential Benefits to Federal Agencies from Remote Sensing for RMF 3.3.2

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
Bonneville Power Administration	Power Supply and Scheduling	1,260	9	(12)
U.S. Dept. of Agriculture, Soil Conservation Service	Technical Programming, Installation Services and Snow Surveys	165,713	14	220 (340 - 900)
TOTAL				220 (352 - 912)

Note: Figures in parentheses are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

Increased capability benefits are approximately the same size as equal capability benefits.

RMF No. 3.3.3

MONITOR CHANGES IN GROUND WATER AND AQUIFERS

Rationale for Benefits

This function provides basic data that are used by government planners, hydrologists, town planners and architects, etc. These data are used by government officials as inputs to higher order RMF's. For example, the output of this RMF is a necessary input in RMF 3.4 - Manage Water Impoundment Systems, in RMF 3.7.3 - Monitor Changes in Surface Water Supply Due to Geological Changes, in RMF 3.8.1 - Conduct Hydrological Research, etc.

Federal Government Activities and Responsibilities

The following table gives that Federal statute which mandates or implies activity in RMF 3.3.3 - Monitor changes in ground water and aquifers. A description of this statute is given in Appendix C.

Table 37: List of Federal Statutes Relevant to RMF 3.3.3

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Date Requirement Related to Inland Water
5.	Federal Reclamation Law	43 USC 485g	DI	inventory of irrigated land

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

RMF No. 3.3.3

A list of Corps of Engineers remote sensing research projects for FY 1973, FY 1974, and FY 1975 relevant to RMF 3.3.3 is given in Appendix D.

The following activities, methods and products of the Soil Conservation Service (SCS) are relevant to this RMF. The classification system used is that of the SCS.

Data Categories	Activities	Methods	Products
7. Water (surface and ground water)	7.3 Monitoring	7.31 Survey and inventory changes in water by survey and inventory methods	7.311 Revised data 7.312 Revised map overlays to show changes 7.313 Sequential water data for developing prediction models
9. Flood	9.3 Monitoring	9.31 Survey and inventory flood and tide heights and year of occurrence	9.311 Revised data showing acres flooded

Non-Federal Activities

The California Department of Water Resources carries out investigations to survey and monitor ground water and aquifers with a view toward determining water supply. (Controller's Report 71/72) Appropriate agencies in other states carry out much the same function.

The Function of Remote Sensing

Remote sensing has considerable potential importance in monitoring changes in vegetation patterns that suggest changes in ground water and aquifers. It permits large areas to be monitored with a much greater frequency of update than is practical with other means. This advantage of area of coverage and frequency of update is particularly great in geographically remote areas. Several advantages result from the synoptic view given by remote sensing. Two of these advantages are:

(1) the ability to see features that would not otherwise be observed, and (2) the ability to take a "snapshot" of a large geographic area. A major advantage of remote sensing from an ERS-type satellite is that the incremental cost is low.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

Collins: (ground water surveys)

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

No demonstrated benefits from remote sensing have been located for this RMF.

RMF No. 3.3.4

MONITOR EVAPO-TRANSPORTATION, SOIL MOISTURE, AND DRAINAGE PATTERNS

Rationale for Benefits

This function provides basic data for government planners, farmers, hydrologists, etc. These data are used by government officials as inputs to higher order RMF's. For example, the output of this RMF is a necessary input in RMF 3.4 - Manage Water Impoundment Systems, in RMF 3.7.1 - Provide Early Warning of Disastrous Floods, in RMF 3.8.1 - Conduct Hydrological Research, etc.

Federal Government Activities and Responsibilities

Table 38 gives that Federal statue which mandates or implies activity in RMF 3.3.4, monitor evapo-transpiration, soil moisture, and drainage patterns. A description of this statute is given in Appendix C.

Table 38: List of Federal Statutes Relevant to RMF 3.3.4

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Date Requirement Related to Inland Water
5.	Federal Reclamation Law	43 USC 485g	DI	inventory of irrigated land

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

RMF No. 3.3.4

A list of Corps of Engineers remote sensing research projects for FY 1973, FY 1974, and FY 1975 relevant to RMF 3.3.4 is given in Appendix D.

The following activities, methods and products of the Soil Conservation Service (SCS) are relevant to this RMF. The classification system used is that of the SCS.

Data Categories	Activities	Methods	Products
7. Water (surface and ground water)	7.3 Monitoring	7.31 Survey and inventory changes in water by survey and inventory methods	7.311 Revised data 7.312 Revised map overlays to show changes 7.313 Sequential water data for developing prediction models
9. Flood	9.3 Monitoring	9.31 Survey and inventory flood and tide heights and year of occurrence	9.311 Revised data showing acres flooded. 9.312 Revise map overlays to show changing flood hazard

Non-Federal Activities

State Engineers and Departments of Water Resources, monitor these factors as part of their responsibilities to investigate water supplies and collect basic data for water resource investigations.

The Function of Remote Sensing

Remote sensing has considerable potential importance in monitoring changes in evapo-transpiration, soil moisture, and drainage patterns. It permits large areas to be monitored with a much greater frequency of update than is practical with other means. This advantage of area of coverage and frequency of update is particularly great in geographically remote areas.

Several advantages result from the synoptic view given by remote sensing. Two of these advantages are: (1) the ability to see features that would not otherwise be observed, and (2) the ability to take a "snapshot" of a large geographic area. A major advantage of remote sensing from an ERS-type satellite is that the incremental cost is low.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

Clark:	(seasonal repetition of flood conditions)
Colwell:	Analysis of River Meanders from ERTS-A Imagery
Hollyday:	Basin Characteristics Extracted from ERTS Data for Improving Regression Estimates of Streamflow
Holmgren:	(drainage patterns in tundra areas)
Morrison:	ERTS Application to Accelerated Erosion and to Monitor Future Erosional Changes in Arizona Region
Stoeckeler:	Develop Land Use - Peak Runoff Classification System for Highway Engineering Purposes

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

RMF No. 3.3.4

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 39 are based on Federal budgeting information, Congressional appropriation hearings, and estimated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for program listed in Table 39.

Table 39: Summary of Potential Benefits to Federal Agencies from Remote Sensing for RMF 3.3.4

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RME $ thous. (1973)
U.S. Dept. of Agriculture, Soil Conservation Service	River Basin Surveys and Investigations	15,561	5	(240)

Note: Figures in parentheses are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

Increased capability benefits are approximately the same size as equal capability benefits.

RMF No. 3.3.5

MONITOR CYCLICAL POLLUTION PATTERNS

Rationale for Benefits

This function provides essential data for government planners, recreation developers, industrial firms, fishermen, the general public, etc. These data are necessary in order to make proper decisions on government and private water resource projects, decisions on the location of industrial plants, decisions on recreation facilities, etc. This activity also provides data to government officials to be used as inputs for the higher order RMF's. For example, the output of this function is a necessary input in RMF 3.4.5 - Manage Water Impoundment Systems - for Recreations Purposes, in RMF 3.6.3 - Reduce and Monitor Pollution Damage, in RMF 3.7.2 - Provide Early Warning of Lake Eutrophication, etc.

Federal Government Activities and Responsibilities

The following table gives those Federal statutes which mandate, authorize, or imply activity in RMF 3.3.5, monitor cyclical pollution patterns. A description of these statutes is given in Appendix C.

Table 40: List of Federal Statutes Relevant to RMF 3.3.5

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Date Requirement Related to Inland Water
7.	Outdoor Recreation Act	P.L. 88-29; 77-Stat.49	DI	inventory of outdoor recreation resources
11.	Federal Water Pollution Control Act of 1972	P.L. 92-500; 33 USC 1151	EPA DC	oil spill surveillance, violation detection, pollution surveys and research
16.	Toxic Substance Control Act of 1973	Not Yet Passed	DI	research and monitoring of extent of toxic substances

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

The Corps of Engineers has the following remote sensing research projects initiated in FY 1973 in RMF 3.3.5.

RMF No. 3.3.5

Work Unit Title	Work Unit No.
Data Collection - ERTS	030401
Project Impact	040101
Land Use and Pollution	040102
Tennessee-Tombigbee	040103

A list of Corps of Engineers remote sensing research projects for FY 1973, FY 1974, and FY 1975 relevant to RMF 3.3.5 is given in Appendix D.

Non-Federal Activities

State environmental agencies are primarily concerned with monitoring water pollution in order to locate point sources of pollution and enforce standards.

The Function of Remote Sensing

Remote sensing has considerable potential importance in monitoring cyclical pollution patterns. It permits large areas to be monitored with a much greater frequency of update than is practical with other means. This advantage of area of coverage and frequency of update is particularly great in geographically remote areas. Several advantages result from the synoptic view given by remote sensing. Two of these advantages are: (1) the ability to see features that would not otherwise be observed, and (2) the ability to take a "snapshot" of a large geographic area. A major advantage of remote sensing from an ERS-type satellite is that the incremental cost is low.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

Wells: (lake and river pollution surveys)

RMF No. 3.3.5

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 41 are based on Federal budgetary information, Congressional appropriation hearings, and estimated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for agencies and programs listed in Table 41.

Table 41: Summary of Potential Benefits to Federal Agencies from ERTS for RMF 3.3.5

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Capability Benefit this RMF, $ thous. (1973)
Environmental Protection Agency	Research and Development on Processes and Effects	18,391	8	(50 - 100) (a)
	Abatement and Control: Water Quality Ambient Trend Monitoring	5,274	7	(15 - 60) (a)
	Abatement and Control: Water Quality Control Agency Support	40,000	9	(50 - 220) (a)
	Water Quality Technical Assistance and Planning	11,477	6	(50 - 130) (a)
Tennessee Valley Authority	Regional Water Quality Management: Water Quality Inventory	718	6	(10) (a)
U.S. Dept. of Agriculture, Forest Service	Water Pollution Abatement	16,733	6	(45 - 80) (a)
TOTAL				(220 - 600)

(a) Increased capability benefits are approximately 20% less than equal capability benefits.

Note: Figures in parentheses are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

RMF No. 3.4.1

MANAGE WATER IMPOUNDMENT SYSTEMS FOR POWER GENERATION

Rationale for Benefits

This function is one of the essential "final products" of water management. Proper management of this function provides adequate power for industrial, commercial, and residential requirements.

Federal Government Activities and Responsibilities

The following table gives those Federal statutes which mandate, authorize, or imply activity in RMF 3.4.1 Manage water impoundment systems for power generation. A description of these statutes is given in Appendix C.

Table 42: List of Federal Statutes Relevant to RMF 3.4.1

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Date Requirement Related to Inland Water
5.	Federal Reclamation Law	43 USC 485g	DI	inventory of irrigated land
9.	Act of June 17, 1902	32 STA 388	DI	planning, construction and operation of irrigation and water management facilities
18.	Tennessee Valley Authority Act of 1933	16 USC 12a	TVA	water management of TVA systems

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

Non-Federal Activities

Hydro-electric power generation is largely federal. The California State Water Project is the most extensive non-federal water-impoundment system which includes hydroelectric power generation facilities.

RMF No. 3.4.1

The Function of Remote Sensing

In order to properly manage water impoundment systems for power generation, it is necessary to have good forecasts of future water supplies in watershed areas. The accuracy of these forecasts depends on the frequency and comprehensiveness of the monitoring of free water areas, snow, ice and glaciers, ground water and aquifers, and evapo-transpiration, soil moisture, and drainage patterns. Because of its synoptic capabilities and high frequency of coverage of large geographic areas at low incremental cost, earth resources satellites appear to provide highly significant potential benefits in this RMF area.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

In the EarthSat report, calculations were based on a 10 percent discount rate and a ten year investment horizon. A parametric analysis of the effect of reducing the April 1 forecast error was made. The effects of a 25 percent, 50 percent, and 75 percent reduction in the April 1st forecast error were shown in the Tables presented in their report. To make their results more comparable to ECON's, their assumption of a ten year investment horizon is replaced by an infinite investment horizon. Their results, under this assumption, give an annual range of benefits from hydroelectric power generation for eleven western states of $4,000,000 to $15,000,000. Extrapolating these results, based on the proportion of hydroelectric power production in these eleven states relative to the U.S. in 1964, yields a range of benefits of $6,700,000 to $25,000,000 for the U.S.

However, this RMF bases the new capability benefits in hydroelectric power generation on the results of the Feather River case study, given in Appendix F of this volume. The new capability benefits for the U.S., conservatively estimated, is $42,000,000 per annum.

RMF No. 3.4.1

Current ERTS Activities

Colwell: Use of ERTS-A to Aid in Solving Water Resource Management Problems in California

Cooper: Use of ERTS Imagery in Reservoir Management's Operations

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 43 are based on Federal budgetary information, Congressional appropriation hearings, and estimated ERTS technical capabilities.

Table 43: Summary of Potential Benefits to Federal Agencies from Remote Sensing for RMF 3.4.1

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
Bonneville Power Administration	Power Supply and Scheduling	1,260	9	(18)
Southeastern Power Administration	System Operation and Maintenance	235	6	*
Southwestern Power Administration	System Operation and Maintenance	2,747	7	*
Tennessee Valley Authority	Water Control Operations	1,370	7	(60 - 75) (a)
U.S. Dept. of Agriculture, Soil Conservation Service	Technical Programming, Installation Services and Snow Surveys	165,713	14	330 (500 - 1,350)
U.S. Dept. of Interior, Bureau of Reclamation	Operation and Maintenance	72,176	6	*
TOTALS				330 (578 - 1,443)

(a) Increased capability benefits = $9 - 11 thousand

* Benefit significant but not quantifiable

Note: Figures in parentheses are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON. Inc.

Increased capability benefits are approximately the same size as equal capability benefits, except where otherwise indicated in Table 43.

RMF No. 3.4.1

See Appendix B for additional Federal budget and program information for agencies and programs listed in Table 43.

The new capability benefits in this RMF are evaluated in detail in the Feather River Case Study, presented in Appendix F of this volume. The estimated discounted annual new capability benefit for this RMF is $42,000,000.

RMF No. 3.4.2

MANAGE WATER IMPOUNDMENT SYSTEMS FOR FLOOD CONTROL

Rationale for Benefits

This function is one of the essential "final products" of water management. Proper management of this function minimizes the risk of disastrous flooding.

Federal Government Activities and Responsibilities

The following table gives those Federal statutes which mandate, authorize, or imply activity in RMF 3.4.2 Manage water impoundment systems for flood control. A description of these statutes is given in Appendix C.

Table 44: List of Federal Statutes Relevant to RMF 3.4.2

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Date Requirement Related to Inland Water
5.	Federal Reclamation Law	43 USC 485g	DI	inventory of irrigated land
9.	Act of June 17, 1902	32 STA 388	DI	planning, construction and operation of irrigation and water management facilities
18.	Tennessee Valley Authority Act of 1933	16 USC 12a	TVA	water management of TVA systems

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

Non-Federal Activities

Interstate River Compacts for flood control includes:

Red River of the North

Connecticut River
New England

Merrimack River
New England

Thames River
New England

Wheeling Creek
Pennsylvania and West Virginia

These systems are small and relatively economically insignificant compared with Federal management of reservoirs or flood control.

Examples exist of other forms of local flood management. In the Root River Watershed (Wisc.), 12 communities adopted zoning ordinances to conform to a plan to prevent flood plain encroachment. These communities adopted a coordinated watershed plan. (Report to President: 1973).

The Function of Remote Sensing

In order to properly manage water impoundment systems for flood control, it is necessary to have good forecasts of future water supplies in watershed areas. The accuracy of these forecasts depends on the frequency and comprehensiveness of the monitoring of free water areas, snow, ice and glaciers, ground water and aquifers, and evapo-transpiration, soil moisture, and drainage patterns. Because of its synoptic capabilities and high frequency of coverage of large geographic areas at low incremental cost, earth resources satellites appear to provide highly significant potential benefits in this RMF area.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

According to a Congressional Report published in 1966, flood damage in the United States has been estimated to average around $1 billion per year.* However, for watershed systems that already have comprehensive flood control through the existence of dams etc., improved management results in increased water available to water management functions 3.4.1, 3.4.3 - 3.4.6. No direct benefit therefore, should be allocated to the flood control function. For watershed systems

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* Task Force on Federal Flood Control Policy (August 1966). A Unified National Program for Managing Flood Losses, House Document No. 465, 89th Congress, 2nd Session. U.S. Government Printing Office, Washington, D.C., page 3.

that do not have flood control, no benefit exists under this RMF, since no allocation function exists. Rather, the benefit from increased warning would show up in other RMF's. This is the principle used in the Feather River case study, presented in Appendix F, where no new capability benefits are attributed to the flood control function.

Current ERTS Activities

Colwell:	Use of ERTS-A in Solving Water Resource Management Problems in California
Cooper:	Use of ERTS Imagery in Reservoir Managment and Operations
Schumann:	Application of ERTS Data Collection System in ARETS

Appendix G contains futher current information on ERTS prinicipal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 45 are based on Federal budgetary information, Congressional appropriation hearings, and estimated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for agencies and programs listed in Table 45.

Increased capability benefits are approximately the same size as equal capability benefits, except where otherwise indicated in Table 45.

RMF No. 3.4.2

Table 45: Summary of Potential Benefits to Federal Agencies from Remote Sensing for RMF 3.4.2

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
Bonneville Power Administration	Power Supply and Scheduling	1,260	9	(18)
Southeastern Power Administration	System Operation and Maintenance	235	6	*
Southwestern Power Administration	System Operation and Maintenance	2,747	7	*
Tennessee Valley Authority	Water Control Operations	1,370	7	(60 - 75) (a)
U.S. Dept. of Agriculture, Soil Conservation Service	Technical Programming, Installation Services, and Snow Surveys	165,713	14	330 (500 - 1,350)
U.S. Dept. of Interior, Bureau of Reclamation	Operation and Maintenance	72,176	6	*
TOTAL				330 (578 - 1,443)

(a) Increased capability benefits = $9 - 11 thousand

* Benefit significant but not quantifiable

Note: Figures in parentheses are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

RMF No. 3.4.3

MANAGE WATER IMPOUNDMENT SYSTEMS FOR URBAN WATER SUPPLY

Rationale for Benefits

This function is one of the essential "final products" of water management. Proper management of this function yields an adequate quantity of high quality water for urban and residential purposes.

Federal Government Activities and Responsibilities

The following table gives those federal statutes which mandate, authorize, or imply activity in RMF 3.4.3, manage water impoundment systems for urban water supply.

Table 46: List of Federal Statutes Relevant to RMF 3.4.3

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Data Requirement Related to Inland Water
2.	Watershed Protection and Flood Protection Act	16 USC 1001-1009	DA ACE	investigations and surveys of flood prevention and watershed program development
5.	Federal Reclamation Law	43 USC 485g	DI	inventory of irrigated land
9.	Act of June 17, 1902	32 STA 388	DI	planning, construction and operation of irrigation and water management facilities
18.	Tennessee Valley Authority Act of 1933	16 USC 12a	TVA	water management of TVA systems

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

Non-Federal Activities

Until recently, cities had almost exclusive responsibility for urban water supply. Increasingly, there are Federal programs to aid municipalities in this area. Some cities manage water impoundment systems for water supply. In many

cases, they receive assistance from Federal agencies. For example, they often are able to store water in federally-owned reservoirs.

The Function of Remote Sensing

In order to properly manage water impoundment systems for urban water supply, it is necessary to have good forecasts of future water supplies in watershed areas. The accuracy of these forecasts depends on the frequency and comprehensiveness of the monitoring of free water areas, snow, ice and glaciers, ground water and aquifers, and evapo-transpiration, soil moisture, and drainage patterns. Because of its synoptic capabilities and high frequency of coverage of large geographic areas at low incremental cost, earth resources satellites appear to provide highly significant potential benefits in this RMF area.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

The new capability benefits to this RMF are estimated from the results of the Feather River case study, which is described in Appendix F.

Current ERTS Activities

Colwell:	Use of ERTS-A to Aid in Solving Water Resource Management Problems in California
Cooper:	Use of ERTS Imagery in Reservoir Management and Operations
Schumann:	Application of ERTS Data Collection System in ARETS

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

RMF No. 3.4.3

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 47 are based on Federal budgeting information, Congressional appropriation hearings, and estimated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for agencies and programs listed in Table 47.

Table 47: Summary of Potential Benefits to Federal Agencies from Remote Sensing for RMF 3.4.3

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
Bonneville Power Administration	Power Supply and Scheduling	1,260	9	(18)
Southeastern Power Administration	System Operation and Maintenance	235	6	*
Southwestern Power Administration	System Operation and Maintenance	2,747	7	*
Tennessee Valley Authority	Water Control Operations	1,370	7	(60 - 75) (a)
U.S. Dept. of Agriculture, Soil Conservation Service	Technical Programming, Installation Services and Snow Surveys	165,713	14	330 (500 - 1,350)
U.S. Dept. of Interior, Bureau of Reclamation	Operation and Maintenance	72,176	6	*
TOTAL				330 (578 - 1,443)

(a) Increased capability benefits = $9 - 11 thousand

* Benefit significant but not quantifiable

Note: Figures in parentheses are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

Increase capability benefits are approximately the same size as equal capability benefits.

The new capability benefits in this RMF are evaluated in detail in The Feather River Case Study, presented In Appendix F of this volume. The estimated annual new capability benefit for this RMF is $860,000.

RMF No. 3.4.4

MANAGE WATER IMPOUNDMENT SYSTEMS FOR AGRICULTURAL WATER SUPPLY

Rationale for Benefits

This function is one of the essential "final products" of water management. Proper management of this function provides adequate water of suitable quality for agricultural purposes.

Federal Government Activities and Responsibilities

Table 48 gives those Federal statutes which mandate, authorize, or imply activity in RMF 3.4.4, manage water impoundment systems for agricultural water supply. A description of these statutes is given in Appendix C.

Table 48: List of Federal Statutes Relevant to RMF 3.4.4

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Date Requirement Related to Inland Water
5.	Federal Reclamation Law	43 USC 485g	DI	inventory of irrigated land
9.	Act of June 17, 1902	32 STA 388	DI	planning, construction and operation of irrigation and water management facilities
16.	Tennessee Valley Authority Act of 1933	16 USC 12a	TVA	water management of TVA systems

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

Non-Federal Activities

In the area of agricultural water use, state and local bodies are primarily concerned with distribution. No specific state or local agencies charged with managing water impoundment system for agriculture have been found but it is likely that agencies such as the New Mexico Soil and Water Conservation Committee have some interest in this area.

RMF No. 3.4.4

The Function of Remote Sensing

In order to properly manage water impoundment systems for agricultural water supply, it is necessary to have good forecasts of future water supplies in watershed areas. The accuracy of these forecasts depends on the frequency and comprehensiveness of the monitoring of free water areas, snow, ice and glaciers, ground water and aquifers, and evapotranspiration, soil moisture, and drainage patterns. Because of its synoptic capabilities and high frequency of coverage of large geographic areas at low incremental cost, earth resources satellites appear to provide a highly significant potential benefits in the RMF area.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the Source Document, Volume II, for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

According to the EarthSat Report on Water Resources Management, the total net value of irrigated water that may be impacted by ERS is $129 million per annum in 1973 dollars. This amount represents the increase in net farm income due to irrigation of land with rainfall of less than 15 inches per year. The EarthSat report gives no dollar value for the potential increase in land acreage under irrigation due to better management of water resources using ERS. On the contrary, without well supported justification, it states that such benefits are likely to be insignificant*.

A case study was performed by ECON to evaluate the potential benefits of ERS in the Feather River System. From this case study, it is clear that a major portion of the potential hydrological benefits of ERS occur in the area of irrigation. By extrapolating the results of this case study to other geographic areas of the U.S. that could clearly benefit from improved hydrological information, a conservative new capability benefit for the U.S. of $7,720,000 per annum is obtained.

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* Snow Mapping and Runoff Forecasting: Examination of ERTS-1 Capabilities and Potential Benefits from an Operational ERS System, Interim Report of Water Resources Management, Case Study Team, March 13, 1974, performed for United States Department of Interior, Office of Economic Analysis, Contract No. 14-08-001-13519.

RMF No. 3.4.4

Current ERTS Activities

Colwell:	Use of ERTS-A in Solving Water Resource Management Problems in California
Cooper:	Use of ERTS Imagery in Reservoir Management and Operations
Schumann:	Application of ERTS Data Collection System in ARETS

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 49 are based on Federal budgetary information, Congressional appropriation hearing, and estimated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for agencies and programs listed in Table 49.

Increased capability benefits are approximately the same size as equal capability benefits, except where otherwise indicated in Table 49.

The new capability benefits in this RMF are evaluated in detail in the Feather River Case Study, presented in Appendix F of this volume. The estimated discounted annual new capability benefit for this RMF is $7,720,000.

RMF No. 3.4.4

Table 49: Summary of Potential Benefits to Federal Agencies from Remote Sensing for RMF 3.4.4

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
Bonneville Power Administration	Power Supply and Scheduling	1,260	9	(18)
Southeastern Power Administration	System Operation and Maintenance	235	6	*
Southwestern Power Administration	System Operation and Maintenance	2,747	7	*
Tennessee Valley Authority	Water Control Operations	1,370	7	(60 - 75) (a)
U.S. Dept. of Agriculture, Soil Conservation Service	Technical Programming, Installation Services and Snow Surveys	165,713	14	330 (500 - 1,350)
U.S. Dept. of Interior, Bureau of Reclamation	Operation and Maintenance	72,176	6	*
TOTAL				330 (578 - 1,443)

(a) Increased capability benefits = $9 - 11 thousand

* Benefit significant but not quantifiable

Note: Figures in parentheses are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

RMF No. 3.4.5

MANAGE WATER IMPOUNDMENT SYSTEMS FOR RECREATIONAL PURPOSES

Rationale for Benefits

This function is one of the essential "final products" of water management. Proper management of this function provides sufficiently clean water for recreational purposes.

Federal Government Activities and Responsibilities

Table 50 gives those Federal statutes which mandate, authorize, or imply activity in RMF 3.4.5, manage water impoundment systems for recreational purposes.

Table 50: List of Federal Statutes Relevant to RMF 3.4.5

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Data Requirement Related to Inland Water
2.	Watershed Protection and Flood Protection Act	16 USC 1001-1009	DA ACE	investigations and surveys of flood prevention and watershed program development
5.	Federal Reclamation Law	43 USC 485g	DI	inventory of irrigated land
9.	Act of June 17, 1902	32 STA 388	DI	planning, construction and operation of irrigation and water management facilities
18.	Tennessee Valley Authority Act of 1933	16 USC 12a	TVA	water management of TVA systems

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

Non-Federal Activities

State, local and private interests are heavily involved in management of impoundment systems for recreational purposes. The Federal government has appropriated $940 million since 1965 for grants-in-aid to states and local governments for outdoor recreation land acquisition and development. Two-thirds of this has been used for water-oriented recreation.*

* Commission on Water Resource Management, Report to the President: 1973.

State departments of Parks and Recreation, Fish and Game, etc. have direct interests in the management of state impoundment systems for recreational purposes. They also cooperate extensively with various federal government programs. For example, the New Mexico Game and Fish Department cooperates with the U.S. Department of the Interior in development and management of the Navajo Reservoir for sport fishing purposes.*

The Function of Remote Sensing

In order to properly manage water impoundment systems for recreational purposes, it is necessary to have good information on watershed hydrology. Useful recreation management information includes data on drainage patterns, sedimentation, pollution and eutrophication, and water supply. The potential benefits of this information can only be realized through frequent, comprehensive monitoring of free water areas, snow and ice and watershed conditions. Because of its synoptic capabilities and high frequency of coverage of large geographic areas at low incremental cost, earth resources satellites appear to provide highly significant potential benefits in this RMF area.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

The EarthSat report on Water Management indicates that possible (new capability) recreational benefits from potential ERS capabilities for snow mapping and runoff forecasting are negligible for the following reasons**.

> "Investment in recreation facilities frequently depends upon assurance of a dependable water supply."
>
> "Water rights assure water allocation if water is available at all."

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* New Mexico State Budget Commission on Water Resource Management, Report to President: 1973.

** Snow Mapping and Runoff Forecasting: Examination of ERTS-1 Capabilities and Potential Benefits from an Operational ERS System, Interim Report of Water Resources Management, Case Study Team, March 13, 1974, performed for United States Department of Interior, Office of Economic Analysis, Contract No. 14-08-001-13519.

RMF No. 3.4.5

Current ERTS Activities

Colwell: Use of ERTS-A in Solving Water Resource Management Problems in California

Cooper: Use of ERTS Imagery in Reservoir Management and Operations

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

See Appendix B for additional Federal budget and program information for agencies and programs in Table 51.

Table 51: Summary of Potential Benefits to Federal Agencies from Remote Sensing for RMF 3.4.5

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
Bonneville Power Administration	Power Supply and Scheduling	1,260	9	*
Southeastern Power Administration	System Operation and Maintenance	235	6	*
Southwestern Power Administration	System Operation and Maintenance	2,747	7	*
Tennessee Valley Authority	Water Control Operation	1,370	7	*
U.S. Dept. of Agriculture, Soil Conservation Service	Technical Programming, Installation Services, and Snow Surveys	165,713	14	*
U.S. Dept. of Interior, Bureau of Reclamation	Operation and Maintenance	72,176	6	*

* Benefit significant but not quantifiable.

Source: ECON, Inc.

RMF No. 3.4.6

MANAGE WATER IMPOUNDMENT SYSTEMS FOR NAVIGATION

Rationale for Benefits

This function is one of the essential "final products" of water management. Proper management of this function provides for free and unencumbered navigation.

Federal Government Activities and Responsibilities

The following table gives those Federal statutes which mandate, authorize, or imply activity in RMF 3.4.6 Manage water impoundment systems for navigation. A description of these statutes is given in Appendix C. .

Table 52: List of Federal Statutes Relevant to RMF 3.4.6

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Date Requirement Related to Inland Water
5.	Federal Reclamation Law	43 USC 485g	DI	inventory of irrigated land
9.	Act of June 17, 1902	32 STA 388	DI	planning, construction and operation of irrigation and water management facilities
18.	Tennessee Valley Authority Act of 1933	16 USC 12a	TVA	water management of TVA systems

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

Non-Federal Activities

States and local interests are frequently involved in management of canals or navigable rivers. However, there are apparently few state or local activities directly related to the management of water impoundment systems for navigation.

RMF No. 3.4.6

The Function of Remote Sensing

In order to properly manage water impoundment systems for navigation, it is necessary to have good forecasts of future water supplies in watershed areas. The accuracy of these forecasts depends on the frequency and comprehensiveness of the monitoring of free water areas, snow, ice and glaciers, ground water and aquifers, and evapo-transpiration, soil moisture, and drainage patterns. Because of its synoptic capabilities and high frequency of coverage of large geographic areas at low incremental cost, earth resources satellites appear to provide highly significant potential benefits in this RMF area.

Economic and Technical Models for Estimating Benefits

The benefit estimates for the RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

The EarthSat report on Water Management made the following statement about improved navigation.*

> "Use of ERS-assisted runoff forecasts could potentially aid navigation by assuring water availability for augmenting low flows in navigable streams. Such releases, however, are mandatory if sufficient water is available. Therefore, since the improvement from improved ERS-assisted water supply forecasts will be minimal, no benefits from this source have been estimated."

Current ERTS Activities

Colwell:	Use of ERTS-A in Solving Water Resource Management Problems in California
Cooper:	Use of ERTS Imagery in Reservoir Management and Operations

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

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* Snow Mapping and Runoff Forecasting: Examination of ERTS-1 Capabilities and Potential Benefits from an Operational ERS System, Interim Report of Water Resources Management, Case Study Team, March 13, 1974, performed for United States Department of Interior, Office of Economic Analysis, Contract No. 14-08-001-13519.

RMF No. 3.4.6

Estimate of ERTS Economic Capabilities

See Appendix B for additional Federal budget and progarm information for agencies and programs listed in Table 53.

Table 53: Summary of Potential Benefits to Federal Agencies from Remote Sensing for RMF 3.4.6

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
Bonneville Power Administration	Power Supply and Scheduling	1,260	9	(a)
Southeastern Power Administration	System Operation and Maintenance	235	6	(a)
Southwestern Power Administration	System Operation and Maintenance	2,747	7	(a)
Tennessee Valley Authority	Water Control Operation	1,370	7	(a)
U.S. Dept. of Agriculture, Soil Conservation Service	Technical Programming, Installation Services, and Snow Surveys	165,713	14	(a)
U.S. Dept. of Interior, Bureau of Reclamation	Operation and Maintenance	72,176	6	(a)

(a) ERTS capability in this RMF undetermined.

RMF No. 3.4.7

PLAN CHANGES IN DRAINAGE AND WATER IMPOUNDMENT SYSTEMS

Rationale for Benefits

This planning function is essential to the maintenance and development of adequate drainage and water impoundment systems for future urban water supply, commercial and agricultural water supply, navigation, flood control, and power generation needs.

Federal Government Activities and Responsibilities

The following table gives those Federal statutes which mandate, authorize, or imply activity in RMF 3.4.7, plan changes in drainage and water impoundment systems. A description of these statutes is given in Appendix C.

Table 54: List of Federal Statutes Relevant to RMF 3.4.7

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Date Requirement Related to Inland Water
5.	Federal Reclamation Law	43 USC 485g	DI	inventory of irrigated land
9.	Act of June 17, 1902	32 STA 388	DI	planning, construction and operation of irrigation and water management facilities
18.	Tennessee Valley Authority Act of 1933	16 USC 12a	TVA	water management of TVA systems

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

Non-Federal Activities

All states have developed State water plans and state and local agencies have interest in drainage and water impoundment systems to assure water supply.

States also participate in Federal programs to drain land in agricultural production and develop water impoundment systems. This participation generally takes the form of cost-sharing.

RMF No. 3.4.7

The Function of Remote Sensing

In order to properly plan changes in drainage and water impoundment systems, it is necessary to have good forecasts of future water supplies in watershed areas. The accuracy of these forecasts depends on the frequency and comprehensiveness of the monitoring of free water areas, snow, ice and glaciers, ground water and aquifers, and evapo-transpiration, soil moisture, and drainage patterns. Because of its synoptic capabilities and high frequency of coverage of large geographic areas at low incremental cost, earth resources satellites appear to provide significant potential benefits in this RMF area.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities:

Myers: Effective Use of ERTS Multisensor Data in Great Plains Corridor

Appendix E contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 55 are based on Federal budgetary information, Congressional appropriation hearings, and estimated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for agencies and programs listed in Table 55.

RMF No. 3.4.7

Table 55: Summary of Potential Benefits to Federal Agencies from Remote Sensing for RMF 3.4.7

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
Alaska Power Administration	Resource Development Studies	190	3	(8 - 70)
Army Corps of Engineers	Northeastern U.S. Water Study	1,950	3	(30 - 450)
Tennessee Valley Authority	Preliminary Investigations	90	1	(7 - 30)
U.S. Dept. of Agriculture, Soil Conservation Service	Small Watershed Project Investigations and Planning	12,756	1	(500 - 900)
	Flood Prevention Project	25,270	1	(400-4000)
U.S. Dept. of Interior, Bureau of Land Management	Soil and Watershed Conservation	16,565	4	(40 - 120)
U.S. Dept. of Interior, Bureau of Reclamation	Plan Formulation Investigations	9,800	1	(390 - 3100)
	Regional Planning Service	1,282	6	(30 - 90)
TOTAL				(1,405 - 8,760)

Note: Figures in parentheses are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

Increased capability benefits are approximately the same size as equal capabilty benefits.

RMF No. 3.5.1

CONSERVE FRESH WATER RESOURCES

Rationale for Benefits

This RMF covers a broad range of activities ranging from watershed preservation to water use optimization. Benefits accrue to water users in the form of reduced costs, to users of recreational facilities in watershed areas, and to water related industries such as fishing and tourism. In addition, significant benefits in areas such as flood control may result from well-designed programs to implement this RMF.

Federal Government Activities and Responsibilities

The following table gives those federal statutes which mandate, authorize, or imply activity in RMF 3.5.1, Conserve Fresh Water Resources. A description of these statutes is given in Appendix C.

Table 56: List of Federal Statutes Relevant to RMF 3.5.1

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Date Requirement Related to Inland Water
7.	Outdoor Recreation Act	P.L. 88-29; 77-Stat.49	DI	inventory of outdoor recreation resources
8.	Water Resources Planning Act	P.L. 89-80; 42USC1962D-12	DI,DA, HEW, FPC	studies of water supply supply adequacy

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

The Corps of Engineers has the following remote sensing research projects initiated in FY 1973 in RMF 3.3.1.

Work Unit Title	Work Unit No.
Use of Remote Sensing in Planning	050206

A list of Corps of Engineers remote sensing research projects for FY 1973, FY 1974, and FY 1975 relevant to RMF 3.5.1 is given in Appendix D.

RMF No. 3.5.1

Non-Federal Activities

Most states have soil and water conservation districts and state agencies coordinating water conservation programs. In California, the Department of Conservation is concerned with, among other things, watershed preservation.

There are also a number of public interest groups such as the Sierra Club which are devoted to environmental protection and conservation.

State and local environmental protection agencies, fish and game departments, and parks and recreation departments are also involved in water conservation.

The Function of Remote Sensing

Remote sensing can provide extensive information relevant to the execution of this RMF. Frequent and reliable inventories of fresh-water resources, data on erosion and runoff, and inputs to evapo-transpiration and drainage models make it possible to make the most efficient use of available resources and to locate problem areas where corrective action is called for. Remote sensing's synoptic capability makes it especially useful for regional conservation planning.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the Source Document, Volume II, for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

Weaver:	Research and Investigation of Geology, Mineral and Water Resources of Maryland
Welby:	Use of ERTS-A in Geological Evaluation, Regional Planning, Forest Management and Water Management in Northern California

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

RMF No. 3.5.1

The estimated benefits shown in Table 57 are based on Federal budgetary information, Congressional appropriation hearings, and estimated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for the program listed in Table 57.

Table 57: Summary of Potential Benefits to Federal Agencies from Remote Sensing for RMF 3.5.1

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
U.S. Department of Interior, Bureau of Land Management	Soil and watershed conservation	16,565	4	(40 - 120)

Note: Figures in parenthesis are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

Increased capability benefits are approximately the same size as equal capability benefits.

RMF No. 3.6.1

ASSESS AND REDUCE FLOOD DAMAGE

Rationale for Benefits

This RMF provides essential information to local, state and federal disaster relief coordinators, insurance companies, and industries and residents in flood-prone areas. This information is useful not only in the aftermath of flooding but also in decisions on industrial and residential site locations, in the planning of preventive measures and in the determination of insurance rates.

Federal Government Activities and Responsibilities

The following table gives those Federal statutes which mandate, authorize, or imply activity in RMF 3.6.1, access and reduce flood damage. A description of these statutes is given in Appendix C.

Table 58: List of Federal Statutes Relevant to RMF 3.6.1

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Data Requirement Related to Inland Water
3.	Flood Control Act of 1960	P.L. 86-645; 33 USC 709a	ACE	identification of flood plain areas, damage assessment
4.	Taylor Grazing Act	43 USC 315a	DI	studies of erosion and flood control
12.	Flood Disaster Protection Act of 1973	P.L. 93-234	HUD	flood plain mapping

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

The Corps of Engineers has the following remote sensing research projects initiated in FY 1973 in RMF 3.6.1.

Work Unit Title	Work Unit No.
Missouri River	030201
Fishtrap Reservoir	030501

A list of Corps of Engineers remote sensing research projects for FY 1973, FY 1974, and FY 1975 relevant to RMF 3.6.1 is given in Appendix D.

RMF No. 3.6.1

The following activities, methods and products of the Soil Conservation Service (SCS) are relevant to this RMF. The classification system used is that of the SCS.

Data Categories	Activities	Methods		Products	
9. Flood	9.3 Monitoring	9.31	Survey and inventory flood and tide heights and year of occurrence	9.311	Revised data showing acres flooded.
				9.312	Revise map overlays to show changing flood hazard

Non-Federal Activities

The majority of the activities in this area is Federal. There are some state and interstate programs designed to reduce flood damage but they are generally quite limited. States also participate in river basin commissions which are primarily planning organizations with reduction of flood damage as one of several planning considerations. In Wisconsin, the Root River Watershed, local communities have worked together to reduce flood damage through planning. (See RMF No. 3.4.2)

The Function of Remote Sensing

Remote sensing provides one of the most efficient means of surveying an entire flood plain in the short period during and after a flood when such information is most useful. This information is useful to disaster-relief planners, local officials, and insurance appraisers. Remote sensing also contributes to the reduction of losses by providing geographic and hydrological data which facilitate preventive measures and aid in flood prediction.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the

introductory section in this volume on economic and technical models.

There are two components of equal-capability remote-sensing benefits to this RMF -- reduction of actual damage and reduction of costs of damage assessment.

In the latter category, remote sensing has been shown to be effective in flood-plain delineation and mapping*, an activity which is included in the Army Corps of Engineers' 1975 budget request for $11 million for "flood plain information and related technical cost planning assistance."** Remote sensing could provide equal-capability benefits of as much as $10 million of this, and ERTS in particular seems capable of realizing a substantial proportion of this.

The combination of equal-capability and increased-capability benefits, a unit-elastic demand curve, could reach $20 million. In addition, there will be new-capability benefits of undetermined magnitude resulting from the capability of remote sensing to provide simultaneous overviews of flood plains in a shorter time after flooding than is possible with aircraft or ground-based means.

More detailed information on the Army Corps of Engineers' program for flood-plain information and technical assistance is required to determine just what proportion is replaceable by remote sensing.

Current ERTS Activities

Dethier:	Phenology Satellite Experiment
Garcia:	Research and Land Use in Soil Erosion, Deficit, Deforest and Floods; Geologic Map and Tectonic Structure Delineation
Higer:	Develop Data Relay System for Monitoring Hydrologic Conditions in Florida

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* Rango and Solomonson, "Regional Flood Mapping from Space," Water Resources Research, June 1974.

** Hearings L7920X, pt. 1, page 215.

RMF No. 3.6.1

Lind: Environmental Study of ERTS Imagery, L. Champlain Basin.

Paulson: Near Real-Time Water Resouces Data for River Basin Management

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 59 are based on Federal budgetary information, Congressional appropriation hearings, and estimated ERTS technical capabilities. See Appendix B for additional federal budget and program information for agencies and programs listed in Table 59.

Table 59: Summary of Potential Benefits to Federal Agencies from Remote Sensing for RMF 3.6.1

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
Tennessee Valley Authority	Flood Control Operations	425	4	(4)
U.S. Department of Agriculture, Soil Conservation Service	Technical Programming, Installation Services and Snow Surveys	165,713	14	220 (340 - 900)
Delaware River Basin Commission	Flood Loss Reduction	76	3	(8 - 20)
Army Corps of Engineers	Flood Plain Information Reports	5,750	5	40 (140 - 600)
TOTAL				260 (492 - 1524)

Note: Figures in parenthesis are order-of-magnitude estimates which are not supported by in-depth case studies.
Source: ECON, Inc.

Increased capability benefits are approximately the same size as equal capability benefits.

RMF No. 3.6.2

REDUCE DAMAGE TO WATER IMPOUNDMENT SYSTEMS FROM SILTING AND SEDIMENTATION

Rationale for Benefits

This RMF yields benefits (1) in the form of reduced maintenance costs for dredging and silt removal; (2) through more efficient operation of hydroelectric power facilities; and (3) by extending the useful life of water-impoundment systems. The reduction of silt and sedimentation also results in increased recreational and wildlife-management benefits in the area surrounding the impoundment system.

Federal Government Activities and Responsibilities

The following table gives that Federal statute which mandates or implies activity in RMF 3.6.2, reduce flood damage to water impoundment systems from silting and sedimentation. A description of these statutes is given in Appendix C.

Table 60: List of Federal Statutes Relevant to RMF 3.6.2

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Date Requirement Related to Inland Water
9.	Act of June 17, 1902	32 STA 388	DI	planning, construction and operation of irrigation and water management facilities
12.	Flood Disaster Protection Act of 1973	P.L.93-234	HUD	Flood Plain Mapping
18.	Tennessee Valley Authority Act of 1933	16 USC 12a	TVA	water management of TVA system

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

Non-Federal Activities

State soil and water conservation districts are concerned with erosion, protection of watersheds, silting and sedimentation. In New Mexico, the Soil and Water Conservation Committee assists soil and water conservation districts in their programs and secures cooperation from other state and federal agencies for the districts.

RMF No. 3.6.2

The Function of Remote Sensing

Remote data-collection systems used in conjunction with a satellite relay system provide a means of monitoring silting and sedimentation with greater frequency and efficiency than conventional ground-based methods. This is particularly true of remote or inaccessible data collection points. This information is useful to managers of water impoundment systems and related recreational and wildlife areas in providing a basis for timely and efficient corrective action.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

Alexander:	Central Atlantic Regional Ecological Test Site
Cast:	Remote sensing of reclamation projects
Jain:	Evaluation Effects of Construction and Staged Filling of Reservoirs on Environment and Ecology
Landgrebe:	Study of the Utilization of ERTA-A Data From Wabash River Basin
Morrison:	ERTS Application to Accelerated Erosion and to Maintain Future Erosional Changes in Arizona Region
Pluhowski:	Dynamics of Suspended Sediment Plumes in Lake Ontario
Polcyn:	Hydrologic Problems of Lake Ontario Basin for IFYGL
Yarger:	Study of Monitoring Fresh Water Resources

RMF No. 3.6.2

Appendix G contains further current information on FRTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 61 are based on Federal budgetary information, Congressional appropriation hearings, and estimated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for agencies and programs listed in Table 61.

Table 61: Summary of Potential Benefits to Federal Agencies from Remote Sensing for RMF 3.6.2

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
U.S. Department of Interior, Bureau of Reclamation	Water quantity management and control	121	1	*
	Operation and maintenance of water-improvement systems	72,176	7	*
Southeastern Power Administration	System operation and maintenance	235	6	*
Bonneville Power Administration	Power supply and scheduling	1,260	9	*
U.S. Department of Interior, Bureau of Reclamation	Operation and Maintenance	72,176	6	*
Southwestern Power Administration	System operation and maintenance	2,747	7	*

Note: Figures in parenthesis are order-of-magnitude estimates which are not supported not supported by in-depth case studies.

* Benefit significant but not quantifiable

Source: ECON, Inc.

RMF No. 3.6.3

REDUCE POLLUTION OF FREE WATER

Rationale for Benefits

This RMF covers a broad range of control functions mandated by Federal, State and local pollution regulations. There are substantial potential benefits in the areas of wildlife management, fishing, forestry, and agriculture to residents of the affected areas in the form of reduced pollution damage.

Federal Government Activities and Responsibilities

The following table gives that Federal statute which mandates or implies activity in RMF 3.6.3 Reduce pollution of free water. A description of this statute is given in Appendix C.

Table 62: List of Federal Statutes Relevant to RMF 3.6.3

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Date Requirement Related to Inland Water
7.	Federal Water Pollution Control Act of 1972	P.L.92-500 33USC1151	EPA DA	oil spill surveillence violator detection pollution

General Federal budgeting data and programs that impact this RMF are given in Appendix B.

RMF No. 3.6.3

Non-Federal Activities

Local and state agencies, such as the California Environmental Quality Council, are charged with the responsibility of planning, implementing and administering programs designed to reduce water pollution. EPA sets standards and provides consultation services to the States in their efforts to meet water quality standards.

The Function of Remote Sensing

Remote sensing's capability for frequent synoptic monitoring of free water areas provides a reliable data base for effective enforcement of pollution regulations. In addition, this information can be used to direct efforts to remedy existing pollution problems. The low incremental cost of earth resources satellite data makes it efficient to detect and monitor pollution in areas that might otherwise remain uncontrolled.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

Alexander: Central Atlantic Regional Ecological Test Site

Wells: (lake and river pollution surveys)

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Capabilities

The estimated benefits shown in Table 63 are based on Federal budgetary information, Congressional appropriation hearings, and estimated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for agencies and programs listed in Table 63.

Table 63: Summary of Potential Benefits to Federal Agencies from ERTS for RMF 3.6.3

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
U.S. Dept. of Agriculture, Forest Service	Water pollution abatement	16,733	6	(45 - 80) (a)
Army Corps of Engineers	Lake Erie waste water management study	670	4	
Environmental Protection Agency	Research and Development on processes and effects	18,391	8	(50 - 100) (a)
Environmental Protection Agency	Abatement and control: water quality ambient trend monitoring	5,274	7	(15 - 60) (a)
Environmental Protection Agency	Abatement and control: water quality control agency support	40,000	9	(50 - 220) (a)
Delaware River Basin Commission	Water quality management	632	3	(10 - 18) (a)
Environmental Protection Agency	Water quality technical assistance and planning	11,477	6	(50 - 130) (a)
Environmental Protection Agency	Water quality municipal source control	14,951	3	(90 - 180) (a)
Environmental Protection Agency	Water quality enforcement	11,450	3	(150 - 300) (a)
TOTAL				(460 - 1,088)

(a). Increased capability benefits are approximately 20% less than equal capability benefits.

Note: Figures in parenthesis are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

RMF No. 3.7.1

PROVIDE EARLY WARNING OF DISASTROUS FLOODS

Rationale for Benefits

This RMF provides benefits not only in the form of reduced losses of life and property in the event of flooding, but also in the form of increased efficiency of preventive measures. In addition, reduced risk of flood damage makes possible the siting of higher-return economic activities in flood-prone areas.

Federal Government Activities and Responsibilities

General Federal budgetary data and programs that may impact this RMF are given in Appendix B.

The following activities, methods and products of the Soil Conservation Service (SCS) are relevant to this RMF. The classification system used is that of the SCS.

Data Categories	Activities	Methods		Products	
9. Flood	9.3 Monitoring	9.31	Survey and inventory flood and tide heights and year of occurrence	9.311	Revised data showing acres flooded.
				9.312	Revise map overlays to show changing flood hazard

Non-Federal Activities

Most flood warning and forecasting is done by the Federal government (National Weather Service). The responsibilities of state and local agencies in this area are confined largely to assisting NWS in information gathering.

The Function of Remote Sensing

Remote sensing's capability for frequent monitoring of watershed moisture, snow-cover and runoff characteristics, together with its integral function in weather forecasting, make it especially well suited to this RMF. Remote-sensing

data contribute to flood warning systems by increasing the effectiveness of hydrological models of flood-prone watershed areas as well as by providing information which is directly useful in predicting the severity of flooding.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources in contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

Clark: (Seasonal repetition of flood conditions - flood assessment)

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, afficiliation, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 64 are based on Federal budgetary information, Congressional appropriation hearings, and estimated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for agencies and programs listed in Table 64.

Table 64: Summary of Potential Benefits to Federal Agencies from Remote Sensing for RMF 3.7.1

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
Army Corps of Engineers	Flood plain information reports	5,750	5	40 (140 - 600)
Army Corps of Engineers	Stream gaging	5,105	2	(500 - 600) (a)
U.S. Department of Agriculture, Soil Conservation Service	Technical programming installation services and snow surveys	165,713	14	220 (340 - 900)
TOTAL				260 (980 - 2,100)

(a) increased capability benefits = $75 - 90 thousand

Note: Figures in parenthesis are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

Increased capability benefits are approximately the same size as equal capability benefits, except where otherwise indicated in Table 64.

RMF No. 3.7.2

PROVIDE EARLY WARNING OF LAKE EUTROPHICATION

Rationale for Benefits

This RMF makes possible timely and efficient measures to prevent damage to fish and wildlife and to preserve recreational values in threatened free-water areas. The benefits of early warning are particularly significant in view of the relatively high cost of remedial action to reverse advanced eutrophication.

Federal Government Activities and Responsibilities

General Federal budgetary data and programs that may impact this RMF are given in Appendix B.

Non-Federal Activities

Eutrophication is a major problem in the Great Lakes. Eight states, 191 U.S. counties and many municipalities are concerned with decisions and activities affecting various components of the Great Lake system. (Source: Water Resource Management Commission, Report to the President: 1973). Many of these agencies as well as the Federal Government are members of the Great Lakes Basin Commission. This commission is involved in developing mathematical simulation models to study eutrophication as well as water quality, food chains in the lakes, etc.

State and local water pollution control and water conservation agencies need information on eutrophication but are not involved in prediction or early warning of lake eutrophication.

The Function of Remote Sensing

Remote sensing contributes to this function by providing frequent synoptic coverage of watershed areas, some areas of which might remain unnoticed by responsible agencies until costly or irreversible damage had taken place. Because of its low incremental cost, earth resources satellite data related to this RMF can be efficiently made available to managers in fish and wildlife conservation, recreation, and water-management programs on a regular basis.

RMF No. 3.7.2

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to warer resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

Cast:	Remote Sensing of Reclamation Projects
Landgrebe:	Study of the Utilization of ERTS A Data from Wabash River Basin.
Lind:	Environmental Study of ERTS Imagery, Lake Champlain Basin.
Rogers:	Utilization of ERTS A Data to Monitor and Classify Eutrophication of Inland Lakes
Yarger:	Study of Monitoring Fresh Water Resources

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 65 are based on Federal budgetary information, Congressional appropriation hearings, and estimated ERTS technical capabilities. See Apprendix B for additional Federal budget and program information for agencies and programs listed in Table 65.

Table 65: Summary of Potential Benefits to Federal Agencies from ERTS for RMF 3.7.2

Government Agency	Relevant Program	FY75 Program Budget $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
Environmental Protection Agency	Research and development on process and effects	18,391	8	(50 - 100) (a)
Environmental Protection Agency	Abatement and control: water quality ambient trend monitoring	5,274	7	(10 40) (a)
Environmental Protection Agency	Abatement and control: water quality control agency support	40,000	9	(50 - 220) (a)
Tennessee Valley Authority	Regional water quality management water quality inventory	718	6	(10) (a)
TOTAL				(120 - 370)

(a) Increased capability benefits are approximately 20% less than equal capability benefits.

Note: Figures in parenthesis are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

RMF No. 3.7.3

MONITOR CHANGES IN SURFACE WATER SUPPLY DUE TO GEOLOGICAL CHANGES

Rationale for Benefits

This RMF makes an essential contribution to water-resource planning, and water management, and to the construction of hydrological models. Benefits accrue to Federal, state and local agencies in the form of reduced survey costs and to water users in the form of reduced costs of water supply.

Federal Government Activities and Responsibilities

General Federal budgetary data and programs that may impact this RMF are given in Appendix B.

Non-Federal Activities

This RMF falls under state water resources agencies' general responsibility for monitoring intrastate water supplies.

The Function of Remote Sensing

Remote sensing contributes to this function by providing clear and accurate revisions of geological maps and fault-line information which are expensive or impossible to obtain by other means. In addition, remote sensing techniques provide frequent synoptic coverage of surface-water supplies. This information is useful to water-management planners, municipal officials, geologists, and affected industries.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

RMF No. 3.7.3

Current ERTS Activities

Cast:	Remote sensing of Reclamation Projects
Garcia:	Research and Land-Use in Soil Erosion, Deficit, Deforest, and Floods, Geologic Map and Tectonic Structure Delineation
Goetz:	Application of ERTS and EREP Images to Geologic Investigation of Basin and Range - Colorado Plateau Boundary in Arizona

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

No demonstrated benefits from remote sensing have been located for this RMF.

RMF No. 3.8.1

CONDUCT HYDROLOGICAL RESEARCH

Rationale for Benefits

This function provides major benefits through increased theoretical and empirical knowledge of hydrological systems. By the existence of this RMF, better designed water impoundment systems for power generation, urban water supply, commercial and agricultural water supply, navigation and recreation purposes can be developed and better management of water impoundment systems for these purposes can be implemented.

Federal Government Activities and Responsibilities

Table 66 gives those Federal statutes which mandate, authorize, or imply activity in RMF 3.8.1, conduct hydrological research. A description of these statutes is given in Appendix C.

Table 66: List of Federal Statutes Relevant to RMF 3.8.1

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Date Requirement Related to Inland Water
8.	Water Resources Planning Act	P.L.89-80; 42USC1962D-12	DI,DA HEW, FPC	studies of water supply supply adequacy
13.	Colorado River Basin Project Act	43 USC 1511	DI	water resources

General Federal budgeting data and programs that impact this RMF are given in Appendix B.

The Corps of Engineers has the following remote sensing research projects initiated in FY 1973 in RMF 3.8.1.

Work Unit Table	Work Unit No.
Missouri River	030201
Fishtrap Reservoir	030501
Use of Remote Sensing in Planning	050206

RMF No. 3.8.1

A list of Corps of Engineers remote sensing research projects for FY 1973, FY 1974, and FY 1975 relevant to RMF 3.8.1 is given in Appendix D.

Non-Federal Activities

Water Resources agencies and state engineers frequently cooperate closely with water research departments of state universities. In some cases, this relationship is similar to the relationship between university agriculture departments, agricultural research and experimental stations, and the U.S. Agricultural Extension Service. Most state universities carry on some hydrological research. State agencies, such as the California Department of Water Resources also have some research and investigative responsibilities, primarily in the area of data collection. The Great Lakes Basin Commission, involving state and federal participants is researching pollution, eutrophication, water use, etc., simulation models.

The Function of Remote Sensing

Remote sensing provides three unique benefits in conducting hydrological research. One of these benefits is that a "snapshot" picture of hydrological conditions over a wide geographic area can be obtained. Another unique benefit is that new features can be observed using remote sensing. A third feature is that high frequency of coverage, as provided for by advanced earth resources satellites and data collection systems permit incorporation of data into hydrological models on a near real time basis.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

Hidalgo:	Preliminary Study of L. Pontchartrain and Vicinity Using Remotely Sensed Data from ERTS
Pluhowski:	Dynamics of Suspended Sediment Plumes in Lake Ontario

RMF No. 3.8.1

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 67 are based on Federal budgetary information, Congressional appropriations hearings, and estimated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for agencies and programs listed in Table 67.

Table 67: Summary of Potential Benefits to Federal Agencies from Remote Sensing for RMF 3.8.1

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMP's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
Army Corps of Engineers	General hydrological Studies	100	2	*
Tennessee Valley Authority	Preliminary research and engineering	309	1	*
U.S. Geological Survey	Water resources investigations	84,880	13	(1,500 - 3,000)
TOTAL				(1,500 - 3,000)

Note: Figures in parenthesis are order-of-magnitude estimates which are not supported not supported by in-depth case studies.

* Benefit significant but not quantifiable.

Source: ECON, Inc.

Increased capability benefits are approximately the same size as equal capability benefits.

RMF No. 3.8.2

CONDUCT FLOOD CONTROL RESEARCH

Rationale for Benefits

This function provides major benefits through increased theoretical and empirical knowledge of flood control. By the existence of this RMF, better designed water impoundment systems for flood control can be developed and better management of water impoundment systems for flood control can be implemented.

Federal Government Activities and Responsibilities

Table 68 gives those Federal statutes which mandate, authorize, or imply activity in RMF 3.8.2, conduct flood control research. A description of these statutes is given in Appendix C. .

Table 68: List of Federal Statutes Relevant to RMF 3.8.2

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Date Requirement Related to Inland Water
3.	Flood Control Act of 1960	P.L.86-645; 33USC709a	ACE	identification of flood plain areas, damage assessment
4.	Taylor Grazing Act	43 USC 315a	DI	studies of erosion and flood control
12.	Flood Disaster Protection Act	P.L.93-234	HUD	flood plain mapping.

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

The Corps of Engineers has the following remote sensing research projects initiated in FY 1973 in RMF 3.8.2.

RMF No. 3.8.2

Work Unit Title	Work Unit No.
Missouri River	030201
Fishtrap Reservoir	030501

A list of Corps of Engineers remote sensing research projects for FY 1973, FY 1974, and FY 1975 relevant to RMF 3.8.2 is given in Appendix D.

Non-Federal Activities

State universities conduct flood control research within the context of wider research on hydrology and water resource development. Most flood control research is carried on at the Federal level; states have fairly limited responsibilities in flood control research.

The Function of Remote Sensing

Remote sensing provides three unique benefits in conducting flood control research. One of these benefits is that a "snapshot" picture of hydrological conditions over a wide geographic area can be obtained. Another unique benefit is that new features can be observed using remote sensing. A third feature is that high frequency of coverage, as provided for by advanced earth resources satellites and data collection systems, permit incorporation of data into flood control models on a near real time basis.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

Higer:	Develop Data Relay System for Monitoring Hydrologic Conditions in Florida
Serebreny:	Time-Lapse Data Processing for Dynamic Hydrologic Conditions

RMF No. 3.8.2

Hollyday: Basic Characteristics Extracted from ERTS Data for Improving Regression Estimate of Stream Flow

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 69 are based on Federal budgetary information, Congressional appropriations hearings, and estimated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for agencies and programs listed in Table 69.

Table 69: Summary of Potential Benefits to Federal Agencies from Remote Sensing for RMF 3.8.2

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
Susquehanna River Basin Commission	Appraisal of measures to reduce future flood damages	126	4	(2 - 6)
U.S. Geological Survey	Water Resources Investigations	34,890	13	(1,500 - 3,000)
TOTAL				(1,502 - 3,006)

Note: Figures in parenthesis are order-of-magnitude estimates which are not supported by in-depth case studies.
Source: ECON, Inc.

Increased capability benefits are approximately the same size as equal capability benefits.

RMF No. 3.8.3

CONDUCT WATER POLLUTION RESEARCH

Rationale for Benefits

This function provides major benefits through increased theoretical and empirical knowledge of water pollution. By the existence of this RMF, improved and more effective measures to control chemical, bacteriological, and thermal water pollution can be implemented.

Federal Government Activities and Responsibilities

Table 70 gives that Federal statute which mandates or implies activity in RMF 3.8.3, conduct water pollution research. A description of this statute is given in Appendix C.

Table 70: List of Federal Statutes Relevant to RMF 3.8.3

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Data Requirement Related to Inland Water
11.	Federal Water Pollution Control Act of 1972	P.L.92-500; 33 USC 1151	EPA DC	oil spill surveillance, violation detection, pollution surveys and research

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

The Corps of Engineers has the following remote sensing research projects initiated in FY 1973 in RMF 3.8.3.

Work Unit Title	Work Unit No.
Project Impact	040101
Land Use and Pollution	040102
Tennessee-Tombigbee	040103

A list of Corps of Engineers remote sensing research projects for FY 1973, FY 1974, and FY 1975 relevant to RMF 3.8.3 is given in Appendix D.

RMF No. 3.8.3

Non-Federal Activities

Water pollution research is done by many state universities. State environmental agencies are responsible for program implementation and control, not research. Most water pollution research is carried out by EPA research agencies.

The Function of Remote Sensing

Remote sensing provides two unique benefits in conducting water pollution research. A major benefit is that a "snapshot" picture of water pollution conditions over a wide geographic area can be obtained. Another unique benefit is that high frequency of coverage, as provided for by advanced earth resources satellites and data collection systems, permit incorporation of data into water pollution models on a near real time basis.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

Alexander:	Central Atlantic Regional Ecological Test Site
Coulbourn:	Determine Boundaries of A/C and S/C Data Within Which Useful Water Quality Information Can Be Extracted
Jain:	Evaluate Effects of Construction and Staged Filling of Reservoirs on Environment and Ecology

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

RMF No. 3.8.3

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 71 are based on Federal budgetary information, Congressional appropriations hearings, and estimated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for agencies and programs listed in Table 71.

Table 71: Summary of Potential Benefits to Federal Agencies from ERTS for RMF 3.8.3

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
U.S. Dept. of Interior, Office of Water Resources Research	Additional water research	3,107	1	(10) (a)
U.S. Dept. of Interior, Bureau of Reclamation	Water resources planning and engineering research	2,630	1	(6)
Environmental Protection Agency	Research and development on processes and effects	18,391	8	(50 - 100) (a)
Environmental Protection Agency	Abatement and control: water quality ambient trend monitoring	5,274	7	(15 - 60) (a)
Environmental Protection Agency	Abatement and control: water quality control agency support	40,000	9	(50 - 220) (a)
TOTAL				(131 - 396)

For benefits to this RMF see also RMFs 3.2.3 and 3.8.1

(a) Increased capability benefits approximately 20% less than equal capability benefits

Note: Figures in parenthesis are order-of-magnitude estimates which are not supported by in-depth case studies.

Source: ECON, Inc.

RMF No. 3.9.1

DESIGN GOVERNMENT PROGRAMS TO REDUCE FLOOD DAMAGE

Rationale For Benefits

This RMF involves both the planning of particular flood-control programs and assessment of various areas for their relative vulnerability to flood damage. Adequate performance of this function requires extensive information on flood-plain contours, run-off, and other parameters. Benefits from more efficient execution of this function, which are potentially very large, accrue to government agencies at various levels, in the form of reduced surveying costs, and to industries and residents of flood-prone areas in the form of reduced risk.

Federal Government Activities and Responsibilities

Table 72 gives those Federal statutes which mandate, authorize, or imply activity in RMF 3.9.1. A description of these statutes is given in Appendix C.

Table 72: List of Federal Statutes Relevant to RMF 3.9.1

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Date Requirement Related to Inland Water
3.	Flood Control Act of 1960	P.L.86-645; 33USC709a	ACE	identification of flood plain areas, damage assessment
12.	Federal Disaster Protection Act of 1973	P.L.93-234	HUD	flood plain mapping
19.	Act of June 17, 1902	32 STA 388	DI	planning, construction and operation of irrigation and water management facilities

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

The Corps of Engineers has the following remote sensing research projects initiated in FY 1973 in RMF 3.9.1.

Work Unit Title	Work Unit No.
Use of Remote Sensing in Planning	050206

RMF No. 3.9.1

A list of Corps of Engineers remote sensing research projects for FY 1973, FY 1974, and FY 1975 relevant to RMF 3.9.1 is given in Appendix D.

Non-Federal Activities

State and local agencies are becoming increasingly involved in programs to reduce flood damage. According to the Chief of the Army Engineers, there is great interest in non-structural approaches to flood plain managemnt - i.e., zoning and land use legislation rather than dam building. (Source: House Appropriation Hearings on Corps FY 1975). In Wisconsin, small communities on the Root River are cooperating to design land use legislation to reduce flood damage. (Source: Water Resource Management Commission Report to President: 1973).

Most state and local programs to reduce flood damag rely on legislative and administrative controls rather than large capital outlays.

The Function of Remote Sensing

By providing synoptic maps of flood plains and data on runoff parameters and other inputs to hydrological models, remote sensing can enable government planners to select the most appropriate areas for flood-prevention programs as well as the most effective means for implementing them. Such information is also useful to municipalities in flood-prone areas in designing local measures to deal with this problem.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

Sattinger:	Planning of Land Use in the Detroit Metropolitan Area
Stoeckeler:	Develop Land-Use-Peak Runoff Classification System for Highway Engineering Purposes

RMF No. 3.9.1

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 73 are based on Federal budgetary information, Congressional appropriations hearings, and estimated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for agencies and programs listed in Table 73.

Table 73: Summary of Potential Benefits to Federal Agencies from Remote Sensing for RMF 3.9.1

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
Army Corps of Engineers	Flood plain information reports	5,750	5	40 (140 - 600)
Susquehanna River Basin Commission	Appraisal of measures to reduce future flood damages	126	4	(2 - 6)
TOTAL				40 (142 - 606)

Note: Figures in parenthesis are order-of-magnitude estimates which are not supported by in-depth case studies.
For benefits to this RMF see also RMF 3.
Source: ECON, Inc.

Increased capability benefits are approximately the same size as equal capability benefits.

RMF No. 3.9.2

INCREASE COMPLIANCE WITH WATER POLLUTION REGULATIONS

Rationale for Benefits

Increased compliance with water pollution regulations results in both a reduction of administrative and enforcement costs and a reduction of costs accruing to those directly affected by pollution. Each of these effects can result in significantly increased net benefits for government programs in this area.

Federal Government Activities and Responsibilities

Table 74 gives that Federal statute which mandates or implies activity in RMF 3.9.2 Increase compliance with water pollution regulations.

Table 74: List of Federal Statutes Relevant to RMF

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Data Requirement Related to Inland Water
11.	Federal Water Pollution Control Act of 1972	P.L.92-500; 33 USC 1151	EPA DC	oil spill surveillance, violation detection, pollution surveys and research

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

The Corps of Engineers has the following remote sensing research projects initiated in FY 1973 in RMF 3.9.2.

Work Unit Title	Work Unit No.
Tennessee-Tombigbee	040103

A list of Corps of Engineers remote sensing research projects for FY 1973, FY 1974, and FY 1975 relevant to RMF 3.9.2 is given in Appendix D.

RMF No. 3.9.2

Non-Federal Activities

State environmental agencies and State judicial systems are responsible in the first instance, for compliance with water pollution standards. Much of the enforcement is done by the 10 EPA regional offices and EPA headquarters.

The Function of Remote Sensing

By reducing the cost of pollution monitoring in streams and free-water areas, remote sensing increases the efficiency of government efforts to monitor and enforce compliance with pollution regulations. Remote sensing also increases compliance by facilitating self-monitoring by the affected industries and by providing data which can be used in class-action suits and other judicial proceedings.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

Wells: (lake and river pollution surveys)

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 75 are based on Federal budgetary information, Congressional appropriations hearings, and estimated ERTS technical capabilities. See Appendix B for agencies and programs listed in Table 75.

Table 75: Summary of Potential Benefits to Federal Agencies from ERTS for RMF 3.9.2

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
U.S. Dept. of Agriculture Forest Service	Water pollution abatement	16,733	6	$ (45 - 80) (a)
Army Corps of Engineers	Lake Erie water management study	670	4	*
Environmental Protection Agency	Research and development on processes and effects	18,391	8	(50 - 100) (a)
Environmental Protection Agency	Abatement and control: water quality ambient trend monitoring	5,274	7	(15 - 60) (a)
Environmental Protection Agency	Abatement and control: water quality control agency support	40,000	9	(50 - 220) (a)
Tennessee Valley Authority	Regional water quality management: water quality inventory	718	6	(10) (a)
Delaware River Basin Commission	Water quality management	632	3	(10 - 18) (a)
Environmental Protection Agency	Water quality technical assistance and planning	11,477	6	(50 - 130) (a)
Environmental Protection Agency	Water quality municipal source control	14,951	3	(90 - 180) (a)
Environmental Protection Agency	Water quality enforcement	11,450	3	(150 - 300) (a)
TOTAL				(470 - 1,098)

(a) Increased capability benefits are approximately 20% less than equal capability benefits.

Note: Figures in parenthesis are order-of-magnitude estimates which are supported by in-depth case studies.

Source: ECON, Inc.

RMF No. 3.9.3

AID IN DESIGNING LEGISLATIVE CONTROLS FOR POLICY IMPLEMENTATION

Rationale for Benefits

More effectively designed legislative controls result in reduced administrative costs, more efficient policy implementation, and increased benefits to agriculture, industry, recreational programs, shipping, and individual consumers.

Federal Government Activities and Responsibilities

The following table gives those Federal statutes which mandate, authorize, or imply activity in RMF 3.9.3, aid in designing legislative controls for policy implementation. A description of these statutes is given in Appendix C.

Table 76 List of Federal Statutes Relevant to RMF 3.9.3

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Date Requirement Related to Inland Water
3.	Flood Control Act of 1960	P.L.86-645; 33 USC709a	ACE	identification of flood plain areas, damage assessment
4.	Taylor Grazing Act	43 USC 315a	DI	studies of erosion and flood control
7.	Outdoor Recreation Act	P.L.88-29; 77-Stat.49	DI	inventory of outdoor recreation resources
10.	Dam Safety Act of 1972	P.L.92-367	ACE	inspection of dams; ERTS data used to locate them
11.	Federal Water Pollution Control Act of 1972	P.L.92-500; 33 USC 1151	EPA DC	oil spill surveillance, violation detection, pollution surveys and research
12.	Federal Disaster Protection Act of 1973	P.L.93-234	HUD	flood plain mapping
16.	Toxic Substance Control Act of 1973	NYP	DI	research and monitoring of extent of toxic substances

RMF No. 3.9.3

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

The Corps of Engineers has the following remote sensing research projects initiated in FY 1973 in RMF 3.9.3.

Work Unit Title	Work Unit No.
Tennessee-Tombigbee	040103

A list of Corps of Engineers remote sensing research projects for FY 1973, FY 1974, and FY 1975 relevant to RMF 3.9.3 is given in Appendix D.

The following activities, methods and products of the Soil Conservation Service (SCS) are relevant to this RMF. The classification system used is that of the SCS.

Data Categories	Activities	Methods		Products	
9. Flood	9.3 Monitoring	9.31	Survey and inventory flood and tide heights and year of occurrence	9.311	Revised data showing acres flooded
				9.312	Revise map overlays to show changing flood hazard

Non-Federal Activities

State legislatures have the primary responsibility for water use legislation. In Oklahoma, rivers and streams can be reserved by the state for recreation or scenic use. Decisions to reserve or appropriate waters is by statute debated in the state legislature. (Source: Water Resource Management Commission Report to President: 1973). Setting policy on water use, water rights, water resource management and water supply is the responsibility of state governments for water within their boundaries and state legislatures are responsible for designing legislative controls to implement these policies. A major portion of state activities in the area of water resources concerns legislation and policy to control and manage water use and water rights.

RMF No. 3.9.3

The Function of Remote Sensing

Because of its capability for synoptic and up-to-date information on watershed areas and other regions affected by water-resources legislation, remote sensing can help provide the basis for balanced and effective program design. This is true not only in the areas of flood control and water pollution (RMF Nos. 3.9.1 and 3.9.2) but also in such areas as shipping regulation, hydroelectric power generation, irrigation, and wildlife management.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

Sattinger: Planning of Land-Use in the Detroit Metropolitan Area

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 77 are based on Federal budgetary information, Congressional appropriations hearings, and estimated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for agencies and programs listed in Table 77.

Table 77: Summary of Potential Benefits to Federal Agencies from ERTS for RMF 3.9.3

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
Environmental Protection Agency	Abatement and control: water quality control agency support	40,000	9	(50 - 220) (a)
Environmental Protection Agency	Water quality technical assistance and planning	11,477	6	(50 - 130) (a)
TOTALS				(100 - 350) (b)

(a) Increased capability benefits are approximately 20% less than equal capability capability benefits.

(b) Because of difficulties in allocating benefits between RMF 3.9.3 and other RMFs, some of the benefits to this RMF are recorded as benefits to RMFs 3.2.5, 3.3.5, 3.4.7, 3.6.3, 3.9.2, and 3.9.4.

Note: Figures in parenthesis are order-of-magnitude estimates which are not supported by in-depth studies.

Source: ECON, Inc.

RMF No. 3.9.4

AID IN PLANNING GOVERNMENT PROJECTS FOR FUTURE WATER SUPPLY

Rationale for Benefits

This RMF includes both the assurance of continued adequate water supplies to existing industrial and population centers and the planning of irrigation and development projects for new areas. Benefits resulting from each of these functions are potentially very substantial.

Federal Government Activities and Responsibilities

Table 78 gives those federal statutes which mandate, suthorize, or imply activity in RMF 3.9.4, aid in planning government projects for future water supply.

General Federal budgetary data and programs that impact this RMF are given in Appendix B.

The Corps of Engineers has the following remote sensing research projects initiated in FY 1973 in RMF 3.9.4.

Work Unit Title	Work Unit No.
Use of Remote Sensing in Planning	050206

A list of Corps of Engineers remote sensing research projects for FY 1973, FY 1974, and FY 1975 relevant to RMF 3.9.4 is given in Appendix D.

The following activities, methods and products of the Soil Conservation Service (SCS) are relevant to this RMF. The classification system used is that of the SCS.

Data Categories	Activities	Methods	Products
9. Flood	9.3 Monitoring	9.31 Survey and inventory flood and tide heights and year of occurrence	9.311 Revised data showing acres flooded 9.312 Revise map overlays to show changing flood hazard

Table 78: List of Federal Statutes Relevant to RMF 3.9.4

No.	Name of Statute	USC or P.L. Reference	Federal Agency	Date Requirement Related to Inland Water
3.	Flood Control Act of 1960	P.L.86-645; 33USC709a	ACE	identification of flood plain areas, damage assessment
6.	Admission of New States	43 USC 857	DI	survey of public lands in a state prior to its admission to the union
7.	Outdoor Recreation Act	P.L.88-29; 77-Stat.49	DI	inventory of outdoor recreation resources
8.	Water Resources Planning Act	P.L.89-80; 42USC1962D-12	DI,DA, HEW, FPC	studies of water supply supply adequacy
9.	National Flood Insurance Act of 1968	P.L.90-500; Title XIII	HUD	establishment of flood risk zones, estimates of flood losses
10.	Dam Safety Act of 1972	P.L.92-367	ACE	inspection of dams; ERTS data used to locate them
11.	Federal Water Pollution Control Act of 1972	P.L.92-500; 33 USC 1151	EPA DC	oil spill surveillance, violation detection, pollution surveys and research
13.	Colorado River Basin Project Act	43 USC 1511	DI	water resources
15.	Cooperative Agreements for Surveys and Investigations	33 USC 883E	ACE	surveying and mapping activities
19.	Act of June 17, 1902	32 STA 388	DI	planning, construction and operation of irrigation and water

Non-Federal Activities

Water supply has traditionally been one of the major local responsibilities. Many of the problems connected with water supply are distributional and not relevant for ERTS data. Many states are preparing water resource plans and are concerned with securing sources of water for municipal, industrial and rural use. The Federal government has a number of programs to help cities (HUD loans and grants), rural districts (FHA loans) and states (through storage in Federal

reservoirs) plan adequate water supplies. Although, there is increasing Federal assistance to local water supply programs, the primary responsibility still lies with local agencies coordinated by state agencies such as state departments of water resources.

The Function of Remote Sensing

Remote sensing is an efficient means of inventorying current water supplies and in monitoring changes in watershed areas. It is also useful for synoptic mapping and surveying of areas being considered for reclamation and water-supply projects. These functions contribute both to the assessment of the need for new programs and in determining the most appropriate methods for implementing such programs once they have been decided upon.

Economic and Technical Models for Estimating Benefits

The benefit estimates for this RMF follow the models developed in the source document for equal and increased capability benefits. Further information on the application of these models to water resources is contained in the introductory section in this volume on economic and technical models.

Current ERTS Activities

Reeves:	Water Budget of Texas High Plains Plaza Lakes
Stoeckeler:	Develop Land-Use-Peak Runoff Classification System for Highway Engineering Purposes
Welby:	Use of ERTS A in Geological Evaluation, Regional Planning, Forest Management and Water Management in North California

Appendix G contains further current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments, etc.

RMF No. 3.9.4

Estimate of ERTS Economic Capabilities

The estimated benefits shown in Table 79 are based on Federal budgetary information, Congressional appropriations hearings, and esitmated ERTS technical capabilities. See Appendix B for additional Federal budget and program information for agencies and programs listed in Table 79.

Table 79: Summary of Potential Benefits to Federal Agencies from Remote Sensing for RMF 3.9.4

Government Agency	Relevant Program Item	FY75 Program Budget, $ thousands	Number of Relevant RMF's	Estimated Equal Capability Benefit this RMF, $ thous. (1973)
U.S. Department of Interior, Bureau of Land Management	Soil and watershed conservation	16,565	4	(40 - 120)
U.S. Department of Interior, Bureau of Reclamation	Regional planning service	1,282	6	(30 - 90)
TOTAL				(70 - 210)

Note: Figures in parenthesis are order-of-magnitude estimates which are not supported by in-depth case studies.
Source: ECON, Inc.

Increased capability benefits are approximately the same size as equal capability benefits.

APPENDIX B

SUMMARY OF APPLICABLE FEDERAL BUDGETS

The equal capability and increased capability benefits of ERS in the inland water area are based on an examination of the programs and budgets of Federal agencies. This evaluation is used to determine the extent to which these programs and budgets are potentially impacted by ERS. Subjective criteria with a conservative bias are applied to Federal programs to give the upper and lower bounds of the potential impact of ERS on the budgets of these programs. The benefit evaluation procedures described in the Introduction are applied to these bounds to yield the equal and increased capability benefits.

Program and budgets are presented here as source material backup to the benefits shown in Appendix A.

Source: Verbatum Extracts from the Budget of the United States Government, FY 75 Appendix, Congressional Hearings on Appropriations, and U.S. Government Manual 1973/1974

Table 80: Location of Federal Agency Budgets

Federal Agency	Page
Department of Agriculture	
Soil Conservation Service	B-3
Agricultural Research Service	B-11
Agricultural Stabilization and Conservation Service	B-12
Forest Service	B-13
Department of Defense (Corps of Engineers - Civil)	B-25
Department of the Interior	
Geological Survey	B-41
Bureau of Reclamation	B-52
Bureau of Land Management	B-60
Bureau of Sport Fisheries and Wildlife	B-67
Bureau of Outdoor Recreation	B-69
Bonneville Power Administration	B-74
Southeastern Power Administration	B-75
Southwestern Power Administration	B-77
Alaska Power Administration	B-78
Office of Water Resources Research	B-81
Environmental Protection Agency	
Research and Development	B-8[illegible]
Abatement and Control	B-95
Enforcement	B-103
Federal Power Commission	B-106
Tennessee Valley Authority	B-107
Delaware River Basin Commission	B-120
Susquehanna River Basin Commission	B-121
Water Resources Council	B-122

DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

The Soil Conservation Service (SCS) was established under authority of the Soil Conservation Act of 1935 (49 Stat. 163; 16 U.S.C. 590 a-f). It has responsibility for developing and carrying out a national soil and water conservation program in cooperation with landowners and operators and other land users and developers, with community planning agencies and regional resource groups, and with other agencies of government--Federal, State, and local. The SCS also assists in agricultural pollution control, environmental improvement, and rural community development.

The soil and water conservation program is carried on through technical help to locally organized and operated conservation districts; local sponsors of watershed protection projects; and consultive assistance to other individuals and groups. More than 3,000 conservation districts cover almost 2 billion acres in all the States, Puerto Rico, and the Virgin Islands.

Assistance to conservation districts, community groups, units of government and other cooperators consists mainly of the following:

(a) Soil surveys and investigations, with interpretations and publications, that provide physical land facts needed for program development, resource conservation planning, installation of planned practices, and for use by other Federal, State, and local agencies;

(b) Technical assistance to cooperating land users, groups and units of government and other policymakers and decisionmakers in the planning of conservation programs and installation of needed conservation treatments;

(c) Technical programming, design, layout, installation services, and consultation on those practices and measures provided for in resource conservation plans;

(d) Technical and other assistance to communities and units of government on land use planning, mine spoil restoration, control of erosion, sedimentation, agricultural related pollutants, and protection and enhancement of the environment, and other special problems that can best be solved through coordinated local action;

(e) The granting of special equipment to soil conservation districts for use in applying conservation practises;

(f) Water supply forecasts prepared from snow surveys in Western States that are useful in making efficient seasonal use of water for irrigation, flood control, fish and wildlife, recreation, power generation, municipal and industrial water supply. and water quality management;

(g) The selection and evaluation of plant materials to determine their suitability for erosion control, conservation purposes, and other environmental improvements;

(h) Technical assistance to participants in the Rural Environmental Program in establishing specified permanent-type practices;

(i) Technical services to participants in other programs involving land use adjustments and soil and water conservation;

(j) Technical assistance in the planning and applying of soil and water conservation practices for which loans are made by the Farmers Home Administration; and

(k) Technical assistance to rural development committees.

Combinations of needed soil and water conservation practices are planned together and in relation to each other so as to have well-balanced conservation programs in each district. The Service aids land users, groups, units of government and other policymakers and decisionmakers marshal the facts and consider the potentials and alternatives before embarking on a course of action. Both vegetative and structural measures are used in accordance with the needs of the land for protection, treatment, and resource improvement. Plans reflect the decisions of the land users, community groups, and units of government as to how they will use and treat the land and water resources.

Snow Survey and Water Supply Forecasting provides valuable service to irrigators and other user groups who rely upon snow data and water supply forecasts in planning their annual operations. More than 9,000,000 acres of irrigated land in the Western States are served by water supply forecasts. Although water supply forecasts are geared primarily to the needs of rural farm and ranch operators, they are also helpful to a wide variety of other water management groups that have responsibility for activities such as flood control, recreation, fish and wildlife, power generation, municipal and industrial water supply and water quality management. A plan to replace, over a five year period, nearly one third of the 1,600 mountain snow courses, where data are manually collected, with 500 automated sites has been initiated.

Available Funds and Man-Years

1973 and Estimated, 1974 and 1975

Item	Actual 1973		Estimated Available, 1974		Budget Estimate 1975	
	Amount	Man-Years	Amount	Man-Years	Amount	Man-Years
Soil Conservation Service						
Conservation Operations	163,370,905	10,056	165,323,000	10,110	192,826,000	10,521
River basin surveys & investigations	11,855,375	569	12,341,000	578	14,167,000	573
Watershed planning	7,785,840	366	9,998,000	493	10,800,000	497
Watershed and flood prevention operations	170,028,614	3,207	133,986,000	3,332	122,828,000	3,144
Great plains conservation program	18,113,500	367	18,172,000	367	---	---
Resource conservation & development	26,594,891	861	17,204,000	714	19,908,000	727
Total	397,749,125	15,426	357,024,000	15,594	360,529,000	15,462
Deduct allotments to other agencies	-13,856,495	-601	-13,002,000	-499	-12,332,000	-450
Net	383,892,630	14,825	344,022,000	15,095	348,197,000	15,012
Other obligations under USDA appropriations:						
Reimbursement for technical assistance to:						
Rural Environmental Assistance Program and Emergency Conservation measures	5,189,014	412	1,800,000	142	---	--
Other USDA agencies & within SCS	1,492,161	80	1,640,000	81	1,680,000	82
Allocations for technical assistance to:						
Water Bank Program	561,786	31	481,000	25	---	---
Non-metropolitan planning	94,395	6	100,000	5	---	---
Total, other USDA	7,337,356	529	4,021,000	253	1,680,000	82
Total, Agriculture Appropriations	391,229,986	15,354	348,043,000	15,348	349,877,000	15,094
Other Federal funds:	1,910,007	67	2,920,600	133	2,850,000	123
Non-Federal funds:	6,765,169	269	8,565,000	300	8,699,000	299
Total, Soil Conservation Service	399,905,162	15,6[illegible]	[illegible]9,528,600	15,781	361,426,000	15,516

End-of-Year Employment:	1973 Actual	1974 Estimated	1975 Estimated
Permanent full-time	14,040	13,260	13,100
Other	1,837	2,293	2,293
Total	15,877	15,553	15,393

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CONSERVATION OPERATIONS

Program and Financing (in thousands of dollars)

Identification code 05-78-1000-0-1-354	1973 actual	1974 est.	1975 est.
Program by activities:			
Direct program:			
Assistance to conservation districts, communities and other cooperators:			
(a) Soil surveys	26,716	26,020	26,049
(b) Technical programing, installation services and snow surveys	131,263	146,999	162,093
(c) Operation of plant materials centers	1,535	1,770	1,900
Total direct program	159,514	174,789	190,042
Reimbursable program:			
Assistance to conservation districts, communities and other cooperators:			
(a) Soil surveys	1,971	2,800	3,080
(b) Technical programing, installation services and snow surveys	7,471	4,625	3,620
(c) Operation of plant material centers	31	75	75
Total reimbursable program	9,473	7,500	6,775
Total operating costs	168,987	182,289	196,817
Unfunded adjustments to total operating costs:			
Depreciation on property	−2,032	−2,300	−2,500
Office space occupied without charge	−5,053	−5,100	----------
Accrued annual leave	1,395	850	700
Total operating costs, funded	163,297	175,739	195,017
Capital outlay:			
Capitalized property	2,765	4,040	4,500
Total program costs, funded	166,062	179,779	199,517
Change in selected resources (stores, undelivered orders)	1,604	130	84
Total obligations	167,666	179,909	199,601

Watershed and Flood Prevention Operations

The Service has general responsibility for administration of activities which include cooperation with local sponsors, State, and other public agencies in the installation of planned works of improvement to reduce erosion, floodwater, and sediment damage; conserve, develop, utilize, and dispose

of water; plan and install works of improvement for flood prevention including the development of recreational facilities and the improvement of fish and wildlife habitat; and loans to local share of the cost of carrying out planned watershed and flood prevention works of improvement. The Farmers Home Administration administers the loan program.

Program and Financing (in thousands of dollars)

Identification code 05-78-1072-0-1-401	1973 actual	1974 est.	1975 est.
Program by activities:			
Direct program:			
1. Works of improvement	108,709	160,346	138,665
2. Loan services	642	512	516
3. Loans	60	.....	.....
Total direct program	109,411	160,858	139,181
Reimbursable program: Works of improvement	897	1,280	920
Total operating costs	110,308	162,138	140,101

Small watersheds. The Department cooperates with the States and other agencies in installing works of improvement in small watersheds to reduce damage from floodwater, sediment, and erosion and for the conservation, development, utilization, and disposal of water and the conservation and proper utilization of land. It provides loans to local organizations to help them finance their share of the costs of certain works of improvement.

Works of improvement. The Department provides technical and financial assistance to local organizations to install the watershed works of improvement for watershed protection, flood prevention, agricultural water management, recreation, water quality, and fish and wildlife development, and other features specified in the work plans.

After local sponsoring organizations have developed, watershed work plans with the Department's assistance or with State and local resources, and the projects have been approved as suitable for Federal participation (projects involving an estimated Federal contribution in excess of $250 thousand for construction of any single structure having a capacity in excess of 2,500 acre-feet require congessional approval), technical services, and financial assistance are provided for specified works of improvement. On non-Federal lands, local sponsoring organizations may contract for construction work or

request the SCS to do the contracting for them, must operate and maintain the projects, and in the case of multiple-purpose structures, must bear a share of construction costs. In addition, local organizations must acquire water rights and furnish land, easements, and rights-of-way for all structural measures except that up to one-half the cost of land, easements, and rights-of-way allocated to public fish and wildlife and recreational developments may be paid with Public Law 566 funds. Federal agencies do this work on Federal lands which they administer with appropriate contributions being made by the local people who receive benefits. During the preconstruction stage, surveys and investigations are made and detailed designs, specifications, and engineering cost estimates are prepared for construction of structural works; areas are delineated where easements are required, and technical services are furnished for accelerating planning and application of land treatment measures if provided for in the watershed work plan.

Flood Prevention. (Works of improvement)--The Department cooperates with soil conservation districts and other local organizations in planning and installing works of improvements for flood prevention and for furthering the conservation, development, utilization, and disposal of water and the conservation and proper utilization of land in the 11 watersheds authorized by the Flood Control Act of 1944. The Federal Government shares in the cost of works of improvement for flood prevention, agricultural water management, recreation, fish and wildlife development facilities, water quality, and other authorized purposes.

The Department furnishes additional technical and, in certain instances, financial assistance to landowners to accelerate planning and installation of land treatment measures for runoff retardation, sediment control, and water management. Local sponsoring organizations must furnish all land easements. and rights-of-way, water rights, and the entire cost of works of improvement for nonagricultural water management measures, except those for fish and wildlife, development and recreation, and operate and maintain all completed works of improvement.

Resource Conservation and Development Program

The Service has general responsibility, under the provisions of the Food and Agriculture Act of 1962 (76 Stat. 608; 16 U.S.C. 1001 et seq.), for this program to assist local sponsoring groups accelerate planning and development of land and water resources in multiple county areas. Projects may include such measures as flood prevention; developing water resources

for recreation, wildlife, agricultural, municipal, or industrial use; conservation planning and establishment on individual land units; improving recreation facilities, including historical and scenic attractions; encouraging new industries to locate in the area and to process products of the area; improving markets for crop and livestock products; upgrading and protecting the quality of the environment; and long-range planning to coordinate public efforts in the area.

Small Watershed Project Investigations and Planning

The Department cooperates with the States and other agencies in planning works of improvement in small watersheds to reduce damage from floodwater, sediment, and erosion and for the conservation, development, utilization, and disposal of water, and the conservation and proper utilization of land.

The Department makes surveys of proposed small watershed projects, and work plans are prepared in cooperation with local sponsors. These plans outline the soil and water management problems in the watershed, the steps that have been or are authorized to be taken to alleviate these problems, the proposed works of improvement to be installed, the estimated benefits and costs, cost-sharing and operation and maintenance arrangements, and other facts necessary to justify Federal participating in project development.

Program and Financing (in thousands of dollars)

Identification code 05-78-1066-0-1-401	1973 actual	1974 est.	1975 est.
Program by activities:			
Direct program:			
Small watershed project investigations and planning	7,052	10,974	10,665
Reimbursable program:			
Small watershed project investigations and planning	1,375	1,884	2,091
Total operating costs	8,427	12,858	12,756

River Basin Surveys and Investigations

Section 6 of Public Law 566, 83 Congress, as amended, authorizes the Department to cooperate with other Federal, State, and local agencies in making surveys and investigations of the watersheds of rivers and other waterways as a basis for the development of coordinated water and related land resource programs, The Department currently is participating in cooperative surveys and investigations in river basins with the Corps of Engineers and other interested Federal and State agencies. The Department also maintains representation on six

river basin commissions and three river basin interagency committees. These serve as points of contact in coordination between representative of this Department and other Federal departments and agencies and the States in these basin areas. They keep all concerned mutually informed of the activities of the member agencies and facilitate matters of interagency coordination. During fiscal year 1973, the Department maintained such representation on committees in the Arkansas-White-Red, Missouri, Pacific-Southwest, and Southeast areas. The MBIAC was dissolved when the MRBC was formed during fiscal year 1972. The Department also is represented on the Water Resources Council which was formed in accordance with section 101, Public Law 89-90. Water Resources Planning Act, to coordinate water and related land resource activities of Federal departments and agencies.

The Senate Select Committee on National Water Resources proposed a goal of surveying all of the Nation's river basins and making determinations of our future water and related land resource needs. Twenty-one planning regions were established nationwide. The Department of Agriculture has cooperated in framework level planning in 14 of these regions. This Department and other member departments of the Water Resources Council have jointly considered needs for additional river basin surveys and investigations necessary to attain the goal.

Based on this joint coordination, current needs are $946 thousand to continue interagency comprehensive surveys now in progress, $10,088 thousand to continue other Federal-State cooperative river basin surveys now in progress and to start five additional surveys in cooperation with States: $1,200 thousand for flood hazard analyses; and $1,708 thousand for interagency coordination and program formulation.

The Department cooperates with other Federal and State agencies in making surveys and investigations of watersheds of rivers and other waterways as the basis for the development of coordinated programs for the development of water and related land resources.

Program and Financing (in thousands of dollars)

Identification code 05-78-1069-0-1-401	1973 actual	1974 est.	1975 est.
Program by activities:			
Direct program operating costs:			
River basin surveys and investigations	11,338	13,735	14,106
Reimbursable program operating costs:			
River basin surveys and investigations	1,114	2,322	1,455
Total operating costs	12,452	16,057	15,561

AGRICULTURAL RESEARCH SERVICE

The Agricultural Research Service (ARS) was established by Secretary's Memorandum 1320, Supplement 4, dated November 2, 1953.

Its basic mission is to provide the necessary knowledge and technology so that farmers can produce efficiently, conserve the environment, and meet the food and fiber needs of the American people. Research efforts are conducted in very close cooperation with the States, as well as with other research agencies in USDA, other Federal agencies, industry, foundations, and private groups.

Program and Financing (in thousands of dollars)

Identification code 05-18-1400-0-1-355	1973 actual	1974 est.	1975 est.
Program by activities:			
Direct program:			
1. Research on animal production	27,078	35,434	38,148
2. Research on plant production	74,846	71,540	73,993
3. Research on the use and improvement of soil, water, and air	34,711	32,872	33,640
4. Research on marketing, use, and effects of agricultural products	59,686	64,280	66,793
5. Construction of facilities	2,612	3,365	6,036
6. Contingencies	.....	1,000	1,000
Total direct program	198,933	208,491	219,610
Reimbursable program:			
1. Research	5,782	7,760	7,487
2. Miscellaneous services to other accounts	18	87	87
3. Agency for International Development (funds appropriated to the President)	1,044	936	944
Total reimbursable program	6,844	8,783	8,518
Total program costs, funded [1]	205,777	217,274	228,128
Change in selected resources (undelivered orders)	−3,041	−329	384
10 Total obligations	202,735	216,945	228,512

Research on the Use and Improvement of Soil, Water, and Air

Research is conducted to improve the management of natural resources, including investigations to improve soil and water management, irrigation, and conservation practices, and to determine the relation of soil types and water to plant, animal, and human nutrition. The research includes studies on hydrologic problems of agricultural watershed and the application of remote sensing techniques in meeting agricultural problems. Research is also conducted on agricultural pollution problems

such as protection of plants, animals, and natural resources from harmful effects of soil, water, and air pollutants, and ways to minimuze and utilize industry processing wastes of agricultural commodities. The increase requested for 1975 would provide for research on the control of water erosion and sedimentation.

AGRICULTURAL STABILIZATION AND CONSERVATION SERVICE

The Agricultural Stabilization and Conservation Service (ASCS) was established June 5, 1961, by the Secretary of Agriculture under authority of revised statutes (5 U.S.C. 301), and Reorganization Plan 2 of 1953, as well as all other statutes and prior reorganization plans vesting authority in the Secretary of Agriculture.

ASCS is the agency of the Department of Agriculture that administers specified commodity and related land use programs designed for voluntary production adjustment, resource protection, and price, market, and farm income stabilization.

Rural Environmental Program

Program objectives and priorities:

The new national program would provide for three groups of practices, or functions, representing the three basic program objectives: (1) Soil and water conservation, (2) timber incentives, and (3) recreation and wildlife. These are discussed below.

1. Soil and water conservation.--The primary objective of soil and water conservation would be to encourage farmers and ranchers to carry out whole-farm, long-term conservation plans that would emphasize conservation benefits of national concern, and achieve desirable land-use adjustments.

Whole-farm conservation plans, developed with SCS assistance and approved by soil and water conservation districts, will be the basis for long-term contracts. While this requirement would not necessarily apply to cost-sharing for timber production, recreation or wildlife practices, or to cost-sharing funds set aside specifically for annual contracts assistance provided for such practices will be on the basis that they are needed, feasible and would be harmonious elements of a soil and water conservation plan for the operating unit.

It is recognized that whole-farm conservation plans and long-term contracts also will contain essential soil and water conservation practices that are profitable for farmers to carry out without cost-sharing.

The emphasis on long-term cost-sharing based on whole-farm plans, approved by soil and water conservation districts, would provide incentives for increased participation in the SCS technical assistance program. Many farm conservation plans would be changed and updated to facilitate this participation, and other farmers and ranchers heretofore nonparticipants in the technical assistance program would be expected to request SCS planning assistance. Annual program funding levels for long-term contracts would be set at "not less than" levels and funds could not be reallocated to other purposes without the specific approval of the Secretary.

Program and Financing (in thousands of dollars)

	Identification code 05-60-3317-0-1-354	1973 actual	1974 est.	1975 est.
	Program by activities:			
	1. Soil and water conservation:			
	a. Annual	.....	.....	70,577
	b. Long term	.....	.....	26,325
	2. Timber incentives	.....	.....	25,000
	3. Recreation and wildlife (long term)	.....	.....	900
	4. Emergency measures	.....	.....	15,400
10	Total program costs, funded—obligations (object class 41.0)	.....	.....	138,202

FOREST SERVICE

Cooperation with the States

The Forest Service cooperates with State and local governments, agencies and organizations, forest industries, and private landowners in the protection, reforestation, management, and utilization of 577 million acres of forested lands and associated lands vital for watershed protection.

Cooperative programs are carried out with State forestry agencies, the Soil Conservation Service, and local water conservation districts to control fires, stabilize gullies, improve forest growth, and prevent floods under the Watershed Protection and Flood Prevention Act of August 4, 1954 (68 STAT 666; 16 U.S.C. 1001-1007) as amended. The Forest Service also runs the naval stores conservation program and assists in the supervision of forestry work in agricultural conservation programs.

Forest Research

The Forest Service carries on basic research throughout the country, often in cooperation with State agricultural colleges, under the authority of the McSweeney-McNary act of May 22, 1928 (45 Stat. 699; 16 U.S.C. 581-811), as amended and supplemented.

Program and Financing (in thousands of dollars)

Identification code 05-96-1103-0-1-402	1973 actual	1974 est.	1975 est.
Program by activities:			
1. Forest land management construction	8,167	9,745	5,946
2. Research construction	3,425	4,243	2,917
3. Pollution abatement	16,132	33,655	16,706
4. Land acquisition, Weeks Act	1,124	1,303	1,578
Total direct program	28,848	48,946	27,147
Total reimbursable program	204	250	250
Total program costs, funded [1]	29,052	49,196	27,397
Change in selected resources (undelivered orders)	394	3,000	−3,000
10 Total obligations	2 446	52,196	24,397

Pollution Abatement

To provide for bringing water and air pollution control at existing recreation, research, fire, and administration facilities to the quality standards adopted pursuant to the Federal Water Pollution Control Act, as amended, the Clean Air Act, as amended, or as prescribed pursuant to Executive Order 11507, dated February 4, 1970. Also, includes work involved in bringing all facilities into compliance with Public Law 92-500 dated October 18, 1972, and related State and Federal standards.

Forest Protection & Utilization Budget:

Forest Land Management: Soil and Water Management

1973	$13,795,000
1974	$15,217,000
1975	$15,215,000

The total program for fiscal year 1975, compared with 1973 and 1974, follows:

	1973	1974	1975	Change: Pay Costs	Change: GSA Space	Change: Program
			(in thousands)			
(1) Soil and water science for management support	$7,232	$8,333	$8,900	$60	$237	$270
(2) Watershed restoration and improvement	1,954	2,029	2,088	15	57	-13
(3) Wild and scenic rivers studies	712	733	758	5	21	-1
(4) Environmental analysis and construction liaison	2,802	2,541	2,645	10	94	--
(5) Planning liaison and protection related to projects of water resource development agencies	1,095	1,581	824	4	29	-790
Total	13,795	15,217	15,215	94	433	-534

(1) Soil and water science for management support ($8,900,000, an increase of $567,000)

Emphasis will continue to be given to:

(a) Management services such as application of technical water, geologic, and soils knowledge to resource management and development activities; advice and counsel on design of specifications for resource management programs to meet specific water management objectives or to enhance soil productivity and avoid problems.

(b) Soil, water, and geologic resource inventories including interpretations and analysis. Inventories conducted by scientists provide basic information interpreted i r both short and long-term planning efforts in such areas as land use, timber management, range management, transportation systems, and the wild and scenic rivers program. As management and development activities move into remote and more fragile areas, minimal levels of basic information about the watersheds become essential as a basis for environmentally sound action.

(c) Surveillance and monitoring of National Forest use and programs to assure that they are compatible with the protection of man's environment. Identifying areas with existing or emerging soil and water quality problems so that corrective action can be formulated and implemented.

The 390.4 million acre-feet of high quality water produced from National Forests is an example of the importance of water in the National Forest Program. In 1972, the dependent regional gross product for all water uses from National Forests averaged $1,157 per acre-foot of water produced, or a total of $167 billion. Protecting the clean water resource will result in substantial and varied social and economic benefits to all citizens.

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Extreme demands are being put upon available water supplies, particularly in the West. The Congress and the courts have determined that the United States has a right to reasonable use of water on National Forests reserved from the public domain except those waters appropriated before the National Forests were created. Efforts are underway to obtain sufficient quantities of water in accordance with legal authority for the administration and development of the National Forest System. This project on a watershed basis includes:

(a) An inventory of present and foreseeable needs.

(b) A determination of water availability.

(c) An assessment of the potential for increasing yields in water-short areas.

(d) Action to secure the water needed for National Forest purposes.

The western States want the Forest Service to complete the inventory program as rapidly as possible. The field inventory of Forest Service consumptive water uses is essentially completed. A major part of the total project effort is expected to be completed by fiscal year 1978.

Additional work is developing due to adjudication proceedings in some western states. Increasing judicial and administrative action in water rights is anticipated, both on lands reserved from the public domain and on acquired lands, over the next several years.

Examples of Recent Accomplishments:

Land use planning--the process for making decisions about long-term allocations of natural resources and the land base from which they are obtained--has received greatly increased emphasis in 1973.

Soil resource inventories were conducted on 15.6 million acres; detailed soil surveys were conducted on about 0.4 million acres in cooperation with the Soil Conservation Service and the State Agricultural Experiment Stations.

Resource protection requirements and design services were provided by geology, hydrology and soil scientists on more than 2,000 projects.

Soil and water condition and trend observations along with monitoring effects of timber management, mineral developments, Boundary Waters Canoe Areas, and suspected pollution problem sites where people physically use the water resource are underway at 2,000 locations. On the Los Padres National Forest in California a survey was made of watershed conditions that caused mudflows to occur as a result of the Molera fire in the Big Sur area.

Cooperative studies are continuing with State Fish and Game Departments to determine minimum flows necessary for fish culture in connection with Federal Power Commission relicensing of "run of the river" power facilities.

On the Tongass National Forest in Alaska, timbered slopes over the critical angle of repose were delineated on 4.5 million acres of land. Timber management procedures have been updated to reflect special considerations for these fragile areas.

(2) Watershed restoration and improvement ($2,088,000, an increase of $59,000);

The purpose of this continuing program is the restoration and maintenance of surface disturbed areas to enhance the quality of the environment and restore productive capacity of renewable resources. Projects include:

(a) The South Fork Salmon River Project (Idaho) where sedimentation has severely damaged anadromous and resident fisheries of regional and possibly national importance.

(b) The Palzo tract project (Illinois) where chemicals and sediment from old surface coal minig operations have seriously degraded water quality and caused the United States to be cited in court by State water quality authorities.

(c) South Fork Holston River and New River Watershed (Virginia) where sedimentation from old manganese mining operations affect stock water, wildlife and resident fisheries.

Restoring the hydrologic functioning of rural lands damaged beyond the point of natural recovery is essential to protecting the beauty and quality of the rural environment. This is a continuing program to:

(a) Meet soil stability and water quality requirements.

(b) Encourage the orderly development of watershed resources.

(c) Repair degraded watersheds.

(d) Provide continuing maintenance to projects completed to keep them effective.

The funds will be used to provide opportunities for utilizing the skills, and to furnish jobs and timely income for local people in rural areas of low income and critical under employment. Illustrative of some of the specific activities are:

(a) Emergency treatment and maintenance for the highest priority areas in the 184,000 acres of National Forest System lands burned annually by wildfires.

(b) Being responsive to treatment and maintenance needs on thousands of miles of abandoned "orphan" roads and trails that are great contributors of sediment and uncontrolled runoff, causing local problems of flooding and the resultant inability of water supply to serve agriculture, domestic, or recreational needs.

(c) Maintenance and reinforcement on the highest priority areas of eroding and gullied land treatments installed during the last 5 years.

(d) Removal of debris in stream channels above reservoirs and in anadromous fish streams.

Improvements of the water resource by scientific management helps individuals and communities in rural areas improve their quality of life, and is an integral part of multiple use management.

In response to public demands, the water resource improvement activity for fiscal year 1975 will consist primarily of:

(a) Application of special treatments to capitilize on opportunities to improve water yield through regular ongoing activities such as timber harvesting, range revegetation, timber stand improvement, and fire control in water short areas.

(b) Maintenance of existing water resource improvement projects to insure continuing effectiveness of work done to date.

(c) Continuation of programs under cooperative agreement with Anaconda Company in Montana and with the Salt River Valley Users Association in Arizona.

Example of Recent Accomplishments:

Rehabilitation of damaged areas is progressing in all parts of the country, but much work still needs to be done. A computer program--CHAGCOM--has been developed to facilitate the design of gully stabilization structures.

Rehabilitation work is coordinated with other resource and service divisions to accomplish an integrated program of management under multiple use.

In fiscal year 1973, Forest Service crews treated and stabilized:

Acres of sheet eroded and deteriorated areas.....	36,000
Miles of streambanks and shorelines.....	350

Treatments to aid in restoring favorable watershed conditions on lands damaged by wildfire continued. Emergency measures (initial treatment on new burns and maintenance on older burns) were applied to 27 fires on 52,000 acres that required onsite protection and posed threats to life, property, public health,

(3) Wild and scenic rivers studies ($758,000, an increase of $25,000)

The purpose of this activity is to carry out comprehensive studies of rivers designated as potential additions to the National Wild and Scenic Rivers System. The Wild and Scenic Rivers Act (PL 90-542) named 27 rivers as potential additions to the national system. The Forest Service is the lead agency for the Department of Agriculture's river study work on nine of the 27 rivers. These nine are: Chattooga River in North Carolina, South Carolina, and Georgia; Flathead River, Montana; Illinois River in Oregon; Pere Marquette River in Michigan; Moyle, Priest, St. Joe and Salmon (main stem) Rivers in Idaho; and the Skagit River in Washington.

The program effort during fiscal year 1975 will essentially complete work on the St. Joe, Skagit, Salmon, Flathead and Pere Marquette Rivers, while making substantial progress on the remainder. All studies are cooperative efforts with States, Federal agencies, and other interested groups and individuals and they provide for employment of local people to collect resource data and data on resource use and capability.

Examples of Recent Accomplishments:

The Department's report and recommendations on the Chattooga River were transmitted to the President and the Congress for their consideration. Also, the Flathead River proposal has been sent to all concerned Federal departments and agencies and to the Governor of Montana for review and comment. The river study report and draft environmental statement for the Pere Marquette River are in the process of being prepared.

(4) Environmental analysis and construction liaison with water resource development agencies ($2,645,000, and increase of $104,000)

Environmental analyses delineate the effects, define necessary mitigating measures, and identify enhancement opportunities relative to proposed water resource development associated with National Forests and National Grasslands. Reports resulting from such analyses document measures which are essential to the attainment of National Forest multiple use objectives and identify how National Forest management can contribute to project purposes to optimize their economic and social contribution to rural America. To be effective, the analysis and report must be concurrent with the construction agency's preliminary planning to permit their findings to be incorporated in the licensing or authorizing document.

Liaison with the construction agency during the construction period is necessary to facilitate coordination between the construction agency and the Forest Service. Protection of the land and resources, minimizing interference with regular protection and management activities, and facilitating construction agency operations are direct economic dividends derived from this program.

Experience has shown that without adequate analysis and liaison effort such as is provided by this activity, natural resources often suffer from enormous waste and misuse, and the project works fail to make their maximum contribution. Natural beauty and high quality water are among those resources most susceptible to loss. The rising value of forest resources and constant increase in demands against the declining resource base requires increased perception, scientific input and thoroughness in making environmental analyses and preparing reports.

Examples of recent accomplishments include environmental analyses and reports for Bath County Pumped Storage Project, Parr Shoals, Skidmore Fork Flood Control Project, and the

Central Utah Project. In addition, construction liaison was carried out on such major developments as the California Water Plan and the ongoing elements of the Central Utah Project.

(5) Soil stabilization and cover improvement ($824,000, a decrease of $757,000):

The treatment of lands tributary to water resource development projects to reduce sediment yield or to modify the pattern of runoff lengthens the life and increases the utility of the water control structures. This work is done on National Forest System Lands tributary to the project, only where hydrologic analysis and other elements of the environmental analysis determine that such work is needed and that benefits to the project purpose are clearly established.

Treatment programs include the following:

(a) Modifying the vegetation to decrease erosion, to reduce flood peaks, and to increase the annual quantity and improve the timing of water yielded from the tributary lands.

(b) Clearing reservoir areas, where not done as part of construction, and keeping the reservoir free of debris to make the area safe for public use and to maintain scenic beauty.

(c) Land treatment measures such as contour terracing, gully plugs, headwaters debris and flow retarding structures, and streambank and shoreline stabilization measures.

Essential land treatment and related measures are planned at small watershed projects authorized by PL-566 and PL-534, and at other major reservoir projects. Treatment measures will include soil stabilization and vegetation management to improve water quality and quantity. Also, in order to provide for public safety and user enjoyment of reservoir areas, debris and stump removal will be accomplished on about 10,000 acres.

Recent accomplishments included the appliation of land treatment measures at Dry Creek, Cottonwood Creek, and Carpinteria PL-566 projects. Stumps were removed at some reservoirs comprising the Yakima Project and reservoir sweeping was done at major reservoirs where the Forest Service has management responsibilities.

Forest Protection & Utilization Budget: Category -

Forest Research: Subcatagory - Forest Watershed

Management Research

1973	$6,726,000
1974	7,710,000
1975	7,716,000

Examples of Recent Accomplishments:

Surface mining may cause chemical pollution of streams in areas where acid is no problem. A four-year study of the chemical quality of water in watersheds in Kentucky showed that some rocks when exposed to weathering and erosion following mining caused water pollution. Increased concentrations of sulfate, calcium, and magnesium were noted in water sample taken from recently mined watersheds. Information on the amounts and kinds of chemicals added to streams will be useful for developing methods to control chemical pollution of streams.

Construction & Land Use Budget

Special project. Reconstruct the Prairie Portage Dam on Sucker Lake within the Boundary Waters Canoe Area and on the border between Minnesota (near Ely) and Ontario, Canada, at a cost of $204,000. The Office of Canadian Affairs, the State Department, Corps of Engineers and the International Joint Committee all are adamant in their desire to see the Forest Service reconstruct this badly deteriorated dam. Over the years it has become a very serious threat to downstream residents.

Examples of Recent Accomplishments:

The following units were constructed or construction contracts awarded in fiscal year 1973:

(1)

Units	No.
Dwellings and barracks	3
Fire lookouts	1
Offices	1
Service and storage building	1
Purchase administrative site	1
Water and sanitation systems	14
Communication systems upgraded and modernized	6

(2) Research construction (No funds are requested, an appropriation decrease of $5,058,000.)

(3) Pollution abatement ($16,733,000, an appropriation decrease of $1,005,000. On the basis of program level, there will be a decrease of $19,625,723 from the 1974 level of $36,358,723.

The decrease is due to the systematic funding and/or completion of those projects in both water and air pollution abatement which have been identified as being required for compliance with Executive Order 11507.

The funds will be used to finalize compliance with the Executive Order and to initiate action on compliance with the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500).

These programs are vitally needed to protect and maintain the resources and environment of the National Forests. They will:

(a) Help prevent a general degradation of the National Forests.

(b) Insure a continued flow of high quality water for domestic and irrigation use.

(c) Help realize the 1985 National goal of elimination of the discharge of pollutants into navigable waters of the United States.

Water pollution abatement ($16,733,000, a program level decrease of $8,830,723 from the 1974 level of $25,563, 723.)

An amount of $5,834,000 will be used for the construction of the following five water pollution abatement projects identified under EO 11507 and previously deferred until fiscal year 1975 in order to cooperate with local communities:

State	Project Name	Project No.	Estimated Cost
Montana	Seeley Lake	1759	$293,000
Arizona	Oak Creek Canyon	56	1,537,000
California	Bass Lake	51	2,340,000
California	Pinecrest Summit	1021	665,000
California	Mammoth Lake	1613, 1621	1,118,100
California	Engineering, related costs of of contract administration, and additional costs of installing projects started in prior fiscal years		830,900
	Total		6,834,000

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An amount of $9,899,000 will be used to initiate action on compliance with PL 92-500, and related State and Federal standards promulgated by that Act. Such action will include investigation of both point and non-point discharges, including establishment of monitoring and surveillance systems and corrective action on 53 identified deficient National Forest administrative sites and approximately 17 recreation sites. Where corrective action on previously unidentified sites is found to be necessary, funds will be used for thorough analysis and preliminary design.

Proposed PL 92-500 Program

(a) Point discharge monitoring, evaluation, and design	$3,161,000
(b) Non-point monitoring, evaluation, and design	3,047,000
(c) Correct deficient administrative site	2,535,000
(d) Correct deficient recreation sites	1,106,000
Total	9,899,000

Pollution abatement and prevention requirements previously aimed largely at point source discharges have been broadened by law to include non-point or dispersed sources. The proposed program would provide for the surveillance of development and use activities on National Forest System lands. Activities or uses which have the potential for environmental pollution include such things as construction, mining, recreation, grazing, and those activities associated with timber management.

The information obtained through surveillance is used to:

(a) Help identify pollution sources.

(b) Provide the facts needed for determining:

(1) Uses for which the water is suited.

(2) When quality of water has dropped below standards for particular uses.

(3) Practical water quality goals.

(4) The effectiveness of current management practices in meeting water quality goals.

(5) Design criteria for future management action to meet established water quality goals.

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DEPARTMENT OF DEFENSE:

CORPS OF ENGINEERS--CIVIL

The Civil Works program of the Corps of Engineers consists of a number of related activities for the control and development for beneficial use of water resources in the United States, Puerto Rico, and the Virgin Islands.

The requested appropriation is $1,620 million, which is $45 million less than the 1974 appropriation, and $332 million less than the appropriation for 1973.

The Army's Civil Works Program, a responsibility of the Corps of Engineers under the direction and supervision of the Secretary of the Army, dates back to 1824 and is the Nation's major Federal water resources development activity and involves engineering works such as major dams, reservoirs, levees, harbors, waterways, locks, and many other types of structures. These works provide flood protection for cities and major river valleys, reduce the cost of transportation, supply water for municipal and industrial use, generate hydroelectric power, provide recreational opportunities for vast numbers of people, regulate the rivers for many purposes including the improvement of water quality and the enhancement of fish and wildlife, protect the shores of the oceans and lakes, and provide still other types of benefits. In addition, through the Civil Works Program the Federal Government protects the navigable waters of the United States under legislation empowering the Secretary of the Army to prohibit activities which would reduce the value of such waters to the Nation.

Surveys:

Navigation and flood control studies are made to determine the need and economic justification for proposed water and related and resource developments. Beach erosion control studies are undertaken to determine the need for shore protection and remedial measures at specific localities. Funds are provided in 1975 to continue 181 studies. Three new studies will be undertaken, placing major emphasis on the solution of urgent urban area water problems.

Comprehensive river basin studies provide for broad consideration of water and related land resource needs of river

basins. They are coordinated with the related river basin planning efforts of the Departments of the Interior and Agriculture and other concerned agencies.

Work will be continued in 1975 on the following comprehensive basin studies:

1. Hawaii framework
2. Long Island Sound Region, Conn. and N.Y.
3. Maumee River Basin, Ohio, Ind., and Mich.
4. Minneapolis-St. Paul Metro Area, Minn.
5. Pacific Northwest River Basins Idaho, Mont., Oreg., and Wash.
6. Platte River Basin, Nebr.
7. Southeastern New England Region, Mass., Conn., and R.I.

In addition, funds are provided for preparation of authorization reports on the following:

1. Big Muddy River Basin, Ill.
2. Connecticut River Basin, Conn., Mass., N.H., and Vt.
3. Kanawha River Gasin, W.Va., Va., and N.C.
4. Puget Sound Region, Wash.
5. Susquehanna River Basin, N.Y., Pa., and Md.
6. Wabash River Basin, Ind., and Ill.
7. Willamette River Basin, Oreg.

Special studies are made to resolve unique or especially complex water resources problems. Funds are requested to continue six special studies.

Funds are provided to restudy one authorized project now carried in a deferred category.

Program and Financing (in thousands of dollars)

Identification code 08-10-3121-0-1-401	1973 actual	1974 est.	1975 est.
Program by activities:			
Direct program:			
1. Surveys:			
(a) Navigation, flood control, and beach erosion studies	21,347	25,035	22,050
(b) Comprehensive basin studies	3,975	3,000	3,500
(c) Special studies:			
(1) Chesapeake Bay study	1,217	6,000	3,500
(2) Coordination studies with other agencies	564	1,000	2,000
(3) Lake Erie wastewater management	125	200	670
(4) Northeastern United States water study	1,708	2,500	1,950
(5) Texas coast hurricane study	551	500	600
(6) Water levels of the Great Lakes	331	60	370
(7) Studies not budgeted in 1975	1,399	465	123
(d) Review of Authorized Projects			
(1) Restudies of deferred projects	69	150	170
(2) Review of Completed projects	132	540	700
(e) Inventory of dams	60	1,500	1,500
2. Collection and study of basic data:			
(a) Stream gaging	400	400	415
(b) Precipitation studies	328	300	265
(c) Fish and wildlife studies	948	1,200	1,500
(d) International water studies	257	290	325
(e) Flood plain management services	8,797	11,000	11,000
(f) Hydrologic studies	237	250	260
(g) Scientific and technical information centers	--------	70	100
3. Research and development	11,588	12,000	13,000
4. Undistributed reduction based on anticipated delays and savings in the regular survey program	--------	--------	--------
Total direct program	54,033	66,460	63,998
Reimbursable program	30	30	30
Total program costs, funded	54,063	66,490	64,028
Change in selected resources (undelivered orders and advances)	1,784	−4,043	−1,898
10 Total obligations	55,847	62,447	62,130

Funds also are provided, in accordance with the Flood Control Act of 1970, to review the operation of completed projects constructed by the Corps of Engineers when found advisable due to significantly changed physical or economic conditions and recommendations are made to Congress for desirable modifications.

Surveys are made in coordination with Federal, State, and local agencies and interests. They give appropriate consideration to present and future requirements for all beneficial uses of water and related land resources, including navigation, flood control, water supply, irrigation, water quality contol, power, recreation, and fish and wildlife conservation.

Collection and study of basic data:

Funds are transferred to the Geological Survey for the Geological Survey for installation, operation, and maintenance of stream gaging stations; to the National Weather Service for hydrometeorological studies; and to the Bureau of Sport Fisheries and Wildlife for preauthorization studies of the effects of porposed projects upon fish and wildlife. The Corps of Engineers participates on a number of engineering and control boards that study and control international streams mutually affecting the United States and Canada. Information about the flood hazard, advice, and assistance are furnished to the States to other Federal agencies for guidance in the management of flood plain areas to assure the best and safest use of such areas. General hydrologic and related studies are are made to assist in optimizing the design, construction, and operation of projects. Scientific and technical information centers prepare and distribute literature to scientists and engineers to improve their knowledge of new developments in their fields.

Research and development:

These studies are conducted to improve procedures for analyzing engineering data; to improve procedures used in formulating plans for water resources development and management; to refine design techniques; and to develop better materials and practices for the construction, operation and maintenance of water resources facilities. The current program of studies comprises irvestigations in the areas of: Materials, primarily soils, rock, concrete, and material interactions; coastal engineering, including wave mechanics, coastal processes, coastal

Program and Financing (in thousands of dollars)

Identification code 08-10-3123-0-1-401	1973 actual	1974 est.	1975 est.
Program by activities:			
Direct program:			
1. Navigation projects:			
(a) Channels and harbors	163,016	206,960	200,000
(b) Locks and dams	62,728	81,062	81,100
2. Flood control projects:			
(a) Reservoirs	49,001	55,515	65,000
(b) Channel improvements, inspections, and miscellaneous maintenance	3,514	5,905	5,900
3. Multiple-purpose projects, including power	80,538	99,632	100,000
Total operation and maintenance of projects	358,797	449,074	452,000
4. Protection of navigation	21,917	16,525	19,000
Total direct program	380,714	465,599	471,000
Reimbursable program	8,379	8,868	8,000
Total program costs, funded	389,093	474,467	479,000
Change in selected resources (undelivered orders, advances, stores and equipment)	29,946	−16,575	−23,000
10 Total obligations	419,039	457,892	456,000

construction, and inlets and estuaries; flood control and navigation, including harbors, waterways, locks and dams, improvement of operation and maintenance techniques and hydrologic engineering; environmental quality, including environmental impact and water quality; and planning methodology, including advance planning and planning alternatives.

Navigation projects:

In 1975, operation and maintenance will be carried out on 258 channel and harbor projects and 33 lock, dam, and canal projects.

Flood control projects:

In 1975, 216 flood control reservoirs and 18 local protection projects will be operated and maintained. Others will be inspected for adequacy of maintenance by local interests.

Program and Financing (in thousands of dollars)

Identification code 08-10-3125-0-1-401	1973 actual	1974 est.	1975 est.
Program by activities:			
Direct program:			
Emergency flood control and shore protection (program costs, funded)	80,538	131,000	39,775
Reimbursable program	133,849	34,000	2,298
Total program costs, funded	214,387	165,000	42,073
Change in selected resources (undelivered orders and advances)	12,059	19,138	−27,073
10 Total obligations	226,446	184,138	15,000

Multiple purpose projects, including power:

By the end of 1975, it is estimated that 65 multiple-purpose projects will be operated and maintained with a scheduled capacity of 15,556,924 kilowatts.

Protection of navigation:

Under laws for the protection and preservation of navigable waters, regulations are established and permits granted for activities and structures affecting navigable waters.

Object Classification (in thousands of dollars)

Identification code 08-10-3124-0-1-401	1973 actual	1974 est.	1975 est.
Direct obligations:			
Personnel compensation:			
11.1 Permanent positions	23,684	27,045	28,003
11.3 Positions other than permanent	274	347	381
11.5 Other personnel compensation	104	68	112
11.7 Pay to commissioned officers	1,268	1,362	1,396
Total personnel compensation	25,330	28,822	29,892
Personnel benefits:			
12.1 Civilian	2,210	2,269	2,390
12.2 Military	236	172	174
13.0 Benefits for former personnel	2	.....	.....
21.0 Travel and transportation of persons	1,077	1,186	1,323
22.0 Transportation of things	55	106	134
23.0 Rent, communications, and utilities	663	666	2,989
24.0 Printing and reproduction	177	168	227
25.0 Other services	1,791	1,516	1,621
26.0 Supplies and materials	217	196	225
31.0 Equipment	216	107	125
Total direct obligations	31,974	35,208	39,100
Reimbursable obligations:			
25.0 Other services	8	10	10
99.0 Total obligations	31,982	35,218	39,110

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This activity involves flood emergency preparation, flood fighting, and rescue operations, and repair of flood control and Federal hurricane or shore protection works. The request is for the replenishment of this fund.

Executive direction and management:

The Office, Chief of Engineers, and 10 division offices supervise work decentralized in 36 district offices.

River and Harbor Board:

The Board reviews reports on proposed projects and makes advisory recommendations to the Chief of Engineers.

Coastal Engineering Research Center:

The Center plans and conducts research in the field of coastal engineering, develops standards, and reviews technical reports.

Commercial statistics:

Data on waterborne commerce are collected, compiled, and published.

Special investigations:

Investigations are made and reports prepared pursuant to congressional and other special requests for information on the civil works program.

Flood Control, Mississippi River and Tributaries

The Corps of Engineers--Civil is responsible for the flood control program for the lower Mississippi Valley from Cape Girardeau, Mo., to the Gulf of Mexico, including the main alluvial stream, the basins of the St. Francis and White, lower Arkansas, Yazoo, Texsas, and Atchafalaya Rivers, and Bayou La Fourche, and the alluvial lands around Lake Pontchartrain. The adopted plan calls for raising and strengthening about 1,600 miles of existing levees along the main river, for enlarging or constructing some 1,700 miles of levees on tributaries and in

side basins, for channel improvement by bank stabilization from Head of Passes, La., to Cairo, Ill., and by dredging a navigation channel 12 feet deep and 300 feet wide from Baton Rouge, La., to Cairo, Ill., and for five flood detention reservoirs on minor tributaries.

General investigations:

Eleven studies will be continued, of which four will be completed with 1975 funds. Basic data subsequently used in planning and designing projects are collected.

Advance engineering and design:

Funds are requested to continue planning on two features.

Construction:

The total cost of flood control and related improvements in the lower Mississippi River and its alluvial valley is estimated at $4,597 million, of which $1,933 million has been appropriated through 1974. The funds requested will be applied to continuation of 12 features.

Maintenance:

Provision is made for operation and maintenance of major features of the project.

APPROPRIATION TITLE: General Investigations, FY 1975

Collection and study of basic data:

Stream Gaging (U.S. Geological Survey)

Scope--This program is part of the 18,000 surface-water gaging stations operated by the U.S. Geological Survey throughout the United States. The Corps of Engineers cooperates with the Geological Survey in this effort and contributes funds for the operation and maintenance for all or a part of the cost of some 2,500 stations which are of special importance to the civil works mission. This cooperative program is a continuing program which was established about 1940 through cooperative arrangements between the Corps and the U.S. Geological Survey in order that pertinent stream flow data would

be available to meet special needs in connection with the Corps' water responsibilities. The program provides essential data for use by the Corps, as well as other Federal and State agencies, and individuals interested in water resources.

Summarized financial data:

Estimated 5-Year (FY 1975-79) Program Cost 1/	$2,225,000
Appropriation Requested for FY 1975	415,000
Balance to Complete 5-Year Program	1,810,000
Appropriation for FY 1974	400,000
Increase of FY 1975 over FY 1974	15,000
Average Annual Allocation for Last 5 Years (1970-1974)	375,000

1/ Corps of Engineers estimate

Justification:

The Corps of Engineers makes extensive use of streamflow records in the planning, design, construction, and operation of water resources projects. The basic network of stream gaging stations operated by the Geological Survey under its normal functions is inadequate to meet all the special needs in connection with the Corps water resource development responsibilities. Accordingly, a cooperative program was established under which funds are transferred to the Survey to partially cover the cost of operating specific stations. Participation in the cooperative program generally meets the Corps requirements more satisfactorily or economically than would be possible through independent action. In the optimum development of water resources, it is essential that continuous records of streamflow be maintained at specific sites over a long period of years in order to provide a measure of water resources available for various uses. The value of these streamflow records is to a large degree dependent upon uninterrupted station operation over a period of years during which a wide range of discharge events, including both flood and drought, may have been observed. This budget item covers only the non-project portion of the cooperative program. To continue the operation of stations of special interest to the Corps, an estimated total of $5,105,700 would be required by the Geological Survey during FY 1975, exclusive of funds received from other cooperative sources. This gross cost will be financed from three sources as follows: (1) $471,900 appropriated directly to the Survey for use in operating stations required by the Corps; (2) $415,000 under this budget item for transfer to the Survey; and (3) $4,218,800 from Corps funds budgeted elsewhere for authorized projects and studies. The basic program will remain at essentially the same level as in FY 1974.

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Accomplishments:

A continuity of discharge records has been maintained for a number of streamflow stations of primary interest to the Corps. Records of these stations, supported by transfer of funds, are published in a regular series of reports by the Geological Survey and provide valuable information for use by the Corps as well as other Federal agencies and the general public.

Fiscal year 1974:

The budget item request for $415,000 in FY 1975 is an increase of $15,000 over FY 1974. This increase is required to maintain the non-project portion of the program at about the same level as in prior years and is a direct result of general increased costs of personnel services, supplies, and materials.

ITEM	FY 1974	FY 1975
Stream Gaging	$400,000	$415,000

Coordination:

This program is fully coordinated with the U.S. Geological Survey, Costs for conducting the work are compiled by representatives of the Survey and form the basis for the transfer of funds to that agency.

System which is already functioning to monitor streamflow at certain points. Potential for this to be done by ERTS or for more data to be made availbable.

Flood Plain Management Services

Scope--This Corps of Engineers Program stems form Section 206 of the 1960 Flood Control Act (PL 86-645), as amended, which authorizes the Secretary of the Army to compile and disseminate data on floods and flood damage potentials and to provide guidance in their use in flood related planning to Federal, State and local agencies. This information and guidance promotes planning and implementing actions which lead to wise use of flood plains.

Summarized Financial Data:

Estimated 5-Year (FY 1975-79) Program Cost	$69,000,000 1/
Appropriation Requested for FY 1975	11,000,000
Balance to Complete 5-Year Program	58,000,000
Appropriation for FY 1974	10,300,000
Increase of FY 1975 over FY 1974	700,000
Average Annual Allocation for last 5 Years (FY 1970-74)	7,810,000

1/ Corps of Engineers estimate.

Justification:

Flood Plain Management Services Program activities include:

(a) Flood Plain Information (FPI) Reports. Graphic and narrative descriptions of the flood hazard needed for land use planning are prepared at the request of State and local agencies. Existing data are used, but often additional physical survey and hydrologic studies are required. Only a fraction of the more than 7500 communities with flood problems or emerging problems have adequate flood hazard information.

(b) Technical Services and Guidance. Responses are made to Federal and non-Federal requests for flood hazard information for sites or short reaches of stream or coast for follow-up technical assistance to communities having completed FPI and related reports.

(c) Guides, Pamphlets, and Supporting Studies. Guides, pamphlets, and results of supporting studies are widely disseminated to convey the nature of flood hazards and to foster needed public understanding of the options for dealing with them.

Accomplishments

Flood Plain Information Reports:

Through FY 1973, 870 FPI Reports had been completed on hazards in about 2500 places throughout the nation and another 125 were underway. In FY 1974, 175 completions and 120 initiations are planned. Regulatory measures have been adopted or strengthened covering 750 report locations and studies are underway for 780. Nearly all completed reports have been used for some aspect of local planning.

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Technical Services and Guidance:

Responses to requests for flood hazard information on sites and short reaches of rivers and coasts numbered over 9,600 during 1973--a large share prompted by EO 11296. Among the responses are 175 Special Flood Hazard Information Reports on onger reaches in 230 places. Regulatory measures have been adopted or strengthened covering 75 report locations and studies are underway for 90. Requests for information are expected to continue to increase significantly in FY 1974 and further expand in FY 1975. As follow-up to completed FPI and Special Reports, and thoses from the HUD flood insurance program, District offices are responding to an increasing number of requests for assistance.

Guides, Pamphlets, and Supporting Studies:

Provided support for (1) appropriate portions of work on flood plain management economic model, (2) training program in flood hydrology for A/E personnel, (3) segment of movie on physical model of flood plain, (4) test studies of urban flood hydrology, and (5) mathematical model study to determine flood levels corresponding to various land fill elevations.

Fiscal Year 1975

Flood Plain Information Reports:

The amount will permit the completion of about 190 FPI reports during FY 1975 and initiation of about 135 others.

Technical Services and Guidance:

The amount is to meet the growing demand expected from Federal and non-Federal agencies for the follow-up to FPI reports, for special flood-hazard information, and for community land use planning assistance.

Guides, Pamphlets and Supporting Studies:

Illustrating alternative ways of coping with flood damages will be continued and additional subjects covered for the benefit of the growing number of concerned local, State, and Federal entities.

Hydrologic Studies:

Scope--The scope of activities under this item is determined annually by field offices, based on current needs. This is a continuing activity and includes the collection and study of basic data which provides a background of information and experience for tuture use in the optimum design, construction, and operation of water control structures. Studies are comprehensive in nature, not properly chargeable to authorized projects. The program consists of four sub-items: Storm Studies, General Hydrologic Studies, Sedimentation Studies, and Stream Flow and Rainfall Data.

Summarized Financial Data:

Estimated 5-Year (FY 1975-79) Program Cost 1/	$1,390,000
Appropriation Requested for FY 1975	250,000
Balance to Complete 5-Year Program	1,140,000
Appropriation for FY 1974	250,000
Increase of FY 1975 over FY 1974	0
Average Annual Allocation for Last 5 Years (1970-1974)	257,000

1/ Corps of Engineers estimate

Justification:

Storm Studies. The Storm Study Program of the Corps is a continuing investigation of major storms for the purpose of accumulating comprehensive data on the most important past and current storms. These data are required in the evaluation of flood producing potentialities of river basins as related to the accomplishment of the civil works mission of the Corps and constitute the major portion of the basic data used in probable maximum precipitation and other hydrometeorological determinations. Funds in the amount of $25,000 will be required in FY 1975 to continue the program at approximately the same level as in recent years.

General Hydrologic Studies. Studies under this sub-item include hydrologic analyses of rainfall-runoff relationships, snowmelt studies, flood forecasting, analyses of past floods, infiltration indices, unit hydrographs, development of flood hydrographs, and other studies of related hydrologic nature that are not clearly chargeable to authorized projects. Criteria developed in these background studies are required in

determining economic justifications, capacity of flood control works, developed in these background studies are required economic justifications, capacity of flood control works, provision for security against failure of projects during extreme flood emergencies, proper hydrologic design for optimum performance, economy of construction and proper operating procedures after completion of construction. Funds in the amount of $100,000 will be required to continue this sub-item at a level to insure proper and orderly progress.

Sedimentation Studies. This program is a continuing effort in which funds are allocated to field offices for conducting non-project sedimentation studies and to finance the Corps share of an interagency sediment investigation program. The sediment studies include the collection of suspended and bed load data, data on degradation, aggradation and delta formations, investigations of sediment transport, characteristics of natural streams and laboratory studies. One of the major efforts under this sub-item is a cooperative interagency project for investigating methods for measuring and analyzing sediment loads in streams and for developing new sediment sampling equipment. The interagency project is conducted at the St. Anthony Falls Hydraulic Laboratory at the University of Minnesota and is sponsored by the Sedimentation Committee, Water Resources Council. Funds in the amount of $75,000 will be required to carry on sedimentation studies at the same level as FY 1974.

Stream Flow and Rainfall Data. This is a continuing program for which funds are allocated for use in installation and operation of stream flow and rainfall gages of a non-project nature that are required by the Corps in addition to the stations in the cooperative programs conducted by the Geological Survey and the National Weather Service for the Corps. These stations are operated independently by the Corps in connection with some special study or purpose. Due to the special nature of the stations and to the limited time in which they are usually operated, inclusion in the cooperative program is not practicable. An amount of $50,000 is required by field offices to continue the establishment and operation of these special purpose gages at the same level as FY 1974.

Accomplishments:

Storm Studies. The storm study program was organized in 1939 for the purpose of investigating major storms of record throughout the entire United States. The studies that appeared to produce critical rainfall values were assigned for complete analysis; others were deleted. Also, new major storms are added to the list as they occur. For example, the Hurricane Agnes generated storm and the Rapid City, S.D., storm of June 1972, have been added to the storm study assignment list. The program does require a continuing analysis of current storms of unusual proportions, and most Districts have a backlog of storms to study. Generally, first priority is given to preserving important storm data through reconnaissance surveys immediately following a major storm to collect and appraise unofficial data on quantity of rainfall measured by residents, which supplement the official data obtained from regular precipitation gages. The storm data are analyzed in a preliminary manner for immediate use in current work and the final storm study is completed as workload and funding permits. Sufficient progress was made on a substantial number of assigned storm studies during FY 1973 to permit effective use of the data in field offices. Similar accomplishments will be made in FY 1974.

General Hydrologic Studies. The accomplishments achieved from studies conducted under this activity have resulted in general improvement in the development and quality of hydrologic criteria.Examples of some of the more important activities accomplished under this progarm are: determination of rainfall-runoff relationships; unit hydrograph investigations, snow cover surveys; and participation in hydrologic engineering training programs. In addition to continuation of the general hydrologic studies mentioned above, continued emphasis will be given to the development of programs for the adaptation of computer techniques to hydrologic problems and to increased participation in selected hydrologic engineering training activities.

Sedimentation Studies. A large portion of funds allotted to this sub-item is used to assist in financing the Corps share of the cooperative interagency sedimentation project at the St. Anthony Falls Hydraulic Laboratory. This project has been in operation since 1939. The balance of the sedimentation funds are allotted to Districts for use in the collection of

suspended and bed-load data, data on degradation, aggradation and delta formation and investigation of sediment transport characteristics of natural streams to ascertain if any significant changes have taken place in the behavior of streams as sediment carriers.

Stream Flow and Rainfall Data. Basic data obtained from stations in this program have provided information that normally would not have been available elsewhere for use in subsequent project reports or special studies. Station funded under this sub-item are generally established and operated several years prior to anticipated authorizations for project-type activities in order to provide a backgound of observed data on which to base the planning and design of projects.

Fiscal Year 1975

The appropriation requested for FY 1975 is based on field requests and is required to continue the hydrologic studies program at a level to insure proper and orderly progress.

ITEM	FY 1974	FY 1975
1. Storm Studies	$ 25,000	$ 25,000
2. [illegible]	100,000	100,000
3. [illegible]	75,000	75,000
4. [illegible]	50,000	50,000
Total	$250,000	$250,000

Coordination

The storm studies are prepared by Corps field offices and are reviewed by the National Weather Service in the preparation of probable maximum precipitation estimates for the Corps. The Interagency Sedimentation Project is conducted cooperatively, and jointly funded, by eight Federal agencies. Information concerning stream flow and rainfall data collection by the Corps under this activity is made available to the Geological Survey and the National Weather Service.

DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

The Geological Survey was established by the act of March 3, 1879 (20 Stat. 394; 43 U..C. 31), which provided for the"classification of the public lands and the examination of the geological structure, mineral resources and products of the national domain." The act of September 5, 1962 (76 Stat. 427; 43 U.S.C. 31(b)), expanded this authorization to include such examinations outside the national domain. Topographic mapping and chemical and physical research were recognized as an essential part of the investigations and studies authorized by the Organic Act, and specific provision was made for them by Congress in the act of October 2, 1888 (25 Stat. 505, 526).

The broad objectives of the Geological Survey are to perform surveys, investigations, and research covering topography, geology, and the mineral and water resources of the United States; classify land as to mineral character and water and power resources; enforce departmental regulations applicable to oil, gas, and other mining leases, permits, licenses, development contracts , and gas storage contracts; and publish and disseminate data relative to the foregoing activities.

6. Water resources investigations.- The continuing national program of water resources investigations during 1975 has the objective of seeing that the Nation's water resources are appraised and that the necessary water data to develop and manage them efficiently are available when needed. The program produces data and information relevant to the flow and sediment discharge of rivers, location and quantity of undergraound waters, chemical quality and temperatures of waters, changes caused by nature and by man, availability and suitability of water supplies for present and future demands - all of which are essential to water planning, water management, energy development, and improvement of the environment. Included in the program is research needed to increase our understanding of fundamental principles of water occurrence, movement, and interaction with its environment, and also to increase the accuracy and usefulness of water data through improvements in technology. Increased funds in 1975 are requested to strengthen and expand activites in the water quality segment of the National Water Data System.

Program and Financing (in thousands of dollars)

Identification code 10-28-0804-0-1-409	1973 actual	1974 est.	1975 est.
Program by activities:			
Direct program:			
1. Special resource and environmental projects	3,565	4,232	4,258
2. Alaska pipeline related investigations	1,214	905	347
3. Topographic surveys and mapping	32,182	36,784	44,688
4. Geologic and mineral resource surveys and mapping	39,030	46,720	57,390
5. Minerals discovery loan program	331	333	203
6. Water resources investigations	37,106	45,480	50,849
7. Conservation of lands and minerals	12,661	17,773	22,628
8. General administration	2,859	3,087	3,191
9. Facilities	337	5,761	10,986
10. Earth resources observation systems	7,689	8,954	7,573
11. Resource and land investigations	.....	944	954
12. Land use data and analysis	.....	.....	2,509
Total direct program	136,974	170,973	205,576
Reimbursable program:			
3. Topographic surveys and mapping	4,651	5,980	6,380
4. Geologic and mineral resource surveys and mapping	8,586	14,178	10,153
6. Water resources investigations	26,786	33,182	34,031
7. Conservation of lands and minerals	24	9	9
10. Earth resources observation systems	.....	570	832
Miscellaneous services to other accounts	2,576	2,993	3,278
Total reimbursable program	42,623	56,912	54,683
Total program costs, funded	179,597	227,885	260,259
Change in selected resources (undelivered orders)	12,996	.....	.....
10 Total obligations	192,593	227,885	260,259

Justification

Funding of Geological Survey Programs (Obligations)

	Actual 1972	Estimate 1973	Estimate 1974
Special resource and environmental projects:			
Direct appropriation	$ 1,666,600	$ 3,753,000	$ 3,[illegible],000
Alaska pipeline related investigations:			
Direct appropriation	1,338,900	1,339,000	850,000
Miscellaneous Federal agencies	62,000	--	--
Total	1,400,900	1,339,000	850,000
Topographic surveys and mapping:			
Direct appropriation	34,545,495	34,559,000	34,259,000
States, counties, and municipalities	3,20[illegible],288	3,800,000	4,000,000
Miscellaneous non-Federal sources	356,737	625,000	960,000
Office of Territories	21,351	8,300	--
National Aeronautics and Space Administration	137,70[illegible]	306,600	275,000
National Science Foundation	255,700	250,000	200,000
Miscellaneous Federal agencies	215,639	275,000	800,000
Total	38,736,910	39,823,900	40,494,000

	Actual 1972	Estimate 1973	Estimate 1974
Geologic and mineral resources surveys and mapping:			
Direct appropriation	33,265,456	39,965,000	42,795,000
States, counties, and municipalities	1,358,886	1,376,000	1,350,000
Kingdom of Saudi Arabia	2,[illegible]9,490	2,200,000	2,000,000
Miscellaneous non-Federal source	47,433	47,000	40,000
Bureau of Reclamation	23,424	5,000	--
Department of Defense:			
Military	3,113,331	2,158,000	350,000
Civilian	105,908	34,000	50,000
Department of Housing and Urban Development	280,646	287,000	250,000
Agency for International Development	1,986,756	1,920,000	2,300,000
Atomic Energy Commission	2,089,944	2,181,000	1,900,000
National Aeronautics and Space Administration	5,037,476	5,900,000	3,100,000
National Science Foundation	649,998	107,000	125,000
Miscellaneous Federal agencies	209,544	328,000	150,000
Bureau of Mines	80,371	44,000	50,000
Saline Water	31,476	154,000	100,000
Total	50,550,139	56,706,000	54,560,000
Minerals discovery loan program:			
Direct appropriation	330,000	441,541	277,000

Water resources investigations:			
Direct appropriation	$ 37,748,818	$ 40,129,000	$ 39,854,000
States, counties, and municipalities:			
Matched Federal funds	19,815,002	20,695,000	20,695,000
Unmatched	1,479,001	1,850,000	1,850,000
Permittees and licensees of the Federal Power Commission	533,132	550,000	550,000
Miscellaneous non-Federal sources	145,775	144,000	143,000
Bureau of Land Management	153,667	155,000	155,000
Bureau of Reclamation	632,608	806,000	765,000
National Park Service	507,695	597,000	465,000
Department of Agriculture	268,222	258,000	255,000
Department of Commerce	84,894	101,000	105,000
Department of Defense:			
Military	911,516	847,000	835,000
Civilian	4,967,716	5,660,000	5,400,000
Department of Housing and Urban Development	920,747	2,130,000	2,140,000
Department of State	245,484	241,000	234,000
Agency for International Development	557,283	600,000	600,000
Atomic Energy Commission	1,021,936	1,100,000	1,100,000
Environmental Protection Agency	627,067	754,000	735,000
National Aeronautics and Space Administration	265,595	517,000	255,000
Tennessee Valley Authority	198,468	258,000	245,000
Miscellaneous Federal agencies	340,372	424,000	420,000
Bonneville Power Administration	100,728	71,000	75,000
Bureau of Sport F & W	101,169	128,000	130,000
Total	71,626,895	78,015,000	77,006,000
Conservation of lands and minerals:			
Direct appropriation	13,392,954	14,259,000	16,029,000
Miscellaneous non-Federal sources	993	4,000	4,000
Miscellaneous Federal agencies	570	5,000	5,000
Department of Defense - Military	25,000	25,000	25,000
Total	13,419,517	14,293,000	16,063,000
General administration:			
Direct appropriation	2,884,518	2,831,000	2,831,000
Facilities:			
Direct appropriation	34,765	715,235	5,910,000
Earth resources observation systems:			
Direct appropriation	5,744,110	10,343,000	8,[illegible]
National Aeronautics and Space Administration	574,563	1,260,000	[illegible]
Total	6,318,673	11,603,000	9,295,000
Resource and land information program:			
Direct Appropriation	--	--	1,000,000
Miscellaneous services to other accounts:			
Miscellaneous non-Federal sources	$ 29,281	$ 30,000	$ 29,000
Computer services for other bureaus and agencies	1,511,033	1,894,000	2,467,000
Miscellaneous Federal agencies	487,150	418,000	434,000
Total	2,027,464	2,342,000	2,930,000
Summary:			
Direct appropriation	130,951,616	148,334,776	156,005,000
States, counties, and municipalities	25,857,177	27,721,000	27,895,000
Miscellaneous non-Federal sources	3,382,841	3,600,000	3,726,000
Other Federal agencies	28,804,747	32,206,900	27,347,000
Total	188,996,381	211,862,676	214,973,000

1. Special Resource and Environmental Projects

FY 1973, $3,753,000; FY 1974, $3,753,000; no change.

Analysis by Subactivities

Subactivity	FY 1972 Amount Available	FY 1973 Amount Available	FY 1974 Estimate
(a) Urban area studies	$ 969,700	$ 973,000	$ 973,000
(b) Responsibilities under the Mining and Minerals Policy Act of 1970	--	250,000	250,000
(c) Geothermal investigations	696,900	2,530,000	2,530,000
Total	1,666,600	3,753,000	3,753,000

(a) Urban Area Studies: FY 1973, $973,000; FY 1974, $973,000; no change.

Program of Work:	FY 1974
San Francisco Bay	$300,000
Seattle-Puget Sound	30,000
Phoenix-Tucson	80,000
Denver	140,000
Pittsburgh	138,000
Connecticut Valley	155,000
Baltimore-Washington	130,000
Total	$973,000

2. Alaska Pipeline Related Investigations

FY 1973, $1,339,000; FY 1974, $550,000; decrease, $489,000.

Program of Work:

The FY 1974 program continues, on a diminishing scope and scale, the investigations begun in FY 1971 to provide geologic, geophysical, hydrologic and topographic data, and alternatives needed by the Federal Government for critical engineering and management decisions concerning right-of-way and construction permits, and environmental protection requirements of the proposed trans-Alaska hot-oil pipeline system. Assuming the permit is granted, the need for these data and advisory services will continue through the construction phase and into the initial operational and monitoring phase.

The demands for these data and services should gradually diminish, assuming all problems can be resolved to acceptable environmental impact levels and assuming that no new or alternative proposals are received that would require further or new investigations.

Status of Program:

2) Hydrologic investigations having engineering design significance in the construction phase and monitoring significance in the initial operation phase are underway. These include continued data gathering from established baseline stations, flood frequency and magnitude modeling, research studies of special problems such as stream icings and breakup, channel migration and scour characteristics especially at stream crossings, drainage disturbances and changes, and the hydrologic effects of a hot-oil pipeline in permafrost. A preliminary analysis of these data has been made available.

The Geological Survey's pipeline investigations program was begun by redirection of ongoing activities in late FY 1969 in response to the urgent needs for data and advice, created by the northern Alaska oil development and pipeline proposal. The above program of work outlines the type of studies that have been completed and are continuing. The basic data gathered to date have been published in various forms and provided to the Department of Interior and other concerned agencies through conferences and the inter-agency Technical Advisory Board. The Geological Survey had a major role in the preparation of the Environmental Impact Statement.

The follow through by the Geological Survey in FY 1974 is essential to the success of the design, construction, and operational phases and particularly to the monitoring of the environmental protection requirements established by the Department of Interior.

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6. Water Resources Investigations

FY 1973, $40,129,000; FY 1974, $39,854,000. Decrease, $275,000.

The Water Resources program of the Geological Survey proposed for 1974 will require direct appropriation of $39,854,000 (52% of total program). In addition, the Survey performs extensive water-data acquisition for other Federal agencies under a reimbursable arrangement ($14,697,000; 19% of total program), and receives fiscal support from the States through the Federal-State program of cooperative work ($22,545,000; 29% of total program), making a total projected program of $77,006,000 for 1974.

Analysis by Subactivities

Subactivity	FY 1972 Amount Available	FY 1973 Amount Available	FY 1974 Estimate	Increase (+) or Decrease (-) 1974 Compared with 1973
A. National Water Data System:				
(1) Federal Program	$14,840,460	$15,948,875	$16,048,481	$+ 99,606
(2) Federal-State Program.....	20,008,002	20,948,000	20,948,000 a/	—
B. Critical National Water Problems..	2,597,317	2,887,000	2,487,000	-400,000
C. Employee Compensation Payments....	303,039	345,125	370,519	+ 25,394
	37,748,818	40,129,000	39,854,000	-275,000

a/ Includes $253,000 for administration of the cooperative program and $20,695,000 for matching State

A. National Water Data System

The National Water Data System embraces the total effort of government (Federal, State, local) to acquire, process, store and disseminate water-resources and water-use information. The Geological Survey is the principal Federal water-data agency. As such, its programs constitute a major part of the system.

(1) FEDERAL PROGRAM: FY 1973, $15,948,875; FY 1974, $16,048,481; increase, $99,606.

Program of work:

The water-data collection, resources investigation, and research activities included in this program support that segment of the National Water Data System in which the Federal interest is paramount, including the public domain, river basins and aquifers that transcend State boundaries, and other areas of international or interstate concern. Major program segments are: streamflow, ground-water and water-quality data acquisition, analysis, storage, and dissemination (including baseline water quality data) $7,327,000; regional resource appraisals including ground-water studies ($589,000); basic hydrologic investigations and research aimed at increased understanding of the operation of hydrologic systems ($4,298,000); hydrologic investigations on public lands managed by Bureau of Land Management ($274,000); International Hydrological Decade studies, $195,000; training, publication and other supporting services ($2,476,481); coordination of National water data activities ($689,000); National Water Data Exchange ($200,000).

Status of program:

Although many data have been and are being collected, there remain major deficiencies in the geographical distribution and in the kinds of data required. This situation exists not only because of population growth and shifts and depletion of some local sources of water but also because the development and management of water requires on a regional and national basis more and better supporting data.

While the long established streamflow program is responsive in general to the current need, there is a severe shortage of data on the very large number of small streams. In addition, the lack of adequate data on the ground water resource and quality of water, especially in urban areas and in estuaries, reduces the effectiveness of planning, design, development, management and use of the Nation's waters and poses a problem to concerned Federal and State planning and enforcement agencies.

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The following table indicates the approximate level of adequacy of principal kinds of water data and information activities on a nationwide basis.

Kinds of information	% of current need being met
Surface water:	
Average streamflow	80
Floods	50
Low flows	25
Stream systems studies	10
Ground water:	
Resource appraisal	45
Subsurface waste storage	5
Systems studies	20
Water quality:	
Resource appraisal	35
Surveillance	20
Urban hydrology	10
Estuaries	5
Water use	20

In keeping with the Survey's responsibility for national leadership in water data, the 1974 Federal program component of the National Water Data System is aimed at alleviating the most critical of these deficiencies in areas where the interest is primarily Federal.

(2) FEDERAL-STATE PROGRAM: FY 1973, $20,948,000; FY 1974, $20,948,000; no change.

Program of work:

Cooperative projects are jointly planned by State and Federal representatives at grass-roots level which assures optimum melding of Federal and State priorities. Major program activities and estimated 1974 funding are:

	Federal matching funds	State and local funds
Collection, analysis, and dissemination of streamflow, ground-water, and sediment data	$10,140,000	$11,000,000
Areal resource appraisal	5,680,000	5,800,000
Studies related to critical water problems	2,200,000	2,300,000
Other data collection and applied research	2,675,000	3,445,000
TOTAL	20,695,000	22,545,000

Projects approved for cooperative funding contribute to solution of urgent national and State problems and strengthen the National Water Data System effort, thereby appreciably reducing the amount of data collection requiring all-Federal funding. At present, the total increase in offerings for matching by the more than 500 cooperating agencies for FY 1974 is expected to approximate $5,300,000. Because there is no increase proposed in Federal funds, this $5,300,000 offering will go unmatched. Programs of utmost urgency may be initiated or broadened only by decreasing or eliminating ongoing programs of lesser priority.

Status of Program:

Efficient and effective conservation, development, and utilization of the Nation's water resources is impossible without an adequate data base. This program provides more than half of that base and is a continuing program with direct response to changing and increasing mutual needs of Federal and local governments for data in support of water resources decision-making.

As problems arise and as the need for new kinds of water information develops (e.g., pesticides, radioactive materials in water, systems modeling, urban hydrology), the States increase their requests and offerings for the cooperative program. Although the studies are often linked closely to local water problems, they are of substantial national, as well as local, interest because they yield information that has applicability to similar problems elsewhere. More importantly, they comprise segments of the regional or national picture.

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Data collection activity through operation of network stations is primarily a long-term continuing function. Areal appraisals and interpretive studies, which are an important segment of this program, comprise hundreds of individual projects which, for the most part, are completed in one to three years with a published report.

On-going activities are distributed as follows:

Site data collection, analysis and dissemination; includes 7,400 continuous record and 5,400 partial record streamflow stations, 1,200 lake or reservoir stations; 2,800 water quality stations, 13,500 ground water observation wells and 11,800 project type short term wells.

Areal resource appraisals and problem studies include urban hydrology, sedimentation, estuaries, lakes, hydrobiology, stream system modeling, aquifer modeling; water quality modeling; saline waters; flood frequency and magnitude; floods and droughts; waste disposal and others totaling 400 projects.

Studies related to critical problems include 42 projects on urban and flood mapping; 23 projects on deep waste emplacement; 10 projects on estuarine problems and 20 projects on artificial recharge.

WATER RESOURCES INVESTIGATION: FEDERAL-STATE PROGRAM
ESTIMATES OF STATE AND MUNICIPAL OFFERINGS FOR FY 1974
(Thousands of dollars)

State	State Offerings to be Matched 1973	Estimated Offerings for Matching 1974	Increase (+) Decrease (-)
Alabama	378	450	+ 72
Alaska	224	302	+ 78
Arizona	483	562	+ 79
Arkansas	228	253	+ 25
California	1,855	2,307	+452
Colorado	496	629	+133
Connecticut	202	286	+ 84
Delaware	39	59	+ 20
Florida	1,432	2,476	+1,044
Georgia	339	419	+ 80
Hawaii	314	311	- 3
Idaho	330	466	+136
Illinois	249	265	+ 16
Indiana	454	528	+ 74
Iowa	261	292	+ 31
Kansas	554	580	+ 26
Kentucky	348	408	+ 60
Louisiana	531	689	+158
Maine	55	60	+ 5
Maryland	310	426	+116
Massachusetts	224	255	+ 31
Michigan	307	380	+ 73
Minnesota	339	492	+153
Mississippi	253	305	+ 52
Missouri	288	330	+ 42
Montana	183	338	+155
Nebraska	281	354	+ 73
Nevada	178	200	+ 22
New Hampshire	55	68	+ 13
New Jersey	413	452	+ 39
New Mexico	484	656	+172
New York	1,015	1,534	+519
North Carolina	361	425	+ 64
North Dakota	313	328	+ 15
Ohio	419	456	+ 37
Oklahoma	233	303	+ 70
Oregon	343	419	+ 76
Pennsylvania	835	994	+159
Rhode Island	39	46	+ 7
South Carolina	200	323	+123
South Dakota	165	210	+ 45
Tennessee	244	350	+106
Texas	1,462	1,746	+284
Utah	452	478	+ 26
Vermont	58	60	+ 2
Virginia	297	368	+ 71
Washington	892	934	+ 42
West Virginia	131	212	+ 81
Wisconsin	430	486	+ 56
Wyoming	265	304	+ 39
American Samoa	36	40	+ 4
D.C.	1	1	0
Guam	20	25	+ 5
Puerto Rico	347	353	+ 6
Trust Terr. Pac.	58	84	+ 26
Virgin Islands	2	5	+ 3
SUBTOTAL	20,695	26,049	+5,354
Adjustments to be made (shortfall)		-5,354	
Program admin.	253	253	
TOTAL Federal funds, Coop program	20,948	20,948	

B. Critical National Water Problems

The activities in this program are directed toward providing hydrologic data required for the evaluation and solution of urgent existing and emerging problems.

FY 1973, $2,897,000; FY 1974, $2,487,000; decrease, $400,000.

Program of work:

Major program components and estimated funding are: Continue field investigations to evaluate the feasibility of ground-water recharge techniques in different geohydrologic environments, and research on chemical and physical phenomena that control artificial recharge ($1,041,000); continue and extend field investigations on subsurface waste disposal and research on fundamental problems related to waste injection ($977,000); delimit flood hazards on about 800 standard quadrangle maps ($348,000); extend data collection and studies of currents and dissolved and suspended solids of specific estuaries necessary to develop models for identifying and alleviating coastal problems ($121,000).

Status of program:

Ground-water recharge studies are in three different geohydrologic environments, the semi-arid High Plains, the glacial deposits of Long Island, and in fractured carbonate rock. The field studies identify the physical, chemical, and organic controls that determine whether or not injection and water spreading are successful water-management techniques to use ground-water storage to supplement surface reservoirs. Supporting research on the principles of ground-water recharge continue. Investigation of recharge through a well penetrating fractured limestone overlying a sandstone aquifer near St. Paul, Minn., showed that the recharge water was distributed over a large area of the sandstone aquifer by the fractured limestone. This technique prevents the usual problem of plugging of the well bore that occurs when sandstone wells are recharged directly. A report describing the experiment is in preparation. The project on the High Plains has developed methods to sample water moving down from spreading ponds to the deep water table in order to observe geochemical changes in the recharge water and the effects on soil permeability to improve capability in predicting changes that will have transfer value.

completed early in FY 1973 indicates that surface and near-surface disposal of wastes, accidental spills, and the incidental results of industrial and agricultural activities have caused some pollution of ground water in every State in the Nation. So far, these individual areas of contamination have been relatively small and the effects have been serious but not disastrous. The prevention of surface-water and shallow ground-water pollution has stimulated requirements for better methods of deep-well injection. Studies are continuing on the chemical reaction of organic substances in ground water, physical and chemical reactions with aquifer materials, the movement, dilution, and dispersion of pollutants in the subsurface, and the measurement of existing stresses to relate to potential injection aquifers are also continuing. A second symposium on deep well injection will be cosponsored in early FY 1974 to bring together industrial representatives, well designers, ground-water consultants, and Federal and State officials responsible for evaluating and regulating subsurface waste disposal to exchange advances in the state of the art.

The objective of the flood-hazard mapping component is to provide flood information as a guide for flood-plain management. The program was started in 1969 in response to recommendation 1(B) of the Task Force on Federal Flood Control Policy (House Document 465, pages 21-22). About 60 percent of the 8,800 maps projected for the program will be completed by the end of FY 1973. Plans for 1974 are to publish 800 maps and 80 descriptive pamphlets concerning flood hazards in municipal areas.

Estuarine and coastal studies will be continued on the geochemistry and circulation patterns in San Francisco Bay and the effects of quality of water on estuary biota in Chesapeake Bay. Coupled with hydrologic studies and data that have been collected in Port Royal Sound, Delaware, Tampa, and other bays under the Federal and the Federal-State cooperative program, models are being developed that will permit assessing the usability of fresh water supplies now naturally present in coastal areas and forecasting the impact of man-made developments on the hydrologic environment.

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BUREAU OF RECLAMATION

The Reclamation Act of 1902 (43 U.S.C. 391 et seq.), authorized the Secretary of the Interior to locate, construct, operate, and maintain works for the storage, diversion, and development of waters for the reclamation of arid and semiarid lands in the Western States. To perform these functions, the Secretary in July 1902 established a Reclamation Service in the Geological Survey. In March 1907 the Reclamation Service was changed to Bureau of Reclamation.

The program of the Bureau of Reclamation is designed to stabilize and to promote the growth of local and regional economies through optimum development of water and related land resources throughout the 17 contiguous Western States. Reclamation projects provide for some or all of the following concurrent purposes: irrigation water service, municipal and industrial water supply, hydroelectric power generation and transmission, water quality improvement, fish and wildlife enhancement, outdoor recreation, flood control, navigation, river regulation and control, and related uses. Through contractual agreements with project beneficiaries, the Bureau arranges for repayment to the Government of reimbursable costs incurred in the construction and operation of water resource projects.

The Bureau plans, constructs, and operates facilities to irrigate lands, furnish municipal and industrial or other water supplies, and develop related hydroelectric power and flood control in the 17 Western States and Hawaii.

Appropriations to the Bureau are made from the general fund and special funds. The special funds are (a) the Reclamation fund, largely derived from certain irrigation and power revenue; receipts from the sale, lease, and rental of public lands; and certain oil and mineral revenue; and (b) the Colorado River Dam fund, derived from the revenue of the Boulder Canyon project. The 1975 estimates are summarized by source, as follows (in thousands of dollars):

Appropriation title	Estimate of appropriation	General fund	Reclamation fund	Colorado River Dam fund	Other
General investigations	17,030	17,030	.....	.....	--
Loan program	12,025	12,025	.....	.....	--
Recreational and fish and wildlife facilities	1,200	1,200	.....	.....	--
Emergency fund	1,000	.....	1,000	.....	--
Construction and rehabilitation	233,784	118,784	115,000	.....	--
Operation and maintenance	94,000	13,052	77,730	3,218	--
General administrative expenses	20,500	.....	20,500	.....	--
Permanent authorizations	3,300	.....	290	3,000	10
Lower Colorado River Basin development fund	[1] 49,250	49,250	.....	.....	--
Upper Colorado River Basin fund	28,616	28,616	.....	.....	--
Total	460,705	239,957	214,520	6,218	10

[1] Includes $31,300 for liquidation of contract authority. The total appropriation request of $460.7 million represents an increase of $35.9 million compared with the current year appropriation which includes a proposed supplemental for civilian pay increase and a decrease of $63.0 million compared with the preceding year.

Program and Financing (in thousands of dollars)

Identification code 10-06-5064-0-2-401	1973 actual	1974 est.	1975 est.
Program by activities:			
Direct program:			
1. Operation and maintenance	61,680	73,779	72,176
2. Purchase power and wheeling	28,561	33,394	39,529
Total direct program	90,241	107,173	111,705
Reimbursable program	326	386	373
Total program costs, funded	90,567	107,559	112,078
Change in selected resources (undelivered orders)	2,773	−8,115	.....
10 Total obligations	93,340	99,444	112,078

The Bureau operates and maintains the power-generation and transmission facilities, and generally the storage dams and reservoirs, of completed projects. Where necessary, irrigation works are operated and maintained until the waters users are able to undertake the responsibilities. In 1975 a total of 31 projects, project areas or divisions of projects will be operated and maintained for irrigation, power, municipal and industrial water supplies, and other benefits with funds made available under this appropriation. The Fort Peck project revolving fund finances the operation and maintenance of project power facilities physically integrated with the Pick-Sloan Missouri Basin progarm.

Provision is also made for flood control operations on certain projects, soil and moisture conservation operations on public lands under jurisdiction of the Bureau, the Colorado River front work and levee system program, negotiation and administration of water marketing contracts on Corps of Engineers' projects in California, marketing of power from the Corps of Engineers' powerplants on the Pick-Sloan Missouri Basin program and from the International Boundary and Water Commission's powerplant in Texas, examination of existing structures, and for purchase power and wheeling.

General Investigations

Program and Financing (in thousands of dollars)

Identification code 10-[illegible]-0660-0-1-401	1973 actual	1974 est.	1975 est.
Program by activities:			
Direct program:			
1. Plan formulation investigations	12,596	12,306	9,839
2. Geothermal investigations	956	2,282	1,270
3. General engineering and research	8,788	7,612	6,338
4. Fish and wildlife studies	395	269	250
5. Undistributed reduction based on anticipated delays	.....	−200	−225
Total direct program	22,735	22,269	17,472
Reimbursable program	6	39	14
Total program costs, funded	22,741	22,308	17,486
Change in selected resources (undelivered orders)	−588	−2,891	−442
10 Total obligations	22,153	19,417	17,044

This appropriation provides for the planning of potential developments for the conservation and utilization of water and related land resources and includes plan formulation investigations, geothermal investigations, and general engineering and research activities.

Investigations and surveys are made to determine the feasibility of potential reclamation projects and the need for rehabilitation of existing Federal reclamation projects.

1. Plan formulation investigations. - These include appraisal surveys, feasibility investigations, and special investigations throughout the 17 Western States to formulate resource development plans for basins and specific projects leading to authorization, including studies relating to the rehabilitation, financial adjustment, or water conservation on existing Federal reclamation projects.

2. Geothermal investigation. - The studies are directed toward determination of the feasibility of developing geothermal resources as a usable water source. Initial efforts have been centered in the Imperial Valley of California.

3. General engineering and research. - Studies directed toward improvements in planning procedures and in engineering methods and materials. Included are studies of atmospheric water resources, of alternative uses and reuse of water and continuing activities in waste water reclamation opportunities in the Western States.

General Investigations Program:
Regional Planning Service
F.Y. 1975 Estimate $1,282,000

Conducting a broad and varied regional investigation program requires a number of activities, general in nature, both recurring and nonrecurring, which are not properly chargeable to any specific investigaitons, project or other item. Activities in this category are carried out in all seven regions, and include such items as obtaining hydrologic data for general basin planning, developing data on water availability and use for water allocation studies, and determining the effects of upstream uses and operations on the quality and quantity of water available downstream under present and future conditions, It includes the cooperation and liaison with the State and Federal agencies and other interest groups, which is necessary to insure compatibility of various water resource matters and the review of the other agencies' reports. Specific examples of this activity include liaison with various River Basin Commissions; studies arising from the responsibilities placed on the Secretary of the Interior under the Supreme Court decision in the Arizona v. California water right litigation; coordination, planning and operation of the Columbia River

of preservation areas; and (3) people-oriented: promote wider distribution of population, provide employment (especially youth and/or unskilled labor), improve recreation quality, maintenance of population in rural environment, and provide quick response for unemployment correction. Other benefits; less capital investment, promotion of comprehensive land use plan, delay in need for new dams, reduction in need and size of long conveyance, and correction of undesirable results. Initial conversion is proposed to be in the Putah Creek watershed above the Bureau's Lake Berryessa.

Water Resources Planning and Engineering Research

Water supply augmentation and conservation (3 projects, $616,000)

Use of water-data collection and analysis.
Irrigation management services.
Economics of water management.

Water quantity management and control (7 projects, $121,000)

Advanced hydrologic techniques.
River channel studies.
Flood hydrology investigations.
Reservoir sedimentation and bank erosion surveys.
Sediment transport studies.
Investigations of aquatic plant control methods and their ecological impact on nontarget organisms.
Ground water analysis by computer.

Water quality management and protection (7 projects, $229,000)

Study of waste water reclamation opportunities.
Predicting mineral quality of return flow water.
Reaeration and control of dissolved gases.
Herbicide residue investigations.
Predicting nutrient and salt loads.
Predictions of water temperatures in large impoundments.
Investigations on desalting for maximum water recovery and minimum chemical requirement.

Water resources planning (12 projects, $369,000)

System analysis of economic data.
Study on population dispersal through water resource developments.
Development of multiobjective planning methods.
Operations research planning tools and applications.
Operations research support for planning studies.
Development of a research budget allocation system.
Identification of socioeconomic aspects of water resource development.
Development of new procedures for water pricing and cost sharing.
Development of concepts and procedures for improvement in benefit analysis.
Land use and environmental planning studies.
Ecological and limnological impact studies of the construction and operation of pump-back storage projects.
Investigations of turbidity measurement and control at construction sites.

Engineering Works (77 Projects, $1,295,000)

Studies of earthquake theory as applied to dams and appurtenant structures.
Development of new or improved structural design and analysis methods.
Study on the effects of cracking in concrete arch dams.
Development of improved hydraulic and structural design-spillways and outlet works.

General Investigations Program
General Engineering and Research
Multiple-Use Watershed Management
(California, Nevada, Oregon)
F.Y. 1975 Estimate $54,000

The study area lies within the Mid-Pacific region boundaries. The study emphasis will be on analysis of conversion of brushlands to grasslands in watersheds above Federal water projects. This will involve identification of suitable conversion areas, determination of environmental effects, development of comprehensive watershed land use plans and identification of measures and costs. Studies will be coordinated with Federal, State, and local agencies. Studies to date indicate that multiple-use watershed management can provide increased water yield as well as many other benefits. The objectives to be accomplished by the study are (1) water-oriented: increased water supply, improved water quality, improved stream fishery, reduced flood damage, and increased effectiveness of rain-making; (2) land-oriented: reduced fire hazard, increased grazing land, improved wildlife habitat, reduced soil erosion, improved soil fertility and reservation associated with the important Corps of Enginners and Bureau of Reclamation dams; and coordination with Geological Survey for collection and anlysis and publishing streamflow data. Also in keeping with the National Environmental Policy Act of 1969, consideration of broad environmental factors including water quality, ecology, and aesthetics are being carried out in connection with present and future water resources projects. The Regional Planning Service line item provides a convenient, equitable, and needed means of funding such activities.

The funds requested for the Operation and Maintenance program of $94,000,000 will provide an increase of $12,000,000 over the appropriation for the preceding year. Of this increase $5,953,000 is for purchase power and wheeling primarily due to payments required for power purchases from the Centralia Thermal Project, Washington, under terms of an agreement to meet power needs of Central Valley project customers. The remaining $6,047,000 increase in appropriation requirements is primarily due to

general increases in requirements on the older projects, including replacements and modernization of features, and to new facilities, inflation, and payments to the General Services Administration for space requirements. Projects with significant cost increases include the Pick-Sloan Missouri Basin Program, and Yakima, Yuma area, Middle Rio Grande, Colorado-Big Thompson, and Central Valley Projects.

The Bureau of Reclamation's fiscal year 1975 program provides for operation and maintenance and allied activities on 31 projects, project areas, or divisions of projects. In addition, the program provides for the Colorado River Front Work and Levee System; negotiation and administration of water marketing contracts on Corps of Engineers' projects in California power marketing programs associated with International Boundary and Water Commission power features in Texas; soil and moisture conservation operations on Bureau lands; examination of existing structures, and for purchase power and wheeling. One new item has been added--Miscellaneous Flood Control Operations--which is a consolidation of flood operations at a number of water user operated reservoirs. Two of the projects and activities are financed wholly from funds advanced by the water users. The total obligation estimates also include funds for operation and maintenance of the Port Peck Project which is financed separately from revenue deposited in the Port Peck continuing fund.

As a permanent activity, the Bureau of Reclamation operates and maintains only power projects and reserved works on multipurpose projects. Completed irrigation facilities are turned over to water user organizations for operation and maintenance as rapidly as the necessary agreements can be consummated. Pending completion or until such agreements are executed, the systems are operated by the Bureau with appropriated or advanced funds. The Bureau will operate and maintain during FY 1975 a total electric generating capacity of 6,586,892 kilowatts in 44 powerplants, a net increase of 32,400 kw over 1974, and 14,392 circuit miles of high voltage transmission. Water systems operated by the Bureau in fiscal year 1975 will serve irrigation water to approximately 405,000 acres.

OPERATION AND MAINTENANCE
General Statement

Summarized Financial Data:

Fiscal Year 1974:

Appropriation.	$82,000,000
Funds advanced by water users.	6,693,300
Funds advanced by States and municipalities and other non-Federal agencies	1,082,211
Fort Peck Continuing Fund	2,645,000
Credits from purchase power and wheeling operations. . .	10,365,000
Total obligations FY 1974.	$102,785,511

Fiscal Year 1975:

Estimate of appropriation.	$94,000,000
Funds advanced by water users.	7,158,100
Funds advanced by States and municipalities and other non-Federal agencies	343,000
Fort Peck Continuing Fund	3,435,000
Credits from purchase power and wheeling operations. . .	10,547,000
Totabl obigations FY 1975	$115,483,100

BUREAU OF LAND MANAGEMENT

The Bureau of Land Management was established on July 16, 1946 through the consolidation of the General Land Office (created in 1812) and the Grazing Service (formed in 1934) in accordance with the provisions of sections 402 and 403 of the President's Reorganization Plan 3 of 1946 (5 U.S.C. 133y-16).

The Bureau classifies, manages and disposes of the public lands and their related resources according to the priciples of multiple-use management. It also administers the mineral resources connected with acquired lands and the submerged lands of the Outer Continental Shelf.

Public land resources managed by the Bureau include timber, minerals, wildlife habitat, livestock forage, public recreation values, and open space. Bureau programs provide for the protection, orderly development and use of all these resources under principles of multiple use and sustained yield, and for a quality environment. It manages watersheds to protect soil and enhance water quality, develops recreation opportunity on public land, and makes public land available through sale to individuals, organizations, local governments, and other Federal agencies when such transfer is in the public interest.

Program and Financing (in thousands of dollars)

	Identification code 10-04-1109-0-1-402	1973 actual	1974 est.	1975 est.
	Program by activities:			
	Direct program:			
	1. Resource management, conservation, and protection	60,842	78,511	97,203
	2. Cadastral survey	7,978	8,624	12,580
	3. Firefighting and rehabilitation	22,804	6,400	5,400
	4. General administration	3,034	3,423	4,151
	Total direct program	94,658	96,958	119,334
	Reimbursable program:			
	1. Resource management, conservation, and protection	1,276	1,900	1,900
	2. Cadastral survey	1,788	2,700	2,700
	3. Firefighting and rehabilitation	2,772	2,503	2,400
	Total reimbursable program	5,836	7,103	7,000
	Total program costs, funded [1]	100,494	104,061	126,334
	Change in selected resources (undelivered orders, stores)	1,575	.....	.....
10	Total obligations	102,069	104,061	126,334

1. Resource management, conservation, and protection.- Includes such activities as land and mineral management, range management, forestry, soil and watershed conservation, protection, and recreation and wildlife. These activities provide realty leasing, and records services as well as related land classification and mineral examination work; utilization of rangelands by livestock to help meet local and regional demands for livestock forage; a sustained yield of timber to help meet demands for wood products; management and treatment practices needed to maintain and improve water quality, reduce flood damage, and prevent and control erosion from BLM lands; contract and force account wildfire protection for public land resources; fish and wildlife habitat management and improvement; and recreation management, planning and site investigation on Bureau administered lands.

Proposed increased funding is required to assure development of public land energy resources; to provide for OCS envioronmental assessment; to safeguard surface resources subject to damage because of mineral leasing and exploration; to help insure that advanced consideration for the environment is given to enery allocation decisions; to provide full year funding for Alaska Pipeline construction supervision, to develop sound land use plans to guide the development of energy minerals and related land uses; to carry out the requirements of the Alaska Native Claims Settlement Act; to adopt a sustained yield public domain timber harvestplan and increase the supply of timber; to manage recreation visitor use and protect affected resources; to carry out provisions of the Wild Horse and Burro Act; to provide for the increased costs of employees compensation; and pay a pro rata share of space costs.

Wild & Scenic Rivers, National Trails and Bicentennial Trails

This program component is intended to preserve, protect and manage selected rivers and trails in national systems as directed in Public Law 90-542 (Wild and Scenic Rivers Act) and 90-543 (National Trails Systems Act.) The increase also funds BLM's participation in the Nation's Bicentennial celebration. The Bureau administers portions of 2 designated Wild and Scenic Rivers, the Rogue and Rio Grande, and is involved in the analysis of four rivers classified under P.L. 90-542 as "Study Rivers" for possible designation. BLM lands border at least 10 additional "Potential Study Rivers". Timely and knowledgeable decisions on potential Wild and Scenic Rivers are critical to long range planning to prevent water impoundment or management actions such as timber harvesting which would alter the character of the river.

Exploding use of white water on three potential Wild and Scenic Rivers dictates a need for additional river management. Some 80,000 enthusiasts rafted a popular stretch of the Stanislaus River in California in 1973. The same intensity of use is being experienced on other rivers in the West, including parts of the Colorado and Green Rivers in Utah. Management implications of this growing sport include a need for sanitation and primitive camping facilities, fire prevention measures, hazard identification, provision of launching and take-out places, and visitor management.

Program features of the Wild and Scenic Rivers increase include:

- Management under the terms of the Act of the two designated Wild and Scenic Rivers, the Rogue and the Rio Grande.

- Participate in the evaluation of the Salmon and the Bureau Rivers for possible inclusion in the Wild and Scenic River system.

- Initiate preliminary analysis on additional potential rivers traversing public lands.

- Implement river management on the white water rivers, such as the Stanislaus River in California, and the Upper Green and Colorado Rivers in Utah.

The increase will also provide for development and implementation of a management plan for the Pacific Crest Trail in cooperation with the Forest Service and evaluation of the Oregon Trail for possible inclusion in the National Trail System.

California Desert Management

The Southern California Desert is a vast area some 240 miles in length and averaging 100 miles in width. Virtually untouched until recent years, the Desert is now undergoing people pressures that if unmanaged will result in widespread and permanent damage to cultural and natural values including archaeological and historic sites, wildlife, vegetation and watersheds. This program increase will provide more intensive management of the desert area to be supported by land use planning and other resource management as necessary to resolve conflicts. It does not duplicate program features in ORV and cultural enhancement increases.

Forest Development--National Resource Lands, Outside western Oregon:

One immediate objective of this program is to restore producing capacity of forest lands where it has been reduced due to logging, insects, stagnation due to overstocking or other causes. Early establishment of cover protects watersheds, restores timber production and enhances physical appearance. This effort also suppresses growth of undesirable species of no economic value and reduces fire hazard. The FY 1975 program level will include 2,800 acres of reforestation, 40 acres of site improvement and about 1,600 acres of stand improvement.

Soil and Watershed Conservation:

The Soil and Watershed program has three primary objectives: (1) to determine condition and evaluation methods; (2) to protect and improve productivity of watersheds on the National Resource Lands; and (3) to establish and maintain acceptable standards of watershed management to control soil erosion and water yield. This program provides technical data and capital investments in support of other resource management programs conducted on the National Resource Lands, and soil and watershed information for the Bureau's planning system.

Effective land management and treatment practices are dependent upon knowledge of soil stability, water quality and quantity, and environmental considerations in determining the proper location and design of roads, location of rights-of-way, provisions for exploration, extraction, and rehabilitation of mineral deposits, timber harvesting, recreation use and development, fish and wildlife habitat, and rehabilitation of watersheds damaged by fire, flood and other events. Support of these activities requires a watershed program which can:

(1) Determine need and use of a sufficient supply of usable water to permit the long term use, management and development of public land resources.

(2) Design and apply management practices to improve water quality, quantity and timing of yield to provide a controlled yield and quality for the user, and avoid pollution of water flowing through or from National Resource Lands.

(3) Provide technical data on soil and water resources to insure the selection of proper rehabilitation measures on

potential energy mineral resource lands destined for development.

(4) Rehabilitate damaged watersheds to restore stability, productivity and proper hydrologic function.

In areas denuded of vegetation, artificial revegetation and other soil conserving practices are required to accomplish desired results. Control of gully, streambank, and streambed erosion often requires special stabilization structures, riprap, sloping and vegetation eroded banks.

The control of soil erosion and water productivity will continue with various practices such as water retention and detention dams, contour furrowing, vegetative manipulation, and weed and pest control practices that affect water quality and quantity.

Watershed conservation program accomplishments, needs and present erosion conditions are reflected in the Tables on the following pages:

CONSERVATION ACCOMPLISHMENTS AND NEEDS OF LANDS UNDER JURISDICTION
of the
BUREAU OF LAND MANAGEMENT

	Units	Inventory of Total Needs 1/	Accomplishments 2/ 1937-1973	Planned 1974	Planned 1975	Remaining Work
Water Control Structures...	Cu. Yds.	242,602,500	30,044,632	65,000	60,000	212,436,646
Other Conserv. Practices 3/	Acres	19,125,900	3,086,369	11,000	200	16,028,331
Undesirable Plant Control..	Acres	121,900	79,680	5,000	2,900	34,320
Revegetation.....	Acres	14,790,000	3,685,388	4,000	2,500	11,105,112
Water Developments.....	Number	85,200	47,647	1,200	1,200	35,153

1/ Inventory of total needs was completed by the Bureau during 1964 and reflected the total needs of the public lands as then identified. The inventory amounts include those listed under "Accomplishments".

2/ Includes all sources; Soil & Watershed, Range Improvements, Fire Rehabilitation, P.L. 566, and Private.

3/ Includes contour trenches, pitting, furrowing, waterspreading, streambank protection, gully control, dune control, and deep tillage.

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PRESENT EROSION CONDITION - ACRES AS OF 12/26/73
WATERSHED INVENTORY 1/

	TOTAL STATE	ACRES INVENTORIED	%	STABLE ACRES	%	SLIGHT ACRES	%	MODERATE ACRES	%	CRITICAL ACRES	%	SEVERE ACRES
ARIZONA	11,000,000	6,627,787(60%)	4	263,663	46	3,078,522	40	2,619,596	9	600,732	1	65,274
CALIFORNIA	14,000,000	6,510,812(46%)	15	992,104	44	2,379,167	36	2,329,787	5	302,153	1	7,601
COLORADO	7,000,000	4,851,473(69%)	22	1,086,035	29	1,395,153	39	1,881,312	9	458,976	1	29,997
IDAHO	11,000,000	6,946,982(63%)	21	1,459,115	50	3,448,974	24	1,663,024	5	367,290	1	8,579
MONTANA	7,000,000	5,741,664(82%)	14	824,014	42	2,428,368	31	1,763,295	11	640,718	2	85,269
NEVADA	48,000,000	30,081,942(63%)	8	2,332,877	50	15,069,677	36	10,898,470	6	1,704,342	1	76,576
NEW MEXICO	12,000,000	7,791,716(65%)	6	455,879	30	2,313,633	41	3,195,481	21	1,667,705	2	159,018
OREGON	13,000,000	11,812,134(91%)	17	2,023,515	52	6,112,609	29	3,375,767	2	280,628	1	19,615
UTAH	23,000,000	14,384,688(63%)	6	783,974	41	5,946,584	36	5,095,763	17	2,464,284	1	93,083
WYOMING	16,000,000	10,169,455(64%)	6	625,931	38	3,832,063	42	4,312,093	12	1,219,041	2	180,327
BUREAU	162,000,000	104,918,653(65%)	10	10,847,107	44	46,504,750	35	37,135,588	10	9,705,869	1	725,339

1/ Definition of terms:

- stable - only natural geologic erosion occurring.
- slight - erosion not sufficient to significantly reduce vegetative productivity.
- moderate - erosion which significantly alters vegetative productivity.
- critical - erosion causing cessation of vegetative production.
- severe - erosion which prevents any vegetative establishment.

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Program of Continuing Work:Cadastral Survey

Cadastral survey is basic to all major resource programs and is the unique responsibility of BLM on National Resource Lands and on publiclands administered by the Bureau of Sports Fisheries and Wildlife, National Park Service, Forest Service, Defense Department, etc. The program is essential for land sales, exchanges and transfers, easement acquisitions, and resource product sales. The Forest Service remonumentation program and the identification of National Park and Indian Reservation boundaries are also requiring considerable effort. Reimbursable surveys are performed by a Portland basedfield office in the states of California, Oregon, Washington, Idaho and Nevada on a priority basis. The Denver Service Center, which has overall responsibility for reimbursable surveys for all states west of the Mississippi River excepting Alaska, performs surveys in the remaining western states. All cadastral surveys east of the Mississippi River are under the jurisdiction of the Bureau's Eastern States Office located in Silver Springs, Maryland.

Cadastral Survey in lower 48 states:

Continuing in FY 1975 will be efforts toward: completing an estimated 2.2 million acres of original and resurveys requested by other agencies; surveying or resurveying 10 million acres of National Resource Lands in support of resource management programs with the goal of providing survey support on a pipeline basis by FY 1979; and refining the formal corner search and evaluation program begun in FY 1973 in the forested areas with cadastral survey followup to rehabilitate existing corner evidence or reestablish lost corners. Much of the original surveys were completed prior to 1910 and corner evidence is deteriorating. Continued effort will also be devoted to the accelerating need for oil and gas leasing maps on the Outer Continental Shelf, and surveys required for other energy resource areas.

The long-term potential survey workload necessary to support Bureau programs follows:

	Miles of Survey	Number of Monuments	Man-Years of Survey Effort
Known Survey Needs.....	313,700	619,400	22,953
Potential Additional Survey Requirements depending upon condition of existing surveys.....	210,000	413,000	15,415
Total Potential Needs.....	523,700	1,032,400	38,368

Benefits of the program include the resolution and prevention of trespasses, better public service, more efficient resource management and prevention of further revenue losses. Potential demand in the Cadastral program as shown above would require 100 years to complete at the present funding and manpower capability.

Alaska Cadastral Survey:

Two legislative actions have brought about a massive survey workload involving the more than 345 million acres of unsurveyed lands in Alaska. The Alaska Statehood Act granted the state 104 million acres through selection, and the Alaska Native Claims Settlement Act provides 40 million acres for native allotments and townsites, trade and manufacturing sites, etc.

Additional Water Research:

Analysis by Activity

Activity	F.Y. 1973 Amount Available	F.Y. 1974 Amount Available	F.Y. 1975 Estimate	Increase (+) or Decrease (-) 1975 compared with 1974
Additional water research.....	$4,300,000	$3,170,000	$3,170,000	--

BUREAU OF SPORT FISHERIES AND WILDLIFE

The Bureau of Sport Fisheries and Wildlife was established in the Department of the Interior on August , 1956, by the Fish and Wildlife Act of 1956, as amended (70 Stat. 1119; 16 U.S.C. 742(a) - 742(l).

In the area of resource management, the Bureau provides leadership for the protection and improvement of land and water environments (habitat preservation), which directly benefits the living natural resources, and adds quality to human life. Activities include:

Biological monitoring, through scientific research; surveillance of pesticides, heavy metals and thermal pollution; studies of fish and wildlife population; and ecological studies;

Environmental impact assessment through river basin studies, including hydroelectric dams, nuclear powersites, stream channelization, dredge and fill permits; associated research; and environmental impact statement review;

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Area planning and preservation involving river basins, wilderness areas, and special studies, such as oil shale and geothermal energy.

Program and Financing (in thousands of dollars)

Identification code 10-18-1611-0-1-405	1973 actual	1974 est.	1975 est.
Program by activities:			
Direct program:			
1. Habitat preservation	11,520	12,408	16,001
2. Wildlife resources	34,674	38,288	45,642
3. Fishery resources	19,663	21,340	23,123
4. Endangered species	4,195	4,660	5,527
5. Interpretation and recreation	6,005	5,670	6,089
6. Administration	3,227	3,623	3,913
Total direct program	79,284	85,989	100,295
Reimbursable program:			
7. Replacement of personal property sold	100	100	100
8. Miscellaneous services to other agencies	4,450	4,400	4,400
Total, reimbursable program	4,550	4,500	4,500
Total program costs, funded	83,834	90,489	104,795
Change in selected resources (undelivered orders)	−2,907	--------	--------
10 Total obligations	80,927	90,489	104,795

1. Habitat preservation.- Alteration of the Nation's natural environment to satisfy man's needs and desires has had a serious impact on and poses a continuing threat to fish and wildlife resources through degradation and destruction of essential habitat. Studies are conducted to determine the type and amount of habitat alteration to arrive at measures to avoid or mitigate unnecessary deterioration. Technical assistance is provided to Federal water resource development agencies and private industry. Biological monitoring of fish, wildlife, and associated ecosystems is used to determine the location, nature and rate of environmental pollution and degradation. Research is conducted to determine the impact of pesticides, chemicals heavy metals, oil and other pollutants on fish and wildlife and their habitats. Continuing studies of natural resource development are used to determine the impact of dredge and fill and pollutant discharge activities in navigable waters; nuclear, thermal, and hydroelectric power projects; major water resource developments; and small watershed projects. Recommendations are formulated to mitigate or minimize unaboidable losses, prevent avoidable losses and enhance resources when feasible. Environmental impact statements for all Federal or federally

assisted projects are reviewed as areate water quality standards. Fish and Wildlife input is provided for comprehensive regional water resource development plans. Studies of the potential wild or scenic rivers and unique areas are carried out.

BUREAU OF OUTDOOR RECREATION

The Bureau of Outdoor Recreation was created April 2, 1962. Under the act of May 28, 1963 (16 U.S.C. 460), the Bureau is responsible for promoting coordination and development of effective programs relating to outdoor recreation. The Bureau carries out most of the responsibilities delegated to the Secretary under the Land and Water Conservation Fund Act of 1965, as amended (16 U.S.C. 4601-4).

Land and Water Conservation

Program and Financing (in thousands of dollars)

Identification code 10-16-5005-0-2-405	1973 actual	1974 est.	1975 est.
Program by activities:			
1. Assistance to States	101,249	135,000	179,000
2. Federal programs	88,596	123,724	97,500
3. Administrative expenses	5,173	5,573	6,500
Total program costs	195,018	264,297	283,000
Change in selected resources (undelivered orders)	108,203	45,625	17,000
10 Total obligations	303,221	309,922	300,000

Assistance to States. Funds are provided for assisting States in financing up to 50% of the cost of preparing recreation plans, acquiring land and water areas, and developing areas for public outdoor recreation purposes.

Federal programs. Funds are provided to the National Park Service, Forest Service, Bureau of Sport Fisheries and Wildlife, and the Bureau of Land Management to acqure certain areas for recreation use and to preserve nationally important natural and historic areas.

Administrative expenses. Funds are provided to coordinate and administer the State and Federal programs, and to review State recreation plans, State project proposals, and Federal land acquisition proposals.

Analysis by Activities

Activity	Amount Available 1974	Fiscal Year 1975 Estimated Total Available	Fiscal Year 1975 Unobligated Balance From 1974	Fiscal Year 1975 Budget Estimate	Total Available 1975 Compared to Total Available 1974	Page Reference
1. Assistance to States -------	$201,840,663	$210,840,663	$ 14,840,663	$196,000,000	$ +9,000,000	BOR-
2. Federal Programs ----------	117,349,141	97,500,000	--	97,500,000	-19,849,141	BOR-
3. Administrative Expenses ----	5,573,000	6,500,000	--	6,500,000	+927,000	BOR-
Total	324,762,804	314,840,663	14,840,663	300,000,000	-9,922,141	

1. Assistance to States--$196,000,000

Funds requested in 1975 together with all unobligated carryover balances will be used for grants-in-aid to States to finance up to 50 percent of the cost of preparing and maintaining outdoor recreation plans, acquiring land and water areas, and developing areas for outdoor recreation purposes.

2. Federal Programs--$97,500,000

Funds requested in 1975 will provide for the acquisition of additional land and water areas by the National Park Service ($71,500,000); Forest Service ($17,000,000); Bureau of Sport Fisheries and Wildlife ($8,500,000); and the Bureau of Land Management ($500,000).

3. Administrative Expenses--$6,500,000

Funds requested in 1975 will finance the cost of administering the Federal and State programs of the Land and Water Conservation Fund Act.

1. ASSISTANCE TO STATES

Need for Increase--(1) The fiscal year 1975 request of $196,000,000 represents an increase of $130,000,000 over the previous fiscal year 1974 appropriation of $66,000,000. This increase is needed to reestablish a program level commensurate with the States' ability to obligate Fund monies at a sustained rate for the orderly and effective acquisition and development of recreation areas and facilities under the Land and Water Conservation Fund authority. Reestablishment of such a program level is essential if acquisition and development of State and local land and facilities for park and recreation purposes is to keep pace with the Nation's needs. The combination of the termination of the HUD Open Space program and the uncertainies growing out of Congressional consideration of special revenue sharing has added further pressure on the Land and Water Conservation Fund. The upcoming Bicentennial celebration may well stimulate State activities to create and develop parks and open space at all levels of government with Land and Water Conservation funds.

In light of the national energy crisis, the Bureau is urging the States to accord priority funding to: (a) acquisition of land located along public transportation corridors, within walking distance of primary user groups, and accessible by non-motorized vehicles and public transit; and (b) gear development funds to projects which provide low energy-consumptive recreation activities, such as bicycling and hiking, and to urban-oriented day-use projects, such as tennis courts, swimming pools, playgrounds and ball fields.

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Under this program, Federal dollars are matched with an equal or larger amount of State or local money to finance the acquisition and/or development of outdoor recreation areas and facilities. As required by the Land and Water Conservation Fund Act, all projects must be in accord with the Comprehensive Statewide Outdoor Recreation Plan prepared by the State and approved by the Bureau of Outdoor Recreation. This requirement establishes an orderly approach to resolving t outdoor recreation needs at the State and local levels. Without exception the State plans indicate a growing need to provide more recreation opportunities and a lack of State and local funds sufficient to do the whole job.

Through F.Y. 1974, approximately $1,005,645,000 will have been appropriated on a 50-50 matching basis for State purposes and more than 13,000 individual grant projects approved by the Bureau of Outdoor Recreation. The F.Y. 1975 appropriations request of $196,000,000 is geared to an ongoing program effort which the States can obligate at present staffing levels without creating large future carryovers of idle public funds.

Highlights of Recent Accomplishments--Through the program of State grants, the Nation's publicly owned outdoor recreation estate has been increased by 134,000 acres at the State and local level during F.Y. 1973. In the same period $126 million in Federal grants matched by an equal amount of non-Federal monies was obligated for the development of outdoor recreation facilities.

2. FEDERAL PROGRAMS

	Fiscal Year 1974	Fiscal Year 1975	Increase (+) or Decrease (-)
National Park Service	$1,000,000	$71,500,000	$+70,500,000
Forest Service	4,000,000	17,000,000	+13,000,000
Bureau of Sport Fisheries and Wildlife	--	8,500,000	8,500,000
Bureau of Land Management	--	500,000	500,000
Total	$5,000,000	$97,500,000	$+92,50 ,000

Need for Funds Requested--The funds requested are for the acquisition of land and water recreation areas of national and regional significance. The large unobligated carryover which was available for acquisition in F.Y. 1974 will have been utilized by the beginning of F.Y. 1975. In developing the F.Y. 1975 program consideration was given to the energy requirements of reaching public outdoor recreation facilities. Recognizing these energy requirements, funds are programmed to acquire areas within reasonable access of major population centers and to continue an acquisition program of needed land and waters which provide a base for outdoor recreation opportunities. Funds are also recommended for the preservation of outstanding resources and certain species of rare and endangered wildlife. The requested funds are necessary to maintain viable acquisition programs and to preserve key properties for public recreation use and enjoyment.

1. PLANNING AND RESEARCH

Analysis by Subactivities

	F.Y. 1973 Amount Available	F.Y. 1974 Amount Available	F.Y. 1975 Estimate	Increase (+) or Decrease (-) 1975 Compared with 1974
1. Nationwide Planning ---------	$ 251,475	$ 268,000	$ 29,000	$-239,000
2. Water Resources and Resource Area Studies ----------	1,636,167	1,866,000	2,160,000	+294,000
3. Research and Education --------	86,260	93,000	101,000	+8,000
Total ----------	$1,973,902	$2,227,000	$2,290,000	$ +63,000

Water Resources Studies

No additional positions are requested in fiscal year 1975; this activity will remain at basically the same program level as in the previous year.

The Bureau's activities in the field of Federal water resources planning stem primarily from the Bureau's Organic Act (P.L. 88-29), the Federal Water Project Recreation Act of 1965 (P.L. 89-72), and the National Environmental Policy Act of 1969 (P.L. 91-190). Planning work will continue in three major areas:

Investigation of Federal Water Developments--The Bureau participates in studies of the recreation aspects of selected Bureau of Reclamation and Corps of Engineers and other Federal water resource development studies. Studies are conducted to relate proposed water development projects to public recreation needs and to ascertain the impacts on outdoor recreation, natural and scenic resources and associated environmental values. Full consideration is given to these elements as identified in the State comprehensive outdoor recreation plans which are required by the Land and Water Conservation Fund Act (P.L. 88-578). The Bureau recommends resource conservation and recreation use enhancement measures for consideration in project plan formulation and encourages non-Federal administration of recreation developments on Federal projects.

Review of Project Reports, License and Permit Applications, and Environmental Impact Statements--The Bureau reviews reports on water resource development proposals by the Corps of Engineers, Bureau of Reclamation, and other governmental agencies, and by private interests requiring a Federal action, license, or permit. Special reviews are made where postauthorization studies of selected Corps of Engineers projects result in significant changes in recreation benefits and costs.

The Bureau determines whether adequate consideration has been given to the preservation of natural, scenic, and recreation resources and related environmental values; to the opportunities which the project may afford for meeting outdoor recreation needs; and to the consistency of the proposals with the policies established by the Nationwide Plan. A determination is also made as to the extent to which proposed recreation and fish and wildlife development conforms to and is in accord with State comprehensive outdoor recreation plans.

The Bureau reviews environmental impact statements prepared in accordance with P.L. 91-190 for proposed Federal water resource developments and for license and permit actions. Comments are made concerning the adequacy of the consideration given to recreational resources and related environmental values and to feasible alternatives which would avoid adverse impacts. Applications for Corps of Engineers permits for dredging, filling, excavation, or other related work in navigable waters are reviewed by the Bureau. Substantive comments are provided on selected permit applications where significant recreational and environmental values are involved.

The Bureau reviews proposals for hydroelectric projects subject to licensing by the Federal Power Commission to assure that optimum public access and recreational opportunities are provided. An increasingly important part of the review function involves the provision of planning assistance to utilities during the early stages of project planning to identify public recreation needs that can be met by the private sector.

Water and Land Use Planning--Comprehensive water and related land resources planning for the Nation is an interagency program coordinated by the Water Resources Council. Field studies are scheduled in accordance with a consolidated interagency budget which provides for reimbursable financing of the work. The Bureau conducts regional studies of outdoor recreation potentials and environmental values, giving full consideration to alternative or competing uses of the resources. A determination is made of the outdoor recreation needs which can be met through conservation, development, and use of water and related land resources. The Bureau assists in plan formulation and prepares reports for river basin commissions or other Federal-State interagency groups having primary responsibility for developing a coordinated plan. The studies identify areas having outstanding recreational and environmental values needed for the Federal recreation estate and those appropriate for non-Federal administration. The Bureau also assists in data collection.

In addition, the Bureau will participate in the 1975 Assessment of Water and Related Land Resources. The recreation water needs will be identified as a part of the Nation's severe and emerging water problems requiring resolution by national, State, and regional actions.

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Highlights of Recent Accomplishments--Within the past year, the Bureau participated in more than 100 Federal water resource development projects proposed mainly by the Bureau of Reclamation and the Corps of Engineers. These projects included a general plan of development with respect to outdoor recreation and related environmental values.

The Bureau reviewed and commented on approximately 900 water resources development proposals submitted by Federal and non-Federal interests during the past year. Of these proposals, about 450 involved environmental impact statements. About 90 were water resources project reports initiated by the Bureau of Reclamation and the Corps of Engineers. Other reviews were made of 60 proposals by utilities requiring licensing by the Federal Power Commission; about 170 recreation related reports of other agencies; and 160 public notices of applications for permits in navigable waters. In addition, the Bureau provided planning assistance to eight applicants with non-Federal project proposals involving the development of recreation plans as part of the Federal Power Commission license application.

The Bureau's participation in comprehensive water and related land resources planning studies involved 13 major water resources regions during the past year. Major effort in providing recreation and related environmental input also continued on the Western U.S. Water Plan under the direction of the Bureau of Reclamation.

Resource Area Studies

The Bureau's activities in this area are under authorities delegated from the Bureau's Organic Act (P.L. 88-29), the Wild and Scenic Rivers Act (P.L. 90-542), the National Trails System Act (P.L. 90-543), the Wilderness Act (P.L. 88-577), the Alaska Native Claims Settlement Act (P.L. 92-203), and the National Environmental Policy Act of 1969 (P.L. 91-190).

Wild and Scenic Rivers Studies--Section 5(a) of the Wild and Scenic Rivers Act (P.L. 90-542) designated 27 rivers for study before October 2, 1978, to determine if they should be included in the National System. Reports on nine of the 18 rivers assigned to the Bureau will have been completed by July 1, 1974. Bureau-led studies on the remaining nine are presently underway. Of the nine river studies under the leadership of the Forest Service, one is completed. Funds requested by the Forest Service in FY 1975 will permit the agency to essentially complete five and make substantial progress on the remaining three.

The additional manpower requested will enable the Bureau also to make substantial progress toward completion of the river studies orginally assigned to it. The rate of urbanization and increasing development of second-home communities associated with recreation areas is an increasing burden on the remaining natural river resources The situation is even more critical than that which existed at the time the legislation was enacted and Congress expressed its interest in preserving significant wild river resources. It, therefore, becomes imperative that the study schedule be adhered to and the studies completed as rapidly as possible. Bills on more than 30 rivers are now pending before the Congress for addition to the study category (section 5(a)) of the Wild and Scenic Rivers Act. If authorized, studies of many of these rivers will be the responsibility of the Bureau of Outdoor Recreation. The Bureau will also participate in those additional river studies led by the Forest Service.

Technical assistance will be provided to State and local governments interested in developing wild rivers systems or in measures to protect the values associated with rivers in which they have an interest.

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BONNEVILLE POWER ADMINISTRATION

The Bonneville Power Administration (BPA) was created pursuant to the act of August 20, 1937 (50 Stat. 731, as amended; 16 U.S.C. 832 et seq.). Through a regionwide interconnecting transmission system, it markets electric power and energy from Federal hydroelectric projects in the Pacific Northwest constructed and operated by the Corps of Engineers or the Bureau of Reclamation. Through interregional connections, it sells power surplus to the needs of the Pacific Northwest outside the region, and participates in other interregional exchanges of power.

The Administration markets power produced by the Federal Columbia River Power System at the lowest rates consistent with sound business practices, for the benefit of the general public.

BPA in cooperation with the Corps of Engineers represents the United States in implementing the provisions of the Columbia River Treaty with Canada for the joint development of the with Canada for the joint development of the Columbia River. BPA plays a key role in the Joint Power Planning Council, comprised of all interested public and private power systems in the region and in formulating cooperative plans for efficient development of the region's future hydrothermal power facilities.

Program and Financing (in thousands of dollars)

Identification code 10-64-0328-0-1-401	1973 actual	1974 est.	1975 est.
Program by activities:			
1. System operation and maintenance	26,966	31,447	34,553
2. Purchase power and wheeling	45,156	33,170	30,210
3. Power contracts and rates	890	900	980
4. General Administration	2,221	2,570	2,980
Total program costs, funded	75,233	68,087	68,723

1. System operation and maintenance.- This activity consists of the scheduling and dispatching of power; the operation of substations; the maintenance of transmission lines, substations, and other facilities; power requirements studies; planning and integration of power resources; and system engineering.

Transmission facilities of BPA are expanded as increased generating capacity becomes available. The system will be operated and maintained at a level which will insure safe operation and provide a reliable grade of service to customers.

Power supply and scheduling. This activity consists of forecasting, on a short-term basis (2-1/2 years), the hourly load requirements of our customers and the interchange of power with other utilities; then scheduling the power to be generated at each Federal plant to meet these needs. This involves weathe and streamflow forecasting, controlling the storage and utilization of water in the reservoirs, and coordination of power production with the multi-purpose operation of the Columbia River system.

Increases in this activity in 1975 provide for continuation of contracts for operational investigations. Also included are a special snow survey and additional maintenance costs on the Hungry Horse hydrometeorological network.

SOUTHEASTERN POWER ADMINISTRATION

The Southeastern Power Administration was created by the Secretary of the Interior in 1950, to carry out functions assigned to the Secretary by the Flood Control Act of 1944 (58 Stat. 890), which pertain to the transmission and disposition of surplus electric power and energy generated at resevoir projects which are or may be under the control of the Department of the Army in the States of West Virginia, Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Tennessee, and Kentucky.

Program and Financing (in thousands of dollars)

Identification code 10-68-0573-0-1-401	1973 actual	1974 est.	1975 est.
Program by activities:			
1. System operation and maintenance	189	212	236
2. Purchase power and wheeling charges	4,609	4,555	4,555
3. Power contracts and rates	287	293	325
4. General administration	164	180	204
Total program costs, funded [1]	5,249	5,240	5,320
Change in selected resources (undelivered orders and accrued annual leave)	.....	−3	−3
10 Total obligations	5,249	5,237	5,317

1. System operation and maintenance.- Provision is made for investigation and planning of proposed water resources projects, scheduling and dispatching power generation, scheduling storage and release of water, administering contractual operation requirements, and determining methods of operating generating plants individually and in coordination with others to obtain maximum utilization of resources.

JUSTIFICATION

SYSTEM OPERATION AND MAINTENANCE.....$235,000

The activity is carried out to provide schedules for the generation of power, supervision of power deliveries as required by contractual arrangements, and determination of methods of coordinating operation of present and proposed generation plants to obtain maximum utilization of resources.

Primary areas of activity are:

1. Appraisal of proposed water resources development
2. Studies of project operations - long range
3. Studies of integrated project operation
4. Current determinations of power and energy available
5. Scheduling, storage, and release of water, and delivery of power and coordination of project operations with other projects and with the operations of utilities receiving power from the projects
6. Administration of contractual operating requirements
7. Meter testing and maintenance
8. Reporting

SOUTHWESTERN POWER ADMINISTRATION

The Southwestern Power Administration was created by the Secretary of the Interior in 1943, to carry out the Secretary's responsibility for the sale and disposition of electric power and energy generated at certain projects constructed and operated by the Department of the Army. For these projects the Administration carries out the functions assigned to the Secretary by the Flood Control Act of 1944 (58 Stat. 890; 16 U.S.C. 825s) in the States of Kansas, Missouri, Oklahoma, Arkansas, Texas, and Louisiana.

The Southwestern Power Administration consists of the headquarters offices located at Tulsa, Okla.; three area offices at Springfield, Mo., Muskogee, Okla., and Jonesboro, Ark., four maintenance units; and three dispatching offices.

Program and Financing (in thousands of dollars)

Identification code 19-72-0277-0-1-401	1973 actual	1974 est.	1975 est.
Program by activities:			
1. System operation and maintenance	2,117	2,347	2,747
2. Purchase of power and wheeling	11,706	15,999	17,110
3. Power contracts and rates	199	213	253
4. General administration	754	727	817
Total program costs, funded	14,776	19,286	20,927
Change in selected resources (undelivered orders)	109	.....	.....
10 Total obligations	14,885	19,286	20,927

Of the $5,817 thousand required for the 1975 operation and maintenance program. 47% is for system operation and maintenance; 35% is for purchase power and transmission service charges; 4% is power contracts and rates; and the remaining 14% is for general administration.

All operation and maintenance activities, with the exception of the expenses for the purchase of power and payment of transmission charges, are financed through direct appropriations. An appropriation for the purchase of power and payment of transmission expenses is necessary to cover monthly expenditures in excess of monthly receipts for each customer furnishing to SPA thermal power and energy and transmission service.

ALASKA POWER ADMINISTRATION

The Alaska Power Administration was created by the Secretary of the Interior in 1967, to carry our functions assigned to the Secretary, including among others the Eklutna Project Act (64 Stat. 382), and the Flood Control Acts of 1944 and 1962 (58 Stat. 890, 76 Stat. 1192; 16 U.S.C. 825's 43 U.S.C. 390), as they relate to the State of Alaska.

The Administration assignments include planning for water, power, and related resources development and utilization in Alaska in cooperation with other State, local, and Federal entities; operation, maintenance, and power marketing for Federal hydroelectric projects; and representing the Secretary of the Interior in Alaska on power matters.

Through the planning process the Administration focuses on problem solving for priority areas of energy, water, and land resources; identifies, and encourages the water, power, and related resources programs that are consistent with State and national needs for economic development and environmental protection; achieves optimum economics and reliability for the

government and consumer in the power operations and marketing functions.

The planning program includes participation in water, power, and related aspects of the land use planning under terms of the Alaska Native Claims Settlement Act, lead agency responsibility in the Alaska regional assessment of water and related land resources (Water Resources Council Program), power system studies, and evaluation of potential water, power, and related resources development.

Program and Financing (in thousands of dollars)

Identification code 10-62-1501-0-1-4-1	1973 actual	1974 est.	1975 est.
Program by activities:			
1. General investigations	504	526	636
2. Fish and wildlife studies	10	15	10
10 Total program costs, funded—obligations.....	514	541	646

1. General investigations. - To provide for investigations, surveys, and comprehensive studies to determine the most economical and appropriate means of development and utilization of water, power, and related resources, and to represent the Secretary of the Interior in Alaska on power matters.

2. Fish and wildlife studies - These funds are transferred to the Bureau of Sport Fisheries and Wildlife for studies of the fish and wildlife aspects of the Alaska Power Administration's General Investigations program (16 U.S.C. 771 et seq.).

Reimbursement of $60,000 is estimated to be received from our projects for technical administrative services provided by Headquarters. This is reflected in our program and financing schedule.

The FY 1975 obligations also include, for the first time, rental cost for space occupied in GSA-controlled buildings. Estimated space rental for FY 1975 is $47,000.

3. Resource Development Studies--$190,000. The resource development studies contribute to long range planning for development and use of Alaska's water, power and related resources.

Highest priority study areas for FY 1975 include assistance and input for the APA program areas to the land use planning under the Alaska Native Claims Settlement Act, cooperative investigations with the Corps of Engineers on the Devil Canyon hydroelectric

project, and providing effective leadership for the Alaska regional assessment under the Water Resources Council's 1975 National Assessment program. Limited updating of information on Alaska's major hydroelectric potentials and continued cooperation in other water and power matters would also be accomplished.

The land use planning under ANCSA, the many key decisions required from the Secretary of the Interior by the Act, and the changes in land ownership and management that will result all have extremely important implications on future development and use of all Alaska resources. The land use decisions will largely determine the nature of long range resource development in Alaska, including water, power, and all other energy systems. APA participation is intended to provide timely data and such additional analyses are merited to ensure appropriate consideration in the land use studies and actions of future needs for the water, power, and related resources.

The regional water resources assessment should also contribute significantly to the land use planning through better identification of the water problems, existing and emerging, the priorities for solving the problems, and the types of solutions that will work. The objective is to provide a low cost "mini-framework" study.

APA chairs the Alaska Water Study Committee comprising 30 State and Federal agencies and designated by the Water Resources Council as regional sponsor for the Alaska regional assessment. This is one of twenty-one regional studies under the 1975 national water assessment program under the Water Resources Planning Act of 1965. The bulk of the work is scheduled for completion in FY 1975.

The Alaska assessment addresses the largest and least understood of the 21 Water Resources Council regions and tremendous water and related resources values. It seeks to provide for the first time a joint Federal-State-local perspective of Alaska water and related land resources and a consensus on the values, problems, opportunities, and related land resources and a consensus on the values, problems, opportunities, and needed water programs.

The new national energy conservation objectives and the rapidly changing outlook for fuels availability and costs have created much new interest in Alaska's hydroelectric potentials. The interest is focusing on the Devil Canyon Project, a key unit of the Upper Susitna River Basin Project. Devil Canyon, with upstream storage at Denali Dam, could provide about 600,000 kilowatts, and 2.9 billion kilowatthours per year to the

Alaska Railbelt area, potential power market with over 70 percent of the electric requirements of the State. Additions of the Vee and Watana units, between Devil Canyon and Denali, would provide a total of 1.6 million kilowatts and 7 billion kilowatthours per year for full development of the Upper Susitna potential.

Alaska Power Admin. transfers to other agencies appropriate portions of the General Investigations program to the end of minimizing requirements for Alaska Power Administration staffing and assuring optimum participation of the other agencies in the investigation findings. This includes arrangements for joint investigations in which all participating Federal and State agencies bear their own costs, with the Alaska Power Administration assuming the overall responsibility and the technical aspects not appropriate to the other entities. It also includes cooperative agreements, under which the Administration funds the services requested of the cooperating agencies.

OFFICE OF WATER RESOURCES RESEARCH

The Office of Water Resources Research (OWRR) administers the program of water resources research and training authorized by the Water Resources Research Act of 1964, as amended (78 Stat. 329, 80 Stat. 129; 42 U.S.C. 1961 et seq.). Major program purposes are to: develop through research new technology and more efficient methods of resolving local, State, and nationwide water resource problems; train water scientists and engineers through their on-the-job participation in research work; and facilitate water research coordination and the application of research results by furnishing information about ongoing and completed research. OWRR does not maintain its own laboratories or perform "in-house" research.

Program and Financing (in thousands of dollars)

	Identification code 10-12-0115-0-1-401	1973 actual	1974 est.	1975 est.
	Program by activities:			
	1. Assistance to states for institutes	5,264	5,100	4,539
	2. Matching grants to institutes	2,998	3,000	3,000
	3. Additional water research	3,904	3,170	3,170
	4. Scientific information center	885	934	940
	5. Administration	952	1,025	1,051
	Total program costs, funded	14,003	13,229	12,700
	Changes in selected resources (undelivered orders	277	--------	--------
10	Total obligations	14,280	13,229	12,700

1. Assistance to States for institutes. - This activity provides annual grants for each of the 50 states and Puerto Rico to assist them in carrying on the work of competent and qualified water resources research institute at one college or university.

2. Matching grants to institutes. - This activity provides for grants to match, on a dollar-for-dollar basis, funds made available to the State water research institutes by States or other non-Federal sources to meet the necessary expenses of specific water resources research projects which could not otherwise be undertaken.

3. Additional water research. - This activity provides for grants to and contracts and matching or other arrangements with educational institutions, private foundations or other institutions, private firms and individuals, and with local, State, and Federal Government agencies, to undertake research into aspects of urgent and significant water problems related to the mission of the Department of the Interior.

4. Scientific information center. - This activity provides for the operation of a national water resources scientific information center.

5. Administration. - This activity provides for the administration of the Water Resources Research Act.

Office of Water Resources Research
Examples of Priority Research Subjects for Title II Support
Fiscal Year 1975

The Title II research program of the Office of Water Resources Research will be directed primarily toward support of certain current priority objectives of the Department of the Interior. These include:

- Solving of Energy Problems.
- Encouraging Indian Self-Determination and Improvement in the Quality of Life on Indian Reservations.
- Promotion of Efficient Allocation and Conservation of Scarce Water and Water-Related Resources in a Manner Compatible with Environmental Considerations. Developing means of achieving more efficient resource management such as reuse and recycling of water,

11. Water Demand Considerations. In regions where water supply is unable to keep up with demand, the value of water for specific purposes will increase. Further research is needed on the effect of price on demand with specific attention to the value of water for irrigated agriculture, recreation, industry, urban use and other purposes. Research is also needed to determine appropriate alternative objectives and to develop methods to evaluate benefits in relation to costs for the different objectives such as, improved distribution of population, environmental quality, and other social values.

Scientific Information Center

Analysis by Activity

Activity	F.Y. 1973 Amount Available	F.Y. 1974 Amount Available	F.Y. 1974 Estimate	Increase (+) or Decrease (-) 1975 compared with 1974
Scientific information center.....	$934,000	$934,000	$940,000	$+6,000

Scientific information center: Fiscal year 1974, $934,000; fiscal year 1975, $940,000; an increase of $6,000. The increase consists of:

Increase (+) or Decrease (-) Amount	Positions	Total Program	Total Positions	Explanation
$+6,000	--	$940,000	8	Pay raise costs

With the proposed $940,000 OWRR's Water Resources Scientific Information Center (WRSIC) will continue its 1975 operations at approximately the same level as in 1974.

In 1975 WRSIC will:

(a) Acquire about 15,000 additional abstracts reflecting the results of completed water resources research as described in technical journals and reports, monographs, books and serials; process these abstracts into machine-readable form for WRSIC's information base; and publish these abstracts with appropriate indexing terms in WRSIC's "Selected Water Resources Abstracts" bulletins that are made available to the water resources community on a twice monthly basis;

(b) Support 9 "literature centers of competence" providing abstracts for the WRSIC information base, and encourage and obtain the cooperation of Federal, State, and other organizations in providing information base abstracts;

(c) Publish, in collaboration with the Smithsonian Science Information Exchange, a comprehensive annual catalog of abstracts describing ongoing research projects;

reassessing the economic value of additional agricultural development and improved irrigation efficiencies in order to save resources, thus reducing the need for large capital investments of the future.

Improving the Quality of our Physical Environment.

In addition to the above Departmental objectives, OWRR has again identified general subject areas of prime interest. These are listed below, with examples of specific research requirements.

Many water-related resource problems are applicable to both Departmental priority objectives and OWRR subject areas of prime interest. Proposals for research which offers a high assurance of increased effectiveness in dealing with such dualistic problems will receive strong consideration for funding.

OWRR will also consider funding other subject areas of research not included on this priority list if the research proposal provides convincing reasons that the subject area is of high priority and within the purview of Title II of the Water Resources Research Act of 1964, as amended.

OWRR Priority Research Subjects

1. Improvement of Water Resource Planning, Managerial, Financial, Operating and Regulatory Policies. In approaching this problem, research goals should be to provide a basis for establishment of improved mechanisms, including evaluation of alternative means of augmenting and conserving supply, for water resources planning, implementation of plans, and to improve management effectiveness through lessening of conflicts, uncertainties, and confusion among claimants to the resource.

2. Water Resources Policy and Political Institutions. Understanding of policy and institutional problems is indispensable to sound water resources management by both the public and private sectors of the Nation. Research is needed on how institutional policy is measured and formulated and what policies and arrangements are conducive to sound water management. Among the questions to which research could be directed are those involving current policies and institutions. The river basin as a water management unit needs further evaluation with respect to the compatibility of water resources management objectives and the needs of regional economic development.

3. Hydrologic Systems Analysis. The application of operations research tools such as mathematical modeling and simulation, optimization and design theory need to be assessed and further explored in relation to hydrologic events and to planning of surface and ground water resources development.

4. Urban and Metropolitan Water Resources Problems. Research is needed on urban hydrology and the effect of man's activities on water. Such research could include evaluation of the impact of urbanization on the frequency and magnitude of flood peaks, reduction of low flows, decrease in natural ground water accretion, impairment of water quality, erosion, etc., and development of methodology and technology to cope with such problems.

5. Evaluation of Economic Importance of Various Uses of Water, Cost Allocation, Cost Sharing, Pricing and Repayment. Methodologies are needed for estimating future water demands in time, place, and quality with full consideration given to the economic relationships between supply and demand as well as the impact of new technologies. Research is needed for improving the methods used in evaluating primary, secondary and externality benefits of water resources projects.

6. Ecologic Aspects and Environmental Consideration of Water Resources Planning and Management. Improved means of identifying, assessing and predicting ecologic impacts of water development such as dam building, drainage, irrigation, dredging, filling, channelization, and weather modification are needed. Conjunctive ecological studies designed to minimize harmful effects and optimize the beneficial effects of these water developments on the environment are also indicated.

7. Analysis and Evaluation of Water Resources Projects. Benefit-cost analysis has been the principal tool for evaluation of public investment programs, including watershed and water resources programs. It has ranked projects and programs in terms of the objective of economic efficiency only. Research is needed to determine appropriate alternatives and multi-objectives which will insure that presently unquantified environmental amenities and values may be given appropriate considerations. Evaluation of methods to quantify values in terms of appropriate objectives and assigning weights to these values is needed so that alternative objectives and/or combinations of objectives can be compared.

8. Ground-Water Supply, Management, and Protection. Research is needed on management methods and techniques to protect the ground-water resource from degradation and overdraft; also to insure its availability and safety for domestic, municipal, industrial, and agricultural purposes, and to accomplish the integrated management of surface and ground water resources. In many areas over the Nation, productive aquifers find limited use because the quality of the native ground water is unacceptable

for the water has become contaminated. Many constitutents or properties imparting objectionable tastes, odors, or esthestic traits exceed allowable limits. Better techniques should be research as to feasibility of water spreading and well injection in various surficial earth materials and aquifers. Research is particularly applicable in regions where the surficial materials are of low permeability. Research is needed also on the geochemical effects of artificial ground-water recharge.

Regarding the degradation of ground-water quality by contaminants, basic research is needed on the geochemistry--reactions among water soil and rock materials, and contaiminants in the aquifer system.

A serious deficiency of aquifer system models is the inability to portray accurately fluid movement in the unsaturated zone, losses from the system by evapotranspiration, and accretions by infiltration or recharge. This aspect of fluid movement also has an important influence on surface runoff. Research is needed on the physics of fluid movement and solute interactions in unsaturated granular media.

9. Protection and Rehabilitation of Estuarine Resources. Research is needed to develop criteria, standards and guidelines for including ecological effects in planning for water resource development of estuaries and coastal bays, such as: dredging, filling, dams, diversions, land-cut canals, hurricane barriers, and waterfront finger-type developments. These studies should attempt among other things to assess the biological effects of these developments by changing temperature, salinity, flow regimes, circulation, flushing and sedimentation, and destruction of vegetation.

10. Thermal Loading Problems. With the expected increase in number of electric generating plants and the consequent thermal loading of rivers, lakes, and estuaries, increased research attention is needed to develop new or improved approaches to physical mixing and thermodynamics of the heated discharges; in development of economically competitive alternatives to use of once-through water as a heat-transfer medium; on biologic, ecologic, environmental and sociologic impacts, on types and quantities of data required to properly evaluate facility sites and to choose among alternative sites; on adequacy of regulations and procedures for site sel ctions with respect to water use and management; and on possible ways of beneficially utilizing the heat for food production, recreation, or other purposes.

(d) Prepare and disseminate several topical bibliographies of special interest and a limited number of state-of-the-art reports on selected subjects;

(e) Respond to the technical information needs of water program officials by employing an automatic retrieval program and growing information base of approximately 70,000 citations and abstracts to economically and rapidly generate topical bibliographies of significant problem areas, and respond to special requests for literature reference relating to specific water resource interests; and

(f) Continue an experimental program of operating a small number of geographically dispersed remote terminals to determine the feasibility of providing improved technical information services.

WRSIC's importance to the Nation's water resources community has steadily grown as its information base has expanded and its reputation for responsiveness has become well known. The Center is: (a) playing a major role in the avoidance of undesirable research replication, thereby contributing to more effective use of available water resources research dollars; (b) improving communication and coordination of efforts among organizations and individuals engaged in water-related research; and (c) serving as a focal point for water resources research information through its comprehensive and responsive program. Persons and organizations familiar with Scientific Information Center's program have been highly complimentary and have in many cases urged continued expansion of the program as rapidly for funding will permit.

The "additional water research" or "Title II" program provides balance and flexibility to the overall water research program by giving the Department access to the specialized research expertise available in private firms and foundations, governmental agencies at all levels, as well as universities not participating in the Title 1 program. It is expected that the $3,170,000 requested for this activity will permit funding for projects to augment and expand work carried out under the Title I program.

For the 1974 "Additional water research" program, over 340 research proposals were received from private firms, universities and others for OWRR's consideration. Total funding requested by these proposals exceeds $31 million. Forty-three of these proposals have been selected for support. OWRR

anticipates that it will receive approximately the same number of proposals for 1975 as were submitted for consideration in the 1974 program. The large number of proposals submitted permits the Department to be very selective in supporting only those having the highest technical merit and greatest relevance to water resource matters of concern to the Department and the Nation.

A few illustrative examples of Title II program project results developed in the past year are set forth below:

(1) The University of Texas has developed a practical and effective strategy of optimization that can be applied to the expansion of a complex water resources system. The problem involved is to specify if and when each dam should be built in the system and also the sequence of reservoir releases so that the revenue function for the water resources system is maximized. To accomplish the objectives, several computer programs have been prepared which carry out the numerical computations for a given water resources system. With the aid of the documentation associated with the computer programs, it is possible to determine what information has to be gathered from the water resources system. Once the information is collected, it is possible to use the computer code to help decisionmakers in evaluating alternative policies over a planning horizon of a large number of years.

(2) A Purdue University Title II project has developed rainfall-ground-water level interaction models for short term forecasting of ground-water levels. The predicted ground-water levels can then be used to specify the variable boundary conditions encountered in the digital ground-water model. The ground-water model now being developed will aid in investigating whether a presently used source of water is adequate to meet the domestic and industrial water requirements in Tippecanoe County, Indiana by the year 2020.

(3) Research by a Walnut Creek, California firm resulted in the development of a method of ecologic simulation for aquatic environments. This provides a useful tool, not previously available, which enables engineers, scientists, and planners to utilize ecologic information in the development and management of water resources. Already there has been a lively response to the findings. The Corps of Engineers' Hydrologic Engineering Center has been granted permission to reprint the report for use in a water quality management training course. A valuable "pay-off" is being realized, under a memorandum of understanding between OWRR and EPA, whereby the project has been extended to apply the

research results to the solution of critical water-quality problems in Puget Sound, Washington. Recently the Netherlands has requested assistance in possibly applying this technique to water quality prediction in the older areas of their country.

(4) A substantial number of families in this country, and particularly in the New England area, are entirely dependent on wells in crystalline rock for their water supply. Commonly the yields from such wells is inadequate or quite small. Research at the University of New Hampshire is seeking to determine if hydraulic fracturing is an effective and economical means of stimulating water well yields. Research results, thus far, in two test wells show that yields of each well were increased from 4 gallons per minute to about 15 and 24 gallons per minute respectively.

(5) Concentrations of naturally occurring uranium and isotopic ratios have been used successfully in a Florida springs and one spring-fed river system. This technique may be adapted to evaluating the pollution potential of ground water in specific areas, evaluating the potential hazard for salt-water intrusion in coastal areas, and determining areas and rates of ground-water recharge.

(6) A dynamic programming optimization procedure that determines the sequence of releases and withdrawals from a system of multiple reservoirs supplying water to metropolitan centers has been developed by a Title II project in Texas. The procedure takes into consideration water losses due to evaporation, flow augmentation requirements and flood spillages and determines the minimum cost policy to meet the metropolitan requirement, while retaining a specified volume of water in storage at the end of a time period. Water treatment costs, power and pumping costs and purchase water costs are included in costs evaluated. The program in currently being implemented and tested on the City of Dallas computer system.

ENVIRONMENTAL PROTECTION AGENCY

RESEARCH AND DEVELOPMENT

Program and Financing (in thousands of dollars)

	Identification code 20-00-0107-0-1-404	1973 actual	1974 est.	1975 est.
	Program by activities:			
	Direct program:			
	Pollution processes effects, and control technology	158,715	178,100	171,000
	Reimbursable program	832	1,200	1,200
10	Total program costs, funded—obligations	159,547	179,300	172,200

EPA's research and development efforts are conducted through grants, contracts, and agreements with universities, industries, other prive commercial firms, non-profit organizations, State and local governemnts, and Federal agencies as well as through research and development at EPA's laboratories and field locations.

These efforts are oriented toward producing the scientific knowledge and the tools for regulating, preventing, and abating pollution and are specifically directed to the problems of air pollution control, water pollution control, water supply protection, solid and toxic waste management, pesticide control, radiation protection, noise abatement, and interdisciplinary studies. Activities encompass research on the effects of pollutants on man, animals, aquatic life, plants, materials, and the general environment; research on the processes, such as dispersion, that affect pollution; the development of new and improved sampling and analytical methods and instruments for measuring pollutants; and the development and demonstration of new and improved technology for preventing and controlling pollution and recovery of materials from wastes. Included with the research and development program is its overall management and support.

Water Quality

Purpose

The water quality research and development program embodies: (1) health effects research dealing with the development of valid criteria for the safe traatment and disposal of effluents and sludges from municipal and industrial wastewater treatment plants; (2) research on the effects of water pollutants on aquatic life and on the chemical and physical quality of water bodies or basins in relation to their intended use; (3) research on the movement, transformation, and fate of water pollutants; (4) the development of new and improved sampling and analytical methods and instrumentation of measuring water quality and effluents; and (5) the development of new and improved technology for abating and preventing water pollution. The effects and processes research is oriented toward development of water quality standards. The analytical methods and instrumentation development is directed toward providing new and improved techniques for water quality and effluent monitoring and surveillance of standards compliance. The purpose of the control technology program is to improve existing processes and to develop new and more effective and economical methods of wastewater treatment. These programs will demonstrate best-available and closed-loop systems and will serve as a sound technical basis

for the establishment and enforcement of effluent guidelines and water quality standards. Like the air research and development program, this is a "foundation" program providing the scientific knowledge and the technology for carrying out an effective national water pollution control program.

	1974	1975	Increase or Decrease
Budget Authority			
Processes and Effects..	$18,462,600	$18,391,400	-$71,200
Control Technology.....	24,896,700	22,606,600	-2,290,100
Total.....	43,359,300	40,998,000	-2,361,300
End-of-Year Employment			
Processes and Effects..	352	324	-28
Control Technology.....	283	262	-21
Total.....	635	586	-49
Man-Years, Total.....	636	592	-44

Water Quality
Processes and Effects

Justification

	1974	1975	Change
Health effects.....	$31,600	$1,131,900	+$1,100,300

The goal of the water quality health effects program is to develop scientifically sound and valid criteria for the safe treatment and disposal of effluents and sludges from municipal and industrial wastewater treatment plants. Current knowledge on the transmission of diseases through mechanisms of transport from wastewater treatment plants and spray irrigation are inadequate. Adverse health effects can result from the use of wastewater effluents and sludges on agricultural land (e.g. pathogen transport or heavy metals concentration in soils, crops, or groundwater).

1975 Objectives

Identification of potential contaminants and/or pathogens resulting from the land treatment and disposal of wastewater effluents and sludges and determination of their transport pathways.

	1974	1975	Change
Other processes and effects.	18,431,000	17,259,500	-1,171,500

EPA has over the past few years been deeply involved in research to provide data and pertinent information for the establishment of water quality criteria that will provide a sound scientific basis for setting standards for such water uses as public water supply, recreation, fish and wildlife propagation, agricultural supply, and industrial purposes. Indepth studies have been carried out to determine the effects of physical, chemical, biological, microbiological, pesticidal, and radiological pollutants on water uses. Related to the effects of various pollutants in water are questions concerning the types, movement, and ultimate fate of pollutants in fresh surface, ground, marine, and large lake waters. Serious deficiencies exist in techniques for tracing pollutants and how they interact within total aquatic ecosystems. This information is needed to relate the concentration and form of pollutants to the size, character, composition, and location of their sources in order to establish effective water quality standards, treatment, and control requirements.

Significant 1974 Accomplishments

- Published a comprehensive report on Thermal Pollution;
- Published reports on photochemical degradation of organo-mercury compounds in aqueous systems;
- Initiated evaluation of the restoration of a eutrophic lake by advanced waste treatment of primary nutrient input;
- Issued report describing alternative lake restoration methods and evaluating results of documented applications;
- Determined effects of waste oil on reproduction and survival of selected freshwater fish species;
- Developed marine water quality information for inclusion in EPA Water Quality Criteria published in 1974; and
- Completed assessment of groundwater pollution problems in Northwestern states.

1975 Objectives

- Initiate investigation of the effect of asbestos on aquatic life;
- Complete Upper Great Lakes Study and issue report.

- Complete report on water quality status of Lake Erie;
- Develop predictive model for eutrophic lakes restored by advanced waste treatment.
- Determination of important reactions, metabolites, and kinetic factors associated with microbial degradation of pesticides in aquatic systems and sediments;
- Determination of water quality effects of cooling tower brines and blowdown, and effects on atrompheric and aquatic systems of plumes, mists, and stack effluents from cooling towers;
- Assess groundwater pollution problems of southeastern and North Central states; and
- Complete Estuarine Research section of the National Estuarine Study as required by P.L. 92-500, Sect. 104 (n).

Water Quality
Control Technology

Justification

	1974	1975	Change
Control technology. . . .	$24,856,700	$22,565,600	-$2,290,100

This activity covers the research, development, and demonstration of new and improved technology to treat wastewaters and to control water pollution from urban and rural population, industrial, agricultural, mining, construction, spills, and other sources. Pertinent technical areas include the development of unit processes and systems to remove organic and other pollutants from sewage and the control and treatment of wastewaters from urban systems carrying storm water and sewage (combined sewers) and urban storm water discharges. This research is in direct support of the Agency's multibillion dollar grants program for construction of public wastewater treatment works. The industrial water pollution control technology program is aimed toward improving industrial wastewater treatment practices. It provides the primary data base for the establishment of economically and technically feasible effluent guidelines, and treatment parameters for liquid waste discharges permits. The water pollution control technology research program relating to mining, agricultural, and other sources includes: the development and verification of analytical/predictive methods to assess the magnitude and

character of these sources, demonstration and documentation of the effectiveness, cost and range of applicability of currently available pollution control options; and the development and demonstration of new, cost-effective systems.

Significant 1974 Accomplishments

- Placed into operation and initiated evaluation of central community demonstration facilities for safe water supply and wastewater control for use in native villages in Alaska;

- Initiated evaluation of the first U.S. full-scale municipal physical-chemical wastewater treatment works;

- Completed demonstration of powdered activated carbon use in municipal wastewater treatment, thereby offering the potential for reduction in capital and operating cost over currently used activated carbon treatment processes;

Water Supply

Purpose

The water supply research and development program provides for research on the effects of water quality on human health and the development of analytical methods for assessing the quality of drinking water and development of water treatment methods for undesirable contaminants of water supplies for which current methods are ineffective. The objective of the program is to provide scientific knowledge necessary for establishing standards for organic, inorganic, and microbiological contaiminants of drinking water and to develop the technology needed to economically attain the drinking water standards.

	1974	1975	Increase or Decrease
Budget Authority			
Processes and Effects.....	$1,902,400	$3,114,100	+$1,211,700
Control Technology.....	599,900	1,404,100	+804,200
Total.....	2,502,300	4,518,200	+2,015,900
End-of-Year Employment			
Processes and Effects.....	55	54	-1
Control Technology.....	20	20	...
Total.....	75	74	-1
Man-Years, Total.....	74	72	-2

ABATEMENT AND CONTROL

Program and Financing (in thousands of dollars)

	Identification code 20-00-0108-0-1-404	1973 actual	1974 est.	1975 est.
	Program by activities:			
	Direct program:			
	Standards setting, planning assistance, and training	194,239	267,723	359,603
	Reimbursable program	2,679	3,977	3,977
10	Total program costs, funded—obligations	196,918	271,700	363,580

EPA is responsible for major Federal environmental pollution abatement and control programs, including programs in air and water pollution control, water supply and radiation protection, solid and toxic waste management, pesticides control, noise abatement, and interdisciplinary activities.

Program efforts entail developing environmental standards; monitoring and surveillance of pollution conditions; grant support of State and local pollution control planning; direct Federal pollution control planning; grant support for State, regional and local pollution control programs, technical assistance to pollution control agencies and organizations; assistance to Federal agencies in complying with environmental standards and insuring that their activities have minimum environmental impact; and training to increase the supply of and improve the skills of pollution control personnel. Increases for drinking water supply and toxic waste management are related to pending legislation.

Water Quality

Purpose

The water abatement and control program encompasses those activities carried out by EPA to implement the Federal Water Pollution Control Act Amendments of 1972, with the exception of activities related directly to research and development and enforcement, which are covered under separate appropriations. The major elements of the program include:

- the assessment of areas in which water pollution is most serious;

- the development of plans for all navigable water under Section 203(e) to provide the basis for establishment of effluent limitations and schedules of compliance for municipal, agricultural, and industrial dischargers;

- the development of guidelines for the issuance of discharger permits specifying effluent limitations to municipalities and industries;

- the approval of Federal grants for the construction of municipal sewage treatment works to enable them to achieve required effluent levels;

- the establishment of effluent guidelines representing best practicable and best available technology for various industries; and

- the study of the nature and extent of nonpoint sources of pollution.

Because the primary responsibility for the control of pollution lies with the States, most of EPA's abatement and control efforts are oriented toward support of State and local efforts. States are responsible for detailed planning, monitoring, and enforcement efforts, as well as establishing the priorities for the commitment of Federal funds for the construction of sewage treatment plants. In addition to their mandated roles, States are being encouraged to undertake the issuance of industrial and municipal permits. A substantial portion of the resources included in this program are in the form of grants to State and interstate water pollution control agencies. EPA activities in monitoring and surveillance are in direct support of the State and local programs; EPA provides technical assistance to the State and local agencies in development and operation of their programs; and EPA provides or supports training to improve the skills of State and local water pollution control personnel as well as to increase the availability of water pollution control manpower. Also, under this program, EPA assists other Federal agencies to bring their facilities into conformance with prevailing pollution standards and helps ensure that the programs, projects, and other activities of Federal agencies produce a minimum water pollution impact.

Water Quality
Ambient Trend Monitoring

Justification

	1974	1975	Change
Ambient trend monitoring.....	$5,418,000	$5,274,800	-$143,200

The water quality monitoring program provides for the collection, processing and analysis of water quality and water management data to implement the Federal Water Pollution Control Act Amendment of 1972. The main analytical tasks are to determine water quality, to measure changes in this quality, and to relate these changes to policy alternatives. The main data processing activities are to maintain water quality data files to support policy analyses and permit issurance, and to maintain operational data files in order to manage programs such as permit issuance and permit enforcement. The main data collection programs are for water management data (largely for the permit program), for the National Water Quality Surveillance System, and for State monitoring programs.

Significant 1974 Accomplishments

- Performed monitoring needed to support load allocations for permits;

- Analyzed water quality and water quality trends for the Nations's 22 major rivers. Analysis was the basis for EPA report to Congress on the Nation's water quality;

- Established network of paired water quality stations for the National Water Quality Surveillance System; and

- Entered all necessary permit data into the General Point Source File as basic data system for water management data.

1975 Objectives

- Reorient State water monitoring programs to be consistent with FWPCA Amendments of 1972;

- Analyze the implications of EPA municipal construction grant program using data merged together from separate municipal data files;

- Collect paired station data in National Water Quality Surveillance System for use in mid-course correction;

- Perform intensive surveys of cause and effect relationships between point sources, nonpoint sources, and water quality in selected National Water Quality Surveillance System segments to assess permit compliance and effectiveness; and

- Prepare 1974 National Water Quality Inventory Report to Congress, including an analysis to determine quantitatively that portion of the Nation's water problem that will be effected by point source controls.

Water Quality

Technical Assistance and Planning

Justification

	1974	1975	Change
Water quality planning.....	$11,477,400	$11,842,200	+$364,800

This area includes funds for water quality planning, technical information, Federal activities, and standards and regulations development.

The principal elements of Water Quality Planning relate to assisting the States in the preparation of Section 303(3) water quality management plans, conducting a Federal overview of the development of areawide waste treatment management plans under Section 208 and reviewing waste treatment facility plans that are the prerequisite first step in the construction grant process.

Under Section 303(e) of the Act, the State plans are being developed for over 550 basins, and are forming the basis for program actions to abate pollution within the States. Preparation of these plans involves collecting water quality and waste discharge data, determing permissible discharges of pollutants which will comply with water quality standards and, as necessary, establishing waste discharge targets for major sources. Additionally, the plans will provide a data base for the annual water quality assessment and projection report to Congress required by Section 305 (b), and for determing nonpoint source controls and practices to alleviate the effects of residual solid waste. EPA provides assistance, including support required in applying stream waste-load analyses, in development of the plans.

Review and assistance is provided on facilities plans developed by local communities. These plans evaluate alternative waste management techniques prior to the award of a construction

grant. An essential element in these plans is the incorporation of cost-effectiveness considerations.

This activity also includes the funding of Great Lakes demonstration projects under Section 108 of the 1972 Amendments. Projects funded under this Section provide for the demonstration of management techniques for controlling and abating pollution of the Great Lakes.

Finally, this activity also provides for the appropriation of funds to be transferred to the Departments of Housing and Urban Development, Commerce, and Transportation and the Atomic Energy and Federal Power Commissions to enable them to participate in Water Resources Council planning studies.

Significant 1974 Accomplishments

- Assisted States in completing 200 basins plans, and conducting water quality analyses in 1,375 stream segments to support development of basin plans; and

- Review 1,000 Section 201 Facilities Plans required for awarding construction grants.

1975 Objectives

- Assist in preparation of 350 additional Section 303(e) river basin plans; and

- Review 1,500 Section 201 Facilities Plans as required for the awarding of construction grants.

	1974	1975	Change
Technical information and assistance.....	$4,881,700	$4,968,900	+$87,200

EPA provides technical guidance, assistance and information to States, other Federal agencies, and local agencies to assist with the development of programs for control of water pollution. These activities include assisting States in the preparation of their annual plan for the prevention, reduction, and elimination of water pollution; by providing guidance on the setting of standards; in the development of uniform laws and international agreements for controlling border pollution; through dissemination of technical information concerning scientific and engineering advances; and through technical consultations, as required. Included in these general activities are specific program actions in providing and implementing water quality criteria and information

Water Quality
Control Agency Support

Justification

	1974	1975	Change
Control agency support.....	$50,000,000	$40,000,000	-$10,000,000

The water control agency support program provides Federal support to State and interstate water pollution control agencies. These agencies have principal responsibilities for implementing many parts of the Act, including basin planning and monitoring. In addition, it is expected that many States will, over time, assume administration of the permit program, with related enforcement and surveillance responsibilities. Where they have not yet done so, EPA and most States mutually undertake the technical analysis for setting the permit conditions. Also, the States have the singular responsibility for undertaking State-wide programs in the area of nonpoint source control.

In the construction grants area, States have been asked to assume primary responsibility for the review of plans and specifications for treatment plants, showing evidence that cost effectiveness, infiltration inflow, and user charge criteria have been met.

In the planning area, States will have full responsibility for the development of Section 303(e) plans over 550 river basins in the country. Many of these require detailed monitoring surveys to determine what levels of effluent control are needed to meet water quality standards.

Significant 1974 Accomplishments

- Awarded grants to 55 State agencies and six interstate agencies to enable them to carry out effective water pollution control programs, including;
  - the development of basin plans to establish program abatement actions;
  - the operation of 10,000 monitoring stations; and
  - the operation and maintenance inspection of treatment plants.

1975 Objectives

- The 1975 objectives for State and interstate water pollution control agencies utilizing control agency support funds are as follows:

  - to process 3,000 project applications for construction grants;

  - to issue 30,000 municipal, industrial, and agricultural permits;

  - to develop Section 303(e) plans for 300 river basins; and

  - To begin to determine the nature of nonpoint source pollution in selected river basins.

Water Supply
Technical Assistance

Justification

	1974	1975	Change
Technical assistance.....	$2,207,100	$3,193,300	+$986,200

The water supply program involves four primary activities: (1) annual certification of all drinking water supply systems serving interstate carriers, such as airplanes, trains, buses, and vessels; (2) development and maintenance of a comprehensive inventory of public water supply systems; (3) technical assistance and training to improve water supply systems and programs, including special studies and comprehensive State program evaluation; and (4) development of drinking water standards and implementation of their use to assure the maximum feasible protection of the public health.

The development of drinking water standards and the certification of interstate carrier water supply systems are legislatively mandated functions. A comprehensive inventory of puclib water supply systems is an essential element in the development and implementation of effective Federal, State, and local water supply programs. Technical assistance and training are vital means to implement the full application of water supply technology to promote safe and adequate drinking water supply systems.

Significant 1974 Accomplishments

- Certified 700 interstate carrier water supply systems;
- Essentially completed the inventory of some 40,000 public water supply systems;
- Completed the comprehensive evaluation of seven State water supply programs;
- Completed the revision of the 1962 Drinking Water Standards;
- Completed three special studies of water supply systems serving the traveling public;
- Completed a monograph on water treatment effectiveness and cost; and
- Completed a Manual for the Evaluation of State Drinking Water Supply Programs.

1975 Objectives

- Fully implement the improvement in the operation of the interstate carrier water supply certification program as recommended in the Comptroller General's Report of November 17, 1973;
- Certify 700 interstate carrier water supply systems;
- Complete the comprehensive evaluation of four State water supply programs;
- Complete a field study of disinfection techniques suitable for use on small water supply systems;
- Develop a series of analytical reports, based on inventory data, characterizing the Nation's public water supply systems;
- Develop additional standards and guidelines for constituents found in drinking water as research data becomes available;
- Complete development of benefit/cost evaluation of the impact of alternative levels for selected drinking water standards on public health and welfare;

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- Complete evaluations of water supply systems staffing, treatment, and chemical usage;

- Continue and complete a study of water treatment cost and effectiveness;

- Complete survey reports characterizing State water supply programs;

- Plan for a study as appropriate to determine the maximum contaminant levels to protect the health of persons from any known or anticipated adverse effects; and

- Complete an inventory of water supply systems at Federal recreational areas.

ENFORCEMENT

Program and Financing (in thousands of dollars)

Identification code 20-00-0106-0-1-401	1973 actual	1974 est.	1975 est.
Program by activities:			
10 Standards, permits, enforcement and legal counsel (costs—obligations)	31,481	48,781	53,340

EPA's enforcement responsibilities are in the areas of air pollution control, water pollution control, and pesticide control. Much of the effort is in support of or in cooperation with State and local enforcement programs, such as the enforcement of air quality standards; navigable and interstate water quality standards; and issuance of discharge permits. Enforcement includes such actions as notices of violation, abatement orders, enforcement conferences, civil and criminal court actions, and, in the case of pesticides, recalls and seizures. Overall management and support is included.

Water Quality
Water Quality Enforcement

Justification

	1974	1975	Change
Water quality enforcement....	$11,338,000	$11,450,700	+$112,700

Water quality standards have been required for all interstate navigable waters in the United States since the passage of the 1965 Amendments to the Federal Water Pollution Control Act. The 1972 Amendments to the Act have extended this regulatory authority by calling for the establishment of compatible water quality

standards for the intrastate waters of each State and requesting that a waste discharge permit system based upon effluent limits for municipal, industrial, and other waste discharges be established.

The focus of the water enforcement program falls on the enforcement of permit conditions as well as the enforcement of the water requirements established under the 1972 Amendments of the Federal Water Pollution Control Act, the Refuse Act, and the Marine Protection, Research, and Sanctuaries Act of 1972.

Emphasis will be placed on two different areas of activity. One area includes those activities which assess whether there is compliance with waste discharge permits. These include the implementation of an effective Federal/State compliance monitoring program which encompasses chemical and biological investigations, the identification of non-filers, and other necessary support for enforcement actions. Other activities involve evaluating self-monitoring data and analyzing the quarterly compliance reports from the EPA regions and approved state agencies. In addition, efforts will be made to provide for effective public participation in the NPDES program. The other area of activity emphasized involves the preparation of appropriate enforcement actions, including administrative orders, imposition of civil penalties, and referrals to the United States Attorney or the United States Coast Guard when there is noncompliance with Section 402 and other parts of the 1972 amendments to the Federal Water Pollution Control Act, the Refuse Act, and the Marine Protection, Research, and Sanctuaries Act of 1972.

Significant 1974 Accomplishments

- Held approximately 350 public hearings prior to the issuance of permits and participated in similar hearings held by the States.

- Surveyed discharges in water quality limited basins to support the development and issuance of permits in these basins.

- Completed case preparation and referred approximately 100 cases to the U.S. Attorney and 500 cases to the U.S. Coast Guard.

- Monitored on an ad hoc basis those dischargers which permits had been issued and developed a total compliance monitoring program for full implementation in 1975.

- Issued administrative orders to those sources found to be in violation of permit conditions and referred civil/criminal actions as appropriate.

1975 Objectives

- Hold approximately 350 public hearings prerequisited to the issuance of permits and participate in similar hearings held by the States.

- Investigate through compliance monitoring approximately 6,000 discharges and review approximately 26,000 self-monitoring reports.

- Issue administrative orders to all those dischargers who are in violation of the conditions of their permits and refer civil/criminal actions as appropriate.

- Initiate approximately 200 referrals to the U.S. Attorney and 500 referrals to the U.S. Coast Guard.

Water Quality
Water Quality Permit Program

Justification

	1974	1975	Change
Water quality permit program.	$12,063,000	$12,502,900	+$439,900

During 1975, the Permit Program will be primarily concerned with completing the review of all initial permit applications, and significantly expanding and improving State and public participation in the National Pollutant Discharge Elimination System (NPDES). Continued emphasis will be focused on delegating the permit issuing authority to States with qualifying permit programs. Also, EPA will continue to ensure that the views of all parties involved in the issuance of permits are considered in this process.

The water quality program primarily involves the review of permit applications, the development of the ocnditions to be made part of the permits (treatment levels, monitoring requirements, compliance schedules, etc.) and the issuance of permits. EPA ensures that State views are considered in the preparation of EPA issued permits and works closely with those States to which the program has been transferred, assisting them in training personnel and in reviewing and developing permit conditions.

EPA estimates that there are a total of approximately 70,000 discharges presently covered under the NPDES: 28,000 industrial; 21,000 municpal; 11,500 agricultural and commercial; and more than 10,000 privately owned treatment works. First priority will be given to the issuance of all identified major industrial discharger permits by December 31, 1974, and, as a minimum, development of draft permits for all remaining minor discharges.

FEDERAL POWER COMMISSION

Program and Financing (in thousands of dollars)

	Identification code 30-80-0100-0-1-401	1973 actual	1974 est.	1975 est.
	Program by activities:			
	Direct program:			
	1. Hydroelectric power regulation	3,073	4,789	5,367
	2. Electric power industry systems evaluation	2,376	3,093	3,438
	3. Electric power utilities regulation	3,006	3,533	3,991
	4. Natural gas pipeline regulation	6,575	8,747	9,839
	5. Natural gas producers regulation	3,527	4,164	4,732
	6. Natural gas industry systems evaluation	903	384	420
	7. Services to other agencies and to the public	1,683	1,856	2,031
	8. Administration	1,617	2,130	2,475
	9. Conservation Research	.....	.....	100
	Total direct program	22,760	28,696	32,393
	Reimbursable program:			
	1. Hydroelectric power regulation	110	.....	.....
	Total program costs, funded	22,870	28,696	32,393
	Change in selected resources (undelivered orders and stores)	359	.....	.....
10	Total obligations	23,230	28,696	32,393

The Federal Power Commission administers the Federal Power Act and Natural Gas Act, and performs other work relating to Federal electric power developments and associated natural resources.

1. Hydroelectric power regulation. - The Commission licenses non-Federal hydroelectric projects, makes water resources appraisal studies, determines whether projects with expiring licenses should be relicensed or recommended to Congress for Federal takeover, and assesses the environmental impact of proposed licensed hydroelectric projects.

2. Electric power industry systems evaluation. - The Commission encourages the interconnection and coordination of the Nation's electric power systems to insure an adequate and reliable supply of electric energy.

The Commission studies the electric power industry's problems and prospects to encourage electric utilities to meet the Nation's power requirements by timely installation of adequate generating and transmission facilities with minimum impact on our environment. Continuous surveillance of the changing requirements of the electric power industry is conducted to identify current trends, project load growth, and suggest patterns of generation and transmission to meet future requirements.

3. Electric power utilities regulation. - The Commission regulates the wholesale rates and service, the accounts reporting requirements, depreciation practices, certain security issues, the disposition of property, mergers, and interlocking directorates of interstate electric utilities.

TENNESSEE VALLEY AUTHORITY

Program and Financing (in thousands of dollars)

Identification code. 33-15-4110-0-3-401	Power proceeds and borrowings			Appropriations and nonpower proceeds			Total		
	1973 actual	1974 estimate	1975 estimate	1973 actual	1974 estimate	1975 estimate	1973 actual	1974 estimate	1975 estimate
Program by activities:									
Operating costs, funded:									
1. Regional development program:									
(a) Water resources development	.....	.....	.....	11,660	12,535	11,833	11,660	12,535	11,833
(b) General resources development	.....	.....	.....	7,302	7,955	8,475	7,302	7,955	8,475
(c) Land Between the Lakes	.....	.....	.....	2,097	2,292	2,322	2,097	2,292	2,322
2. Power program. Power supply and use	576,705	744,312	806,235	.....	.....	.....	576,705	744,312	806,235
3. Fertilizer and munitions development program	.....	.....	.....	33,458	38,573	42,324	33,458	38,573	42,324
4. General service activities	.....	.....	.....	10,600	11,069	8,328	10,600	11,069	8,328
Total operating costs, funded	576,705	744,312	806,235	65,117	72,424	73,282	641,822	816,736	879,517
Change in selected resources (inventories, deferred charges, and deferred credits)	34,915	−4,632	5,613	459	147	396	35,374	−4,485	6,009
Total operating obligations	611,620	739,680	811,848	65,576	72,571	73,678	677,196	812,251	885,526

The Congress created the Tennessee Valley Authority in 1933 for the unified development of a river basin comprising parts of seven States. TVA is a corporation wholly owned by the Federal Government. Its program in 1975 will be financed from

three sources: (1) appropriations by the Congress; (2) proceeds available from current power operations and borrowings against future power revenues; and (3) proceeds available from nonpower activities.

Budget program - 1. Regional development program. - A major objective of the TVA Act is full development and use of all the resources of the Tennessee River Basin. The development of these resources is reflected in regional and national plans in the fields of navigation, flood control, water quality, recreation and wildlife; in land resources-agriculture, forestry, and minerals; in education and manpower development; and in related industrial development.

(a) Water resources development includes continuing development of the all-year 9-foot navigation channel from the mouth of the river at Paducah, Ky., to Knoxville, Tenn., a distance of 650 miles. Technical studies appraise the opportunities for more extensive use of the waterway. Data supplied to shippers and carriers help solve transportation problems. Advisory work with State and local agencies leads to new or improved public programs by those agencies to help assure full industrial use of the waterway.

Flood control activities are concerned with maintenance and use of storage space in upstream reservoirs for seasonal retention of excessive runoff and the regulation of discharges to rates of flow which can be handled safely by downstream channels and reservoirs. Flood crests are reduced along the Tennessee River and along the tributaries downstream from the reservoirs and along the lower Ohio and Mississippi Rivers. Also, TVA collects and analyzes flood data and studies potential flood control projects and ways to improve operations of the existing system. Technical advice and assistance is given to State and local agencies in finding solutions to localized flood control problems.

Regional water quality management comprises the determination of basic facts about water quality, planning of ways of maintaining or upgrading the quality of the water resources, and monitoring and surveillance to assure that water quality does not deteriorate. This work is conducted in cooperation with appropriate Federal, State, and local agencies and with industrial users of water.

Recreation, fisheries, and waterfowl resources development activities are designed to promote the optimum development of the water and other scenic resources of the region in a way that will improve the physical and cultural environment, stimulate economic development, and conserve natural and historical resources.

Flood Control Operations

1973 actual	$955,502
1974 estimate	955,000
1975 estimate	954,000

The TVA system of multipurpose dams and reservoirs affords a substantial degree of flood protection along the Tennessee River and its tributaries, and contributes significantly to the reduction in flood heights along the lower Ohio and Mississippi rivers. However, flooding recurs frequently along unprotected tributary streams throughout the Valley. Continual assessment and updating of current flooding and future flood damage potential is done in order to plan and operate a comprehensive effort to prevent flood damages.

Flood control operations involve (1) assessment of flood damages through the collection and analysis of flood data (2) studies to improve the operation of the existing multipurpose dam and reservoir system during future flooding. (3) assistance to communities in planning and implementation of flood damage prevention measure, and (4) operation of local flood control facilities.

Operation of the TVA multipurpose dam and reservoir system prevented flood damage totaling approximately $630 million from storms that occurred in December 1972; March, May, November, and December 1973; and January 1974. This includes over $550 million at Chattanooga, Tennessee; $56 million eleswhere along the Tennessee River and below the major storage reservoirs on the tributaries; and $16 million along the lower Ohio and Mississippi rivers. Total damages averted on the lower Ohio and Mississippi rivers does not include those prevented by TVA system operation during the January 1974 flood. This total is more than twice the original cost of all TVA flood control facilities plus the cost to date of operating and maintaining these facilities.

System Flood Control Studies and Investigations

1973 actual	$350,077
1974 estimate	382,000
1975 estimate	425,000

This program includes (1) collecting data on current floods, (2) engineering studies to guide current flood operations and appraise results, (3) development and dissemination of flood

information, (4) review of plans which affect the Tennessee River system submitted for approval under Section 26a of the TVA Act, (5) evaluating the hydrologic safety of TVA dams, and (6) appraisal of potential flood damages.

The 1975 estimate provides for data collection and operating studies expected in an average year. Information obtained in these studies is used in establishing logical flood damage reduction objectives in local flood studies. A major emphasis in 1975 will be to accelerate review of hydrologic safety of TVA dams and the appraisal program of potential flood damages. Initiation of a reappraisal of Chattanooga, Tennessee, last studied in 1961, is planned. The workload, particularly that of collecting data on current floods, varies from year to year depending on the number and severity of floods. Accurate flood data are necessary for evaluating the effectiveness of existing facilities and their operation and to appraise flooding problems on unprotected tributaries.

Local Flood Damage Prevention

1973 actual	$436,510
1974 estimate	464,000
1975 estimate	472,000

Most of the towns and cities in the Valley are growing. As they expand, pressure to use floodplains increases. TVA encourages state and local government to assume responsibility for solving local flood problems and provides them flood data and technical assistance in planning for floodplain use in developing codes and ordinances for regulating floodplain use and in promoting other measures to reduce flood losses. Local officials are helped to develop and select from alternatives the best means to meet their community's needs.

In the past 20 years, TVA has prepared comprehensive flood reports for 137 Valley communities and partial data to meet current needs have been furnished to 20 others. In recent years considerable effort has been devoted to revising past flood reports and extending them to encompass areas of future urban expansion. In 1973, over 200 requests were handled for flood information at specific sites being considered for schools, post offices, hospitals, residences, commercial buildings, industries, or other developments. TVA makes special investigations of such situations when the information is not available. The use of this information helps reduce developments at elevations subject to flooding, reduces future flood damages, and demands for future flood protection projects. Executive Order 11296 dated August 10, 1966, directs all Federal executive agencies to evaluate flood

hazards to preclude uneconomic, hazardous, or unnecessary use of floodplains. TVA provides other agencies the flood information necessary to implement this Executive Order in the Tennessee River basin.

Regional Water Quality Management

1973 actual	$1,529,151
1974 estimate	1,456,000
1975 estimate	1,355,000

TVA water quality management activities have as their objective the maintenance of surface and groundwater sufficient ro permit their optimum development for

- municipal, industrial, and agricultural water supplies;
- propagation of fish and wildlife;
- water-contact recreation; and
- aesthetic satisfaction.

To achieve these objectives TVA works with state and local governments, industries, Federal agencies, and private citizens to protect and enhance the water quality of the Velley.

	1973 Actual (Rounded)	1974 Estimate	1975 Estimate
Water quality planning.....	$ 272,000	$ 77,000	$ 77,000
Water quality inventory.....	258,000	803,000	718,000
Pollution abatement activities.....	543,000	173,000	173,000
Special studies and demonstration projects.....	456,000	403,000	387,000
Total.....	1,529,000	1,456,000	1,355,000

a. TVA's regional water quality management program may be divided into four principal areas of activity. The first is water quality planning. A comprehensive report on the water quality situation throughout the Valley has been prepared to assist Valley states in preparing detailed water quality management plans for each major subbasin in the Valley and for

the main stem of the Tennessee River. These basin plans are required of the states by the Federal Water Pollution Control Act Amendments of 1972. TVA assists the states by providing technical input to their plans which varies according to the needs of the individual states. When completed, each subbasin plan will (1) project domestic and industrial waste loads, stream reach by stream reach. to at least the year 2000 by 10-year increments: (2) evalutate water quality conditions, reach by reach, that would normally be expected to exist during these time periods: (3) specify degree of waste treatment required to allow for growth and yet meet state and Federal standards; (4) recommend other means of achieving acceptable water quality conditions; and (5) include a plan of implementation for securing needed pollution abatement. During 1973, considerable water quality data, hydrologic data, and direct staff assistance in determining stream assimilative capacities was provided the State of Tennessee for use in preparing basin plans for the Elk River and Duck River basins. Technical assistance was also provided Alabama in preparation of the Tennessee River basin plan for north Alabama. In 1974 and 1975 TVA assistance to the Valley states will be limited to providing water quality and hydrologic dat and reviewing and commenting on draft basin plans prepared by the states.

b. The second element of water quality management is water quality inventory. This is an inventory of water quality conditions based on monitoring water quality, either periodically or continuously. The objective is to maintain an up-to-date inventory of water quality conditions that will adequately meet the needs of TVA. EPA, state and local governmental agencies, industries, and the general public. In 1973 a water quality monitoring network was developed that includes about 44 sampling stations at "key" locations in the Valley. This network is basically the existing temperature and dissolved oxygen monitoring network expanded to include additional water quality measures and additional stations. This activity will be fully implemented in 1974 and 1975. Detailted water quality studies were carried out in 1973 on one mainstream reservoir and one major subbasin. In 1974 and 1975 these monitoring programs will be increased in planned stages to provide additional aerial coverage and to provide significant additional parameter coverage. Assistance will continue to be given to the Environmental Protection Agency in the operation of its national monitoring system and all data obtained will be made available to Federal, state, and local agencies.

c. The third feature is pollution abatement activities. In the past, TVA's pollution abatement activities included (1) detailed enginnering review of plans to determine adequacy of

water pollution abatement measures at new installations where Section 26a permit or TVA land rights are involved; (2) biological and water quality surveys in the vicinity of existing industries, municipalities, etc., that are the sources of significant pollution in the Valley; and (3) biological and water quality surveys in the vicinity of new industrial sites both before operation and after the industry has been in operation for some time. Future activities will be limited to (1) maintaining a water use and waste discharge (and potential pollutant discharge) inventory; (2) investigating fish-kills, accidental spills of oil and other hazardous materials, and pollution discharges associated with treatment plant malfunctions; and (3) special studies related to water pollution problems, e.g., the mercury problem.

During 1973, twenty fish-kills or other pollution incidents were investigated. In addition, surveillance monitoring of mercury concentrations in fish flesh, water, and sediment were continued for Chickamauga, Pickwick, and Kentucky reservoirs and the North Fork Holston River. Surveillance of the mercury problem will be continued in 1974.

d. Special studies and demonstration projects will be performed to support the water quality management program. Many of these studies will be done in response to problems arising in water quality management, while others are continuing efforts to solve problems of a persistent nature. The continuing investigations are: (1) field documentation of water quality and biological conditions associated with depletion of dissolved oxygen in TVA reservoirs in such a manner to facilitate a more complete understanding of reservoir water quality changes during storage; (2) computer documentation of existing ecologic models and development of improved water quality models; (3) development of methods for predicting the effects or reservoirs on water quality in tailrace streams; (4) pilot-scale studies of oxygen injection at Fort Patrick Henry Dam and the design, construction, and testing of a full-scale reaeration system at this dam; (5) continue review of possible reaeration methods at 10 other TVA dams including the design of a full-scale system for the most problematic case; and (6) perform field studies and utilize temperature monitoring data to improve methods for predicting the rate at which receiving waters will lose excess heat.

RECREATION DEVELOPMENT

1973 actual	694,580
1974 estimate	692,000
1975 estimate	763,000

The objective of TVA's recreation program is to identify resources of potential value for recreation and demonstrate their best alternative uses and conservation, recognizing the social nature of recreation needs. TVA activities in this field include demonstrations and cooperative projects.

TVA offers technical assistance to states, towns, communities, local development groups, and individuals in defining and undertaking their role in Valley recreation resource development. Growth in recreation demand has made it necessary for TVA also to take a more direct role in providing basic recreation opportunities. Direct TVA development remains a relatively minor part of total reservoir recreation development. Since 1969, TVA has developed 80 sites along the shorelines of 15 reservoirs. Nearly 100 public parks (including 17 state parks), over 400 public access areas, 22 state wildlife management areas, and 300 boat docks and marinas have been provided by others on TVA's reservoirs.

A comprehensive land capability analysis or reservoir shorelands will be essentiallly completed in fiscal year 1974. During fiscal year 1975, information from this analysis will provide a basis for recreation development assistance. New ways of expressing the values of recreation development and use will continue to be studied. Research problems of recreation travel economics will be investigated. Attention will be given to scenic and recreation rivers and trails in the Tennessee Valley.

Special Studies

Increased emphasis on recreation has generated a substantial need for information to answer questions on activity and facility preferences and needs; the market for commercial recreation developments in the Valley; and the benefits, costs, and economic impact of recreation resource development.

6. Preliminary Surveys and Engineering

Preliminary surveys and engineering provide background information ananlyses, development of planning procedures, and long-range plans to aid in the determination of the need for more detailed water resources development. Engineering assistance is given to communities and multicounty planning organizations to help them assess needs and to develop possible solutions to water supply and waste water disposal problems. In addition, the program includes research associated with watershed investigations with current emphasis on urban watersheds.

	1973 Actual	1974 Estimate	1975 Estimate
Research on soil-water relationships.	$129,305	$102,000	$ 85,000
Preliminary investigations.	129,053	106,000	90,000
Regional water supply and liquid waste disposal.	139,339	115,000	99,000
Valley-wide assessment of water needs	63,078	77,000	35,000
Total	$460,775	$400,000	$309,000

a. Research on Soil-Water Relationships ($85,000)

This subprogram includes the collection and analysis of basic hydrologic information on small experimental watersheds to determine the effects of land-use changes and management practicies as urbanization, timber harvesting, reforestation, and land reclamation upon the amount and quality of steamflow. This information is used in the development and refining of mathematical models which relate the characteristics of a watershed to its steamflow and water quality. The models are used as planning tools to predict the effects of proposed localized changes in land use of management practices. The models also can simulate steamflow information in areas where historical records are lacking. For example, models based on data now being collected on four urban areas in Knoxville can be used by city planners and engineers to assess and control the proglems of flooding, urban drainage, and water pollution which are created by urban development.

b. Preliminary Investigations ($90,000)

Work under this subprogram includes (1) cooperation with the Water Resources Council in interagency activities related to water resources planning criteris and procedures; (2) limited studies to develop workable improvements in evaluation procedures with emphasis on environmental comparison for alternative plans; (3) preparation of basic population and economic projections and analyses; and (4) preliminary studies of potential modification in reservoir system operations necessary to meet chaning conditions.

c. Regional Water Supply and Liquid Waste Disposal ($99,000)

The urbanization and industrialization of small and intermediate-sized towns in the region, together with a proliferation of utility districts to provide service in rural or

suburban areas, have created problems in water supply and liquid waste disposal. Because many communities have planned and acted independently and concentrated on short-range needs, the quality of better service and lower costs which are attainable from larger systems have not been realized. To encourage broader planning, TVA provides technical assistance to communities and multicounty planning and development organization in assessing current and future needs based on urban and industrial growth forecasts. The engineering concept plans provided by TVA are useful to affected communities in contracting with private consultants for detailed planning and design of appropriate water supply and liquid waste disposal facilities. Technical assistance on groundwater and related geology is also made available. Funding in 1975 is for continuation of these activitives based upon an existing backlog or request for assistance.

d. Valley-wide Assessment of Water Needs
($35,000)

A systematic assessment of current and future water needs and problems in the Valley is under way to provide information for use in guiding TVA water resources programs and to provide basic data periodically called for by the Water Resources Council and other organizations. It is a limited effort designed to draw mostly from ongoing planning by TVA program divisions and other agencies in the region. Therefore, it concentrates on developing a consisten set of planning criteria, assumptions, and time horizons for use in the ongoing work so that it can be summarized on a comparable basis. Although an initial and somewhat incomplete assessment is to be assembled in 1974, a continuing effort over time at a reduced level of funding is planned to improve and update the information. This work complements the Water Resources Council 1975 water assessment by providing data which would not otherwise be available because a framework study was not funded for this region.

7. Multipurpose Reservoir Operations
(Schedule B-1 Operations and Maintenance)

Fiscal year 1975 expenses for multipurpose reservior operations are estimated at $10,377,000 before depreciation, of which $6,603,000 will be financed from appropriations, $3,516,000 from power proceeds, and $258,000 from directly related income.

Multipurpose reservoir operations involve the management, operation, and maintenance of TVA's system of 22

multipurpose projects. These activities assure public benefits from the primary functions of navigation, flood control, and power and from the many other values created by a reservoir system with more than 10,000 miles of shoreline and 347,000 acres of surrounding lands under TVA ownership or control. Operating costs for the system are collected in a single program category and net costs are distributed to the program benefited.

a. Development of Water Resource Management Methods

1973 actual	$256,133
1974 estimate	$270,000
1975 estimate	$200,000

Scientific progress in recent years makes it possible to develop and use improved reservoir operating methods to deal more efficiently and effectively with the multiple objectives and variable in TVA's complex system. New and better procedures make possible current evaluation of changes to guide day-to-day decisions. TVA will develop a mathematical model of the Tennessee River system incorporating all the variables, constraints, and interrelationships which need to be considered for optimal operations.

Development of such a model is a long-term task, and two preliminary steps begun in 1972 will be completed by 1975. In fiscal year 1972 perfection of methods of investigating the effects of scheduled flow for specific purposes on quantatitive system water management, for the power economy of the system, and on water quality were begun. When completed in 1974 this step will allow evaluation of the impact of thermal discharge standards on the system operation. Concurrently, and continuing into fiscal year 1975, available mathematical methods for water resource optimization are being tested for potential use in the final basinwide water management scheme. A river subbasin has been selected as a specific application example. Also the needs for research, data and further method development will be identified.

b. Water Control Operations

1973 actual	$1,309,063
1974 estimate	$1,367,000
1975 estimate	$1,370,000

Water control operations require the collection and evaluation of data on rainfall throughout the watershed, waterflow in the Valley streams and water storage and releases. To

support these activities, TVA maintains a network of about 400 rain gages, 4 evaporation stations, about 160 stream gaging stations, and a VHF radio system for transmission of rainfall and streamflow data from selected remote areas in the Valley. In addition, other agencies maintain about 110 rain gages and the U.S. Geological Survey maintains 149 stream gages in the Valley from which data are supplied to TVA on a regular basis or upon request. TVA pays part of the operating costs for 94 of the USGS gages that essential to TVA operations. Installation and operation of the gages are closely coordinated between the various agencies to prevent duplication and unnecessary installation. The General Weather Center, a private forecasting concern uder contract to TVA, furnishes daily and extended forecasts of rainfall as well as information on expected light intensities, temperatures, and other meteoroglogical factors needed in system operations.

Data from a portion of the overall network, consisting of 200 rain gages, and from about 60 of the stream gages are provided daily or more often, as required, to a central water control office in Knoxville. These data are analyzed, together with data on reservoir elevations, discharges, and power generation schedules, and a plan of operation for several days in advance is formulated for each reservoir. Instructions are then issued to the operators at each dam for storing or releasing water as needed. A daily river bulletin, giving data observed for the previous day and anticipated data for the current and two succeeding days at each principal reservoir, is published in cooperation with the National Weather Service and is distributed to persons and firms concerned with the effects of reservoir elevations and discharges. Data are exchanged regularly and frequent consultations are held with the Corps of Engineers in scheduling Tennessee Valley reservoir system outflow to provide benefits to the lower Ohio and Mississippi rivers during low-flow and flood-flow periods.

c. Water Control Investigations

1973 actual	$189,684
1974 estimate	$167,000
1975 estimate	$ 71,000

Water control investigations include such activities as measurement of sedimentation in streams and reservoirs; checks on the operation of the spillways, sluices, and other hydraulic facilities; basic hydraulic research; investigations of damage claims arising from the operation of multiple-purpose reservoirs; and investigation of applications by others to build structures along the river or its tributaries.

The 1975 estimate of $71,000 provides for (1) continutation of sedimentation surveys and related investigations on the mainstream and tributary reservoirs, (2) continuation of coordination of a wide variety of hydrologic and hydraulic information with other governmental or private organizations, and (3) investigation of damage claims arising from operation of the multipurpose reservoir system.

d. Investigations and Control Reservior Ecology

	1973 Actual	1974 Estimate	1975 Estimate
Insect Control	$604,883	$676,000	$569,000
Aquatic weed control	627,389	525,000	439,000
Total	$1,232,272	$1,201,000	$1,008.000

Insect Control

This activity is directed toward the control of a mosquito that carries malaria. In specific areas limited efforts are made to control floodwater mosquitoes, biting flies, and ticks.

Natural methods are emphasized for mosquito control. Lake water levels are fluctuated to interfere with mosquito production. Water is pumped or drained from low areas. Shoreline vegetation is mowed. Larvicide is applied only when required to supplement these measures. Planned control measures in 1974 and 1975 for the lower river reservoirs are shown below.

	Fiscal Year 1974	Fiscal Year 1975
Plant growth control (mechanical and herbicidal)	5,187 acres	3,818 acres
Drainage maintenance	133,750 linear ft.	130,600 linear ft.
Application of larvicide	29,000 acres	29,000 acres
Operation and maintenance of dewatering projects	18,800 hours	18,800 hours

e. Remote Sensing

1973 actual $ 96,078
1974 estimate $106,000
1975 estimate $102,000

The value and reliability of data obtained by such remote sensing techniques as conventional aerial photography have been firmly recognized and established. Because of the relatively recent availability of both extremely high altitude and satellite imagery, TVA, individually and jointly with other agencies, is investigating the utility of such imagery in TVA programs.

Hyperaltitude aerial photograph has already become a tool in inventorying forests, agriculture, hydrology, geology, surface mining, mineral resources, and land use and its changes. TVA has been designated for an Earth Resource Observation System (EROS) Regional Browse File. In the establishment of this file in Chattanooga, TVA has compiled a microfilm file of the Earth Resources Technical Satellite (ERTS) imagery for the United States and other parts of the world, as well as originals of selected hyperaltitude aerial photography - all of which is available for viewing by the public and private sector.

TVA continues to perform basic research in and investigate the application of airborne thermal scanning for water temperature determination in an effort to meet Federal and state water quality standards. As a result, an atlas of thermal imagery of specific locations in the Tennessee Valley has been created which is continually being updated. The atlas has been used by engineers and environmental biologists for assessing design criterion and biotic effects of warm water effluents. Operational aspects of the activity directly related to thermal power generating plants are funded under the power program.

The 1975 estimate of $102,000 provides for more efficient data-gathering methods and application, together with further cooperative development and demonstration.

DELAWARE RIVER BASIN COMMISSION

Program and Financing (in thousands of dollars)

Identification code 31-10-0102-0-1-401	1973 actual	1974 est.	1975 est.
Program by activities:			
10 Contributions to the Commission (costs—obligations) (object class 41.0)	216	220	238
Financing:			
25 Unobligated balance lapsing	.....	22	.....
40 Budget authority (appropriation)	216	242	238
Relation of obligations to outlays:			
71 Obligations incurred, net	216	220	238
90 Outlays	216	220	238

This appropriation provides for the Federal share of the annual expenses of the Commission. The compact provides that the amount required to balance the Commission's current expenses budget shall be apportioned equitably among the signatory parties by unanimous vote of the Commission. The amount recommended for the Federal contribution is approximately 23% of the $1,046 thousand current expense budget for 1975.

The Delaware River Basin Commission was created by compact (Public Law 87-328) among the States of Delaware, New Jersey, New York, the Commonwealth of Pennsylvania, and the Federal Government to enable them to participate jointly in the development of water and related resources of the region drained by the Delaware River and its tributaries.

Under the terms of the Compact, the Delaware River Basin Commission is responsible for the development and maintenance of a comprehensive plan and for programing, scheduling, and controlling projects and activities within the Delaware River Basin, which will provide regulation and development of gorund and surface water supplies for municipal, industrial, and agricultural uses; abatement of stream pollution; flood damage reduction; promotion of forestry, soil conservation, and watershed projects; propagation of fish and wildlife; development of water-related recreational facilities; and development of hydroelectric power potentialities.

SUSQUEHANNA RIVER BASIN COMMISSION

Program and Financing (in thousands of dollars)

Identification code 31-12-0501-0-1-401	1973 actual	1974 est.	1975 est.
Program by activities:			
10 Contributions to the Commission (costs—obligations) (object class 41.0).....	150	150	150

This appropriation provides for the Federal share of the annual expenses of the Commission. The compact provides that the amount required to balance the Commission's current expenses budget shall be apportioned equitably among the signatory parties by unanimous vote of the Commission. The amount recommended for the Federal contribution is 25% of the $600 thousand current expenses budget for 1975.

The Susquehanna River Basin Commission was created by compact among the States of Maryland and New York, the Commonwealth of Pennsylvania, and the Federal Government to enable them to participate jointly in the development of water and related resources of the region drained by the Susquehanna River and its tributaries.

Under the terms of the Compact the Susquehanna River Basin Commission is responsible for the development and maintenance of a comprehensive plan and for programing, scheduling, and controlling projects and activities within the Susquehanna River Basin, which will provide regulation and development of ground and surface water supplies for municipal, industrial, and agricultural uses; abatement of stream pollution; flood damage reduction; promotion of forestry, soil conservation, and watershed projects; propagation of fish and wildlife; development of water-related recreational facilities; and development of hydroelectric power potentialities.

WATER RESOURCES COUNCIL

Program and Financing (in thousands of dollars)

	Identification code 33-35-0100-0-1-401	1973 actual	1974 est.	1975 est.
	Program by activities:			
	1. Administration and coordination	1,130	1,340	1,332
	2. River basin commissions	1,370	1,298	1,350
	3. Planning grants to States	3,019	3,004	2,400
	4. Comprehensive planning:			
	1975 assessment	151	752	2,013
	Regional or river basin plans	731	875	1,170
10	Total obligations	6,401	7,269	8,265

The Water Resources Council was established to encourage conservation, development and utilization of water and related land resources on a comprehensive and coordinated basis.

1. Administration and coordination. - The Council's activities include directing and coordinating comprehensive regional and river basin planning; recommending to the President needed changes in Federal policies and programs; establishing, for the approval of the President, principles, standards, and procedures for Federal water and related land resources planning; and submitting Council reports on completed plans to the President and the Congress.

2. River basin commissions. - River basin commissions have been established under title II of the act to coordinate Federal, State, and local plans for development of water and related land resources; to prepare comprehensive, coordinated, joint plans to make optimum use of such resources; and to recommend long-range schedules of priorities.

3. Planning grants to States. - Financial assistance on a matching basis is provided to the States to stimulate their participation in water and related land resources planning. Grant funds primarily support personnel in State planning agencies.

4. Comprehensive planning. - The second assessment of national and regional water supplies and requirements is being accomplished through the cooperation of Federal and State agencies.

Regional or river basin plans are prepared under the direction of the Council or of appropriate river basin commissions. Participation of Federal and State agencies in these studies is coordinated through the Council.

APPENDIX C

SUMMARY OF APPLICABLE LAWS AND STATUTES

Table 81 on page C-2 lists the Federal statutes pertinent to remote sensing of inland water. A description of these statutes is given in the rest of this appendix.

Source: MacDonald, Bruce W., The Statutory Basis for Federal Activity in Remote Sensing, Arlington, Va.: System Planning Corporation, 7 August 1974.

Table 81: List and Location of Laws and Statutes Applicable to Remote Sensing

Title	Page
1. Bankhead-Jones Farm Tenant Act	C-3
2. Watershed Protection and Flood Protection Act	C-4
3. Flood Protection Act of 1960	C-5
4. Taylor Grazing Act	C-6
5. Federal Reclamation Law	C-7
6. Admission of New States	C-8
7. Outdoor Recreation Act	C-9
8. Water Resources Planning Act	C-10
9. Act of June 17, 1902	C-11
10. Dam Safety Act of 1974	C-12
11. Federal Water Pollution Act of 1972	C-13
12. Flood Disaster Protection Act of 1972	C-15
13. Colorado River Basin Project Act	C-16
14. Agricultural Research Act	C-17
15. Cooperative Agreements for Surveys and Investigation	C-18
16. Toxic Substances Control Act of 1973	C-19
17. Land Use Policy and Planning Assistance Act of 1973	C-20
18. Tennessee Valley Authority Act of 1933	C-21

1. Bankhead-Jones Farm Tenant Act

Agency Affected: Department of Agriculture

Date Passed: 30 August 1972

Data Collection

Statutory Requirement: The Secretary of Agriculture is directed to carry out a land inventory and monitoring program to include, but not limited to, studies and surveys of erosion and sediment damages, flood plain identification, and utilization, land use changes and trends, and degradation of the environment resulting from improper use of soil, water and related resources. The Secretary shall issue at not less than 5-year intervals a land inventory report reflecting soil, water, and related resource conditions.

Supplementary Information: Present program activity is determined by the status of the Land Inventory and Monitoring Program (L.I.M.) of the Soil Conservation Service. This is a central data bank system for resource information used and collected by the USDA. A report must be filed on the items noted above once every five years. The present program in the planning stage with full operations is dependent upon funding from Congress. Present plans are to use any up-to-date source of information available and to collect raw data only when information is not available through other sources. Information gathered by most of the programs listed in Section A will be used.

> Demand Matrix Input: The present program level reflects the need for land cover data to fulfill the once-every-five years requirement which is not operational at present.
>
> The 1977 level reflects a continuation of the present program level plus an input by ERTS to keep the information updated.

Source: Meetings with the L.I.M. Program officials.

2. Watershed Protection and Flood Protection Act

Agency Affected: Department of Agriculture; Army Corps of Engineers

Date Passed: 4 August 1954; 30 August 1972

Data Collection

Statutory Requirement: Upon suitable application of local organizations, the Department is authorized to conduct such investigations and surveys as may be necessary to prepare plans for flood prevention or the conservation, development, utilization, and disposal of water.

The Department is also authorized in cooperation with other federal, state, and local authorities to make investigations and surveys of the watersheds of rivers and other waterways as a basis for the development of coordinated programs.

Both the Army and Agriculture, when authorized by the House or Senate Public Works Committees, are authorized and directed to make joint investigations and surveys of U.S. watershed areas.

Comments: Very relevant to remote sensing.

Supplementary Information: The present program activities include a broad range of programs administered by the Department of Agriculture and the Army Corps of Engineers. Program requirements are dependent upon the specific requirements of each application. Remote sensing is utilized in this program.

Demand Matrix Input: Present activity level reflects the wide range of requirements of this program.

The 1977 level reflects a continuation of existing programs plus the use of ERTS for updating the studies once every five years.

Source: Conversation with Army Corps of Engineers officials.

3. Flood Protection Act of 1960

Agency Affected: Army Corps of Engineer

Date Passed: 14 July 1960

Data Collection
Statutory Requirement: The Corps is authorized to compile and disseminate information on floods and flood damages, including identification of areas subject to inundation by floods, and general criteria for guidance in the use of flood plain areas; and to provide engineering advice to ameliorate flood hazards.

Specificity: Calls for particular kind of data collection.

Comments: $1[illegible],000,000 is set as the maximum annual expenditure of funds for this purpose. Remote sensing should be applicable.

Supplementary Information: The present program activities are estimated to cover the major floods occurring in the United States. The actual requirements are determined by the frequency and magnitude of major floods during a one year period.

> Demand Matrix Input: The present activity level indicates an estimate of the number of major floods occurring in the U.S. during one year that require aerial coverage.
>
> The 1977 level indicates an increase in the demand for this type of information for purposes of land use planning in flood plains. It is anticipated that the input from ERTS could reduce the area requirements of the present system.

Source: General information on Army Corps of Engineers activities.

4. Taylor Grazing Act

Agency Affected: Department of the Interior, Bureau of Land Management

Date Passed: 28 June 1934

Data Collection

Statutory Requirement: The Secretary of the Interior is directed to make provision for the protection, administration, regulation, and improvement of the grazing districts created under the authority of the Act, and is directed to do any and all things necessary to preserve the land from destruction and to provide for its orderly use. The Secretary is also authorized to continue the study of erosion and flood control.

Comments: Remote sensing is clearly relevant to the full carrying out of these provisions.

Supplementary Information: Although the present program does not involve an inventory of range land, several range condition and trend studies are conducted (with ground surveys) using random sampling and plot monitoring techniques. Aerial photography is used only as a base map where no maps exist.

> Demand Matrix Input: The present program activity reflects the requirement of the ground surveys.
>
> The 1977 level reflects an anticipated input by ERTS in monitoring range conditions to supplement the existing programs.

Source: Conversation with BLM - Division of Range personnel.

5. Federal Reclamation Law

Agency Affected: Department of the Interior, Bureau of Reclamation

Date Passed: 4 August 1939

Data Collection

Statutory Requirement: Those lands which have been, are, or may be included in any reclamation or irrigation project authorized by the Federal reclamation laws or operated and maintained by the Bureau of Reclamation for the reclamation of arid lands or other purposes must be reclassified at five year intervals as to irrigability and productivity.

Comments: The law mandates specific types of data but not for an exact quantity of land. Frequency of data collection is low.

With the development of suitable models, land productivity and irrigability estimates could be aided or accomplished by remote sensing.

Supplementary Information: The present program does not follow the specific reporting requirements of the law. A continuing reporting program from the irrigation districts is used in which land that is being reclaimed or removed from irrigation is noted. Data collection is done by ground survey.

> Demand Matrix Input: The present program activity level reflects the estimated general information reported to the Bureau of Reclamation.
>
> The 1977 level reflects the anticipated inputs of ERTS to supplement the existing program.

Source: Conversations with Bureau of Peclamation officials.

6. Admission of New States

Agency Affected: Department of the Interior, Bureau of Land Management

Date Passed : 4 September 1841

Data Collection Statutory Requirement: The granting of lands by the Government to each new state admitted to the Union must be preceded by a survey of the public lands in that state.

Comments: The thrust of this provision has been upheld in Hastings vs. Jackson, 1873, 46 Cal. 234, Terry vs. Megerle, 1864, 24 Cal. 609, 85 Am., Dec. 84, Doll vs. Meador, 1860, 16 Cal. 295. Remote sensing may have a role to play, but the frequency with which this law will be involved in the future must be considered very small.

7. Outdoor Recreation Act

Agency Affected: Department of the Interior, Bureau of Outdoor Recreation

Date Passed: 28 May 1963

Data Collection
Statutory Requirement: Secretary is authorized to:

- prepare and maintain a continuing inventory and evaluation of outdoor recreation needs and resources of the United States;

- prepare a system of outdoor recreation resources to assist in the effective and beneficial use and management of such resources.

Comments: Possibly relevant to remote sensing.

Supplementary Information: The present program is assumed to maintain a continuing inventory using information collected from any available sources. A comprehensive plan for outdoor recreation was issued in 1973. The level of remote sensing involvement is unknown.

Demand Matrix Input: The present activity level assumes a very broad requirement with data collected by ground survey.

The 1977 level reflects a continuation of the present program.

Source: General information on the Bureau of Outdoor Recreation.

8. Water Resources Planning Act

Agency Affected: Departments of Interior; Agriculture; Health; Education, and Welfare; Federal Power Commission

Date Passed: 22 July 1965

Data Collection

Statutory Requirement: The Water Resources Council, created by this act, is directed to maintain a continuing study of the adequacy of water supplies necessary to meet the water requirements in each water resource region in the U.S.

The Council is also directed to study the relation of regional or river basin plans and programs to national requirements.

Specificity: Law mandates the collection of specific water supply data. The second requirement more indirectly calls for data collection through the determination of national requirements.

Comments: ERTS-1 hydrology experiments indicate feasibility of water supply determination by satellite.

Council is directed to prepare a water supply assessment at 22 year intervals.

Supplementary Information: The present program is reflected by the activities of the Water Resources Council. Information gathered for the biannual reports is assumed to be obtained from the various related programs of the sponsoring Departments with no raw data being collected by the Water Resources Council that would utilize aerial photography. Remote sensing is being used within some of the R & D projects funded.

Demand Matrix Input: The present activity represents the biannual report required by law.

The 1977 level indicates a continuation of the present program with a possible additional input from ERTS.

Source: General information on the Water Resources Council.

9. Act of June 17, 1902
Irrigation Work Surveys
57th Congress, Chapter 1093

Agency Affected: Department of Interior

Date Passed: 17 June 1902

Data Collection
Statutory Requirement: The Secretary of the Interior is authorized and directed to make examinations and surveys for irrigation works and to report to Congress at the beginning of each regular session as to the results of these examinations and surveys.

All monies received from the sale and disposal of public lands in Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Utah, Washington and Wyoming, including the surplus of fees and commissions, are to be set aside and known as the "reclamation fund," to be used in the examination and survey, construction, and maintenance of irrigation works.

Comments: Remote sensing should be useful in the conduct of irrigation examinations and surveys.

10. Dam Safety Act of 1972

Agency Affected: Army Corps of Engineers

Date Passed: 8 August 1972

Data Collection
Statutory Requirement: The Corps is directed to inspect all dams that are over 25 feet in height or impound over fifty acre - feet of water, with the exception of those dams that are less than six feet in height or that are impound less than fifteen acre - feet of water.

Comments: In many regions, particularly the Southeast and parts of the Midwest and West, the registry of dams is poor. Thus, to carrying out this law, the Corps had to search for unregistered dams. ERTS imagery has been useful in identifying water impoundments of as little as five acres. The location of these dams is a non-repetitive use of ERTS, but detection of future unregistered dams may still be mandated.

Supplementary Information: The present program activity is conducted through grants to the states with expected completion by 1975. At present no update is required, but future legislation is expected to require updating approximately once every five years. ERTS is being used in an operational program to update existing sources and to ensure completeness of coverage.

> Demand Matrix Input: The present activity level assumes fifty states must be covered within two years with summer imagery necessary.
>
> The 1977 level reflects anticipated requirements of once every five years update with extensive use of ERTS.

Source: Conversation with remote sensing section of the Army Corps of Engineers.

11. Federal Water Pollution Act of 1972

Agency Affected: Environmental Protection Agency; Coast Guard

Date Passed: 18 October 1972

Data Collection
Statutory Requirements: One of the many provisions of this act calls for the establishment of an oil spill surveillance system designed to provide early notice of oil and other hazardous substances discharge. While nominally designating the President for this task, the Coast Guard has been selected to implement this provision.

On a more general level, Section 309 of the act prescribes a course of action for the EPA Administrator "whenever on the basis of information available to him" he finds any person in violation of certain of the laws provisions.

In addition, the Administrator of EPA is directed to

- conduct and promote the coordination and acceleration of, research, investigations, experiments, training, demonstrations, surveys, and studies relating to the causes, effects, extent ... of pollution; and to cooperate with other public and private groups in doing this.

- conduct public investigations concerning the pollution of any navigable waters

- establish, equip, and maintain a water quality surveillance system for the purpose of monitoring the quality of the navigable waters and ground waters and the continuous zone and the oceans; the Administrator shall, to the extent practicable, conduct such surveillance by utilizing the resources of NASA, NOAA, USGS, and USCG and shall report on this quality.

A proposed Administration amendment to this law would authorize the study of procedures and methods, including land use requirements, to control construction activity related sources of pollution, including run-off from the resultant facilities.

Specificity: The oil spill surveillance system called for by the law mandates a definite type of information gathering program. The language of the law is quite precise on this. The language is much less specific on the precise information-gathering requirements for other types of pollution.

Comments: The Coast Guard began their oil spill surveillance program in the summer of 1973. Surveillance is performed by six HU-16 aircraft which provide bi-weekly coverage of part of the U.S. coastal waterways and weekly coverage of the Great Lakes. The use of satellite surveillance is currently under investigation. The potential for satellite application in this program appears strong.

To the extent that satellite surveillance can detect other forms of water pollution such efforts should receive some impetus from this law, but the data-collection requirements are much less specific. With the success of ERTS sediment loading experiments and others, however, the provisions of this law may have more applicability to remote sensing.

Supplementary Information: The present program is very broad and information requirements are determined by the specific project needs. Remote sensing plays an active role.

Demand Matrix Input: The present activity level reflects the requirements of the oil spill surveillance program described above.

The 1977 level indicates a continuation of the present program supplemented by ERTS to reduce the area requirements for detailed information.

Source: Conversation with Environmental Protection Agency officials.

12. Flood Disaster Protection Act of 1973

Agency Affected: Department of Housing and Urban Development

Date Passed: 31 December 1973

Data Collection Statutory Requirement: The Secretary is authorized to carry out studies and investigations of the adequacy of state and local measures in flood-prone areas as to land management and use, flood control, flood zoning, and flood damage prevention.

Comments: Remote sensing should be useful for both studies and planning.

13. Colorado River Basin Project Act

Agency Affected: Department of the Interior

Date Passed: 30 September 1968

Data Collection
Statutory Requirement: The Secretary of the Interior is directed to conduct complete reconnaissance investigations for the purpose of developing a general plan to meet the future water needs of the western United States. The investigations are to include the long-range water supply available and water requirements in each western water resource region. Progress reports are to be issued every two years, with the final reconnaissance report completed by June 30, 1977.

Comments: Remote sensing should be a useful tool for the reconnaissance investigations. A program activity level is specified, but the program is scheduled to end in 1977.

14. Agricultural Research Act

Agency Affected: Department of Agriculture

Date Passed: 29 June 1935

Data Collection
Statutory Requirement: The Secretary of Agriculture is authorized and directed to conduct research relating to the conservation, development, and use of land, forest, and water resources for agricultural purposes, and other studies bearing on the agricultural industry of the United States.

Comments: As an instrument for the surveying and monitoring of land, forest, and water resources, remote sensing is applicable to the carrying out of the provisions of this law.

15. Cooperative Agreements for Surveys and Investigations

Agency Affected: Department of the Army, Corps of Engineers

Date Passed: 6 August 1947

Data Collection
Statutory Requirement: The Director of the Corps is authorized to enter into cooperative agreements with state and local governments for surveying and mapping activities.

Comments: Remote sensing and earth resources satellites should be pertinent to these activities of the Corps. This statute merely provides authority, however, and does not mandate a particular program activity.

16. Toxic Substances Control Act of 1973

Agency Affected: Environmental Protection Agency

Date Passed: Still Pending

Data Collection
Statutory Requirement: The Administrator of EPA is authorized to conduct such research and monitoring as is necessary to determine the extent of substances deemed toxic for the enforcement of this law.

Comments: No data collection is mandated, authority granted is primary in the realm of enforcement.

Pertinence of this data depends on the ability of remote sensing to monitor trace substances. Application is also possible for remote read-out.

17. Land Use Policy and Planning Assistance Act of 1973

Agency Affected: Department of the Interior, the States

Date Passed: Still Pending

Data Collection
Statutory Requirement: The Secretary of the Interior may authorize program management grants if the State has developed a statewide land use planning process, including

- the establishment of a method for the compilation and revision of data related to inventorying areas of critical environmental concern, areas impacted by key facilities and development of land use of regional development

- the establishment of a method for the compilation and continuing revision of data related to population densities and trends, economic characteristics and projections, or environmenal conditions and trends, and governmental service needs related to those areas reviewed.

The state land use planning agencies established in response to this law shall give priority to the development of an adequate data base for a statewide land use planning process using data available from existing sources wherever feasible.

The Secretary of the Interior, with the assistance of the National Advisory Board on Land Use Policy (established by this law), shall report to the President and the Congress biennially on land resources, uses of land, and the current and emerging problems of land use.

Comments: Calls for data collection on land use as a critical component of the law. Remote sensing has great potential here.

18. Tennessee Valley Authority Act of 1933

Agency Affected: Tennessee Valley Authority

Date Passed: 18 May 1933

Data Collection
Statutory Requirement: The President of the U.S. is authorized to make such surveys of and general plans for the Tennessee basin and adjoining territory as may be useful to the Congress and to the several states in guiding and controlling the extent, sequence, and nature of development that may be equitably and economically advanced through the expenditure of public funds. The President is further authorized in making such surveys and plans to cooperate with the states affected, and to make such studies, experiments, or demonstrations as may be necessary and suitable to that end.

The President shall recommend to Congress such legislation as he deems proper to carry out this provision as to maximize flood control, navigation, electricity generation, land use, reforestation, and economic and social well-being in the basin

Comments: Executive Order 6161, dated 8 June 1933, placed the President's authority under this statute with TVA.

Remote sensing data should be useful in survey assistance, land use, and flood control, and in predicting snow-melt and run-off for hydrological applications, and for planning electricity generation.

APPENDIX D

CORPS OF ENGINEERS REMOTE SENSING PROGRAMS PERTINENT TO INLAND WATER RESOURCES

Table 82: Corps of Engineers Remote Sensing Program Pertinent to Inland Water Resources

Research Category	Sub-Category	Work Unit Number
Flood Control and Navigation	Missouri River	030201
	Data Collection-ERTS	030401
	Inspection of Dams	030404
	Fishtrap Reservoir	030501
	Permafrost Mapping	030505
Environmental Quality	Project Impact	040101
	Land Use & Pollution	040102
	Tennessee-Tombigbee	040103
Planning Methodology	Use of Remote Sensing in Planning	050206

* The Corps of Engineers Research Categories of Materials and Costal Engineering have been omitted from this table.

Source: Department of the Army, Office of the Chief of Engineers DAEN-CWR-S, Circular No. 70-2-14, Table 1, Washington, D.C., 25 March 1974

Table 83: Corps of Engineers Remote Sensing Program*

	Investment, $ thousands						
	Research & Development			Test & Evaluation			
	FY 73	FY 74	FY 75	FY 73	FY 74	FY 75	Work Unit Current Numbers*
Land Cover	60.0	56.0	64.0	5.0	59.0	85.0	030404, 040102, 050201, 050203, 050204
Littoral Processes	406.5	141.0	289.0		22.5	67.0	020201, 020202, 020301, 020302, 020303, 020304, 020306, 020401, 020402, 020403
Sub Surface Water	14.5	3.0	30.0	9.4			010101, 010201, 010202, 010203
Water Quality	25.2	22.0	30.0				030501, 040201, 030506
Geology & Soils	60.0	38.0	32.0				010204, 010205, 010206
Enviornmental Impact	30.0	30.0	44.0	40.0	5.0	50.0	040101, 040103, 040104
River Engineering	25.0	37.0	148.0				030201, 030302, 030303
Flood Plain Mapping		25.0			6.0		050202, 030304
Runoff Prediction	103.0	129.0	60.0				030502, 030503, 030504, 030505
Data Communications	120.0	60.0			60.0	240.0	030401, 030402, 030403
Digital Processing					14.0		070101
Ice Mapping			237.0				020305, 030507
TOTALS	844.2**	541.0**	934.0**	54.4	166.5	442.0***	

* This table documents the rate of technology transfer from research and development to test and evaluation as represented by shifts in funding categories. The application topics are arranged according to implied field priorities.

** R&D funds for FY 73 include 719.0K from NASA, FY 74 includes 429.0K and FY 75 includes 838.0K.

*** T&E funds for FY 75 include 140.0K from NASA.

Underlined work unit numbers are related to Inland Water Resources RMP

Source: The Corps of Engineers, Ibid.

Table 84: Remote Sensing Program Summarized by Funding Source

	Expenditures, $ thousands (1972)								
	FY 1973			FY 1974			FY 1975		
	R&D	Other In-House	NASA	R&D	Other In-House	NASA	R&D	Other In-House	NASA
03 Flood Control and Navigation									
02 Waterways									
01 Missouri River			25.0			15.0			
03 Flood Control and Navigation									
02 River Engineering					22.0		50.0		
03 Mississippi River									93.0
04 Effects of Flooding					6.0				
04 Impr. of O&M Techniques									
01 Data Collection - ERTS	20.0	30.0	70.0			60.0			140.0
02 Data Collection - GOES					10.0				
03 Data Collection					50.0			100.0	
04 Inspection of Dams		5.0			59.0				
05 Hydrology									
01 Fishtrap Reservoir	5.2	20.0							
02 Soil Perm., Snow Cover, and Runoff Relationships							60.0		
03 Watershed Characteristics				19.0					
04 Precipitation Analysis				10.0					
05 Permafrost Mapping			103.0			100.0			
06 Lake Dynamics									30.0
07 River Icing									60.0
04 Environmental Quality									
01 Environmental Impact									
01 Project Impact			30.0			30.0			44.0
02 Land Use & Aquatic Pollution			60.0	40.0			50.0		
03 Tennessee-Tombigbee		40.0							
04 Cuyahoga River					5.0			50.0	
02 Water Quality									
01 Red River Chloride Study						22.0			

Table 84: Remote Sensing Program Summarized by Funding Source (cont'd)

	Expenditures, $ thousands (1973)								
	FY 1973			FY 1974			FY 1975		
	R&D	Other In-House	NASA	R&D	Other In-House	NASA	R&D	Other In-House	NASA
05 Planning Methodology									
02 Planning Alternatives									
01 Soil & Vegetation Mapping						16.0	14.0		
02 Floodplain Delineation						25.0			
03 Urban Studies - Camden								40.0	
04 Merrimack River Basin								45.0	
Program Development									
Systems Development									
01 Actron Scanner					9.0	5.0			
Subtotal*	75.2	104.4	719.0	107.0	183.5	417.0	236.0	302.0	838.0
Program Management									
01 Publication					15.0				
(Use of Remote Sensing in Planning	29.0								
02 Archiving & Distribution									
03 Consultant/Tech. Orgn.									
04 Imagery Acquisition					10.0			10.0	
TOTAL**	104.2	104.4	719.0	107.0	208.5	417.0	236.0	312.0	838.0

* Apparent inconsistancies between totals in Table 3 and subtotals in Table 4 result from the distribution of other In-house funds to R&D or T&E.

** Total includes Materials and Coastal Engineering Categories not shown on this table.

Source: Corps of Engineers, Ibid.

APPENDIX E:

U.S.D.A. SOIL CONSERVATION SERVICE DATA REQUIREMENTS

The following list presents the high priority data categories of the Soil Conservation Service (SCS) of the USDA that are directly related to Inland Water Resources, and, more specifically to RMA 3.1 and RMA 3.2. This list is extracted from an "Advisory LIM-4" by William M. Johnson, Deputy Administrator for Soil Survey dated May 13, 1974.

Data Requirements	Agencies and Department Data Sources
1. Location and extent of surface water.	WRC; state agencies; USDI (GS, BIM, BR); USDA (FS, SCS)
2. Amount of water used.	EPA; state agencies; USDI (GS, BR); DOD (census of irrigation); USDA (ARS, FS, SCS)
2a for irrigation 2b for other	
3. Quality of surface and ground water-sediment, coliform, BOD temperature, TSS, alkalinity, salinity, etc.	EPA; state agencies; USDI (GS, BR); USDA (ARS, ECS, FS)
4. Location and extent of water supply from snow.	USDA (SCS, FS)
5. Location and extent of ground water recharge areas.	USDI (GS: WRC); state agencies
6. Location and extent of ground water aquifers.	USDI (GS: WRC); state agencies
7. Location and extent of flood-prone areas indentified by flood routing procedures.	DOD (Corps of Eng.); USDA (SCS, FS); USDI (GS); HUD; TVA; state agencies
8. Location and extent of flood-prone areas identified by other procedures.	USDA (SCS, FS); USDI (GS); TVA; stage agencies

Data Requirements	Agencies and Department Data Sources
9. Location of areas subject to tidal surge.	DOD (Corps of Eng.); USDC (NOAA); USID (GS); state agencies
10. Location of potential impoundments sites.	USDA (SCS, FS); DOD (Corps of Eng.); USDI (BR, BPA, APA, GS); state agencies River Basin Commissions

The Soil Conservation Service data categories: activities, methods, and products which are relevant to Inland Water follow.

Data Categories	Activities	Methods	Products
7. Water (surface and ground water)	7.1 Surveying	7.11 Snow survey	7.111 Map of location and extent, depth water content of snow cover
	7.2 Inventorying	7.21 Use enumerators to collect data from all available sources.	7.211 Complete data showing acre-feet of water, water quality, irrigation water use, water use, hydrograph forecasts, peak and low flow values, water yield from snow, etc.
		7.22 Develop graphics.	7.22. Map overlays of water areas, snow cover, aquifers, recharge areas, etc.
	7.3 Monitoring	7.31 Survey and inventory changes in water by survey and inventory methods.	7.311 Revised data.
			7.312 Revised map overlays to show changes.
			7.313 Sequential water data for developing prediction models.

Data Categories	Activities	Methods	Products
9. Flood	9.1 Surveying	9.11 Enumerators record flood heights and years of flood; use existing flood routing data available on flood plains, soil surveys, photo interpretation, etc.	9.111 Flood-prone area may show 100-year frequency flood hazard.
			9.112 Map showing flood-prone areas frequency described in general terms only.
			9.113 Map showing areas subject to high tides.
	9.2 Inventorying	9.21 Use ADP tapes developed from 9.11 methods	9.211
		9.22 Tabulate.	9.221 Acres of land with 100-year frequency flood hazard.
			9.222 Acres of land with flood hazard of unknown frequency
			9.223 Acres with flood hazard in urban and built-up.
			9.224 Acres with flood hazard in other areas.
		9.23 Develop graphics.	9.231 Flood-prone area maps.
	9.3 Monitoring	9.31 Survey and inventory flood and tide heights and year of occurrence.	9.311 Revised data showing acres flooded.
			9.312 Revise map overlays to show changing flood hazard.

APPENDIX F:

AD HOC FEATHER RIVER CASE STUDY

In order to evaluate the potential benefit of ERS in the water management field, with particular emphasis on the Feather River System, it is necessary to examine how water management is conducted in the absence of ERS.

An ERS system, like any other information system, does not increase the total supply of water in the system but rather it can improve its management so that the available supply of water can be utilized more effectively. In a managed water impoundment system, water which can be used in economically beneficial ways for purposes such as power generation, irrigation, urban and industrial purposes etc. can be called "economic" water. Water which cannot be utilized for economically beneficial purposes at the right times and in the right amounts and must be dumped to prevent floods can be called "uneconomic water". Even though the total amount of water remains constant, the amount of economic water can be increased and the amount of uneconomic water can be correspondingly decreased through better management decisions that result from greater information.

F.1 The Feather River Project

The Feather River Project is the initial unit of the California Water Plan. The project was approved by the California State Legislature in 1951 and the first appropriation occurred in 1957. The total Feather River Project cost is about $370 million divided between the Upper Feather Division and the Oroville Division. The Upper Feather Division consists of Frenchman Dam and Lake, Antelope Dam and Lake, Grizzly Valley Dam and Lake Davis, Abbey Bridge Dam and Reservoir, and Dixie Refuge Dam and Reservoir plus the Grizzly Valley Pipeline. The Oroville Division consists of the Oroville Dam and Lake Oroville, the Edward Hyatt Powerplant and the Thermalito Facilities. The total drainage basin area of the Feather River Project is 3611 square miles and produces an average annual project impaired flow at the Oroville Damsite of 2.3 million acre-feet (1921-1951). Figure 3 shows the Feather River drainage area.

The analysis of the benefits to be gained through improved water management in the Feather River Project as a result of remote-sensed data requires a description of water management decision parameters as they apply to current procedures employed at the Oroville-Thermalito facilities. These facilities provide the main control of the flow of water

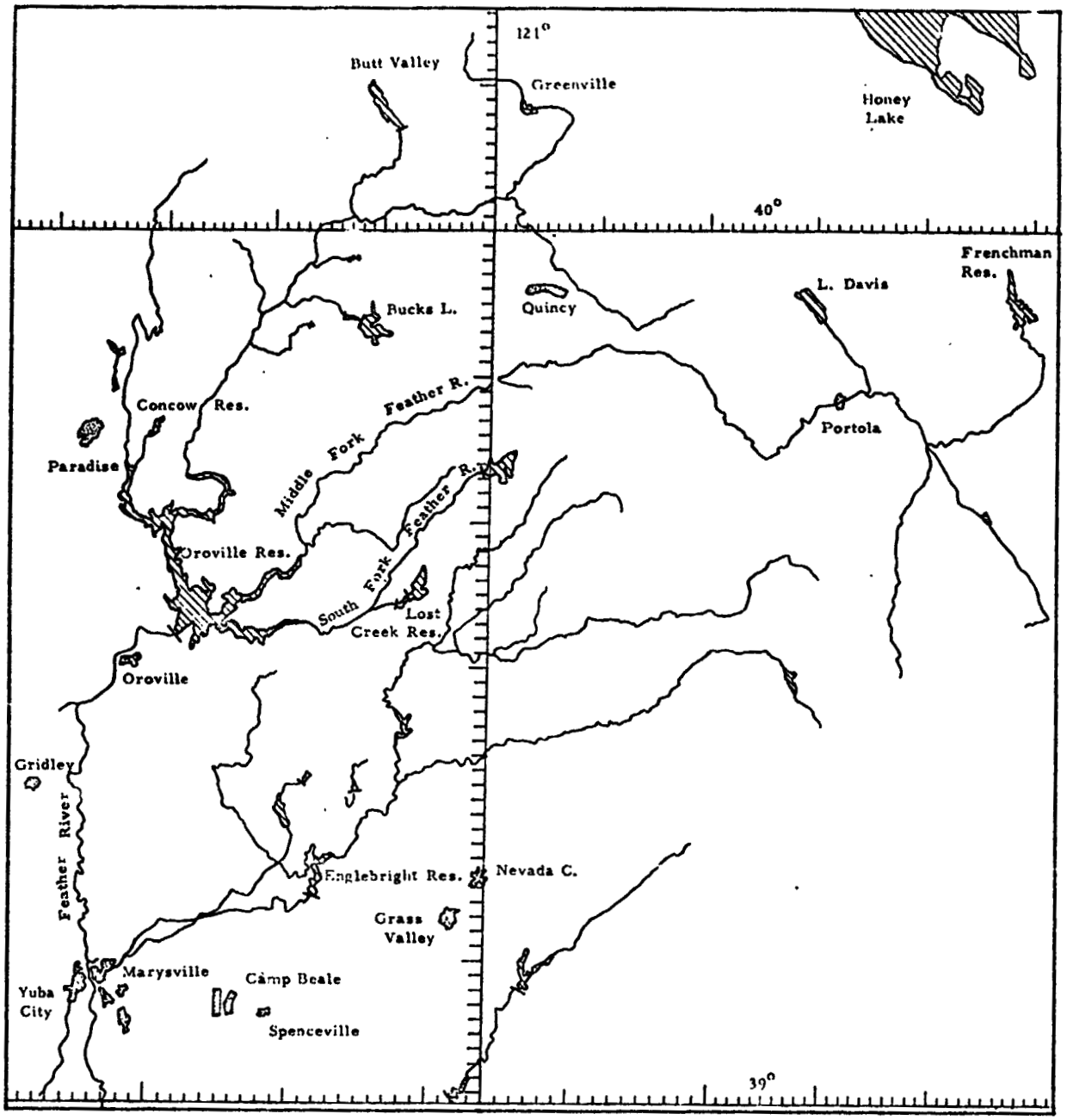

Figure 3 The Feather River Drainage Area

from the Feather River drainage basin into downstream channels which comprise a portion of the California Water Project. Since this drainage basin is an integral part of the California Water Project, procedures employed at Oroville must be related to the effects that they have on the Project as a whole.

F.2 Current Operation of the California State Water Project

In an effort to prevent natural disasters (i.e., floods, droughts, etc.), historical data have been collected by water management officials with regard to uncontrolled flow rates in all water carrying channels. These data have been related to minimum and maximum permissible rates in each channel such that natural disasters will be avoided. Once this information is made available, efforts to control flow rates can be initiated and operational procedures outlined. Currently, control of flow rates at individual facilities is based on three basic parameters, (1) inflow rates into reservoirs, (2) reservoir storage capacity, and (3) downstream channel capacity. Reservoir storage and downstream channel capacity are defined for each facility and require no further discussion; however, inflow rates are stochastic and will therefore be delineated further.

Inflow rates are typically dependent on two basic variables; the state of the terrain (ground wetness, ground cover, soil type, shape, etc.) and precipitation. Currently, only ground wetness is used to approximate the first variable, and precipitation is modelled only from historical data. Also, ground wetness is simplified at present by assuming that it is functionally dependent only on precipitation. Using this type of data, it is apparent that current decisions are based primarily on historical data and therefore employ large safety factors in order to prevent natural disasters. Control of water resources by this procedure does provide assured protection against floods, but it does not provide the ability to manage water resources in a dynamic sense.

F.3 Current Operation of the Oroville-Thermalito Facilities

Currently, the Feather River drainage basin, controlled by the Oroville-Thermalito facilities, is functioning primarily as a flood control and power generation mechanism. It should be noted, however, that water supply and water quality control will play an increasing role as time passes and will provide critical input requirements and constraints to the California Water Project by the late 1980's.

Flood control is currently achieved by investigation of projected reservoir inflow rates, reservoir storage capacity and reservoir outflow rates as determined by downstream channel capacities. Reservoir inflow rates are determined from a probability of a "standard project storm" is statistically based on seasonal precipitation distributions for the Feather River Drainage Basin. This storm is defined as a period of 96 hours during which 14.3 inches of precipitation falls on wet ground in the drainage basin for the reservoir. Historical data have been gathered for the probability of a "standard project storm" and related to the amount of flood control space required. Figure 4 shows the requirements imposed by these historical data.

Along with this flood control requirement, power is generated at Edward Hyatt and Thermalito facilities. Edward Hyatt, with six generators (three reversible for pumpback), has a generation capacity of 678,750 kilowatts, and Thermalito, with four generators (three reversible for pumpback) has a generation capacity of 119,600 kilowatts. Although both facilities are designed for pumpback operations, this aspect of the project has only been used for test purposes to date. Eventually, power generation and pumpback requirements will add constraints to the entire system and impact on the decision policies of the managers.

F.4 Present Uncertainties in Predicting Water Inflow to the Oroville Reservoir

An accurate prediction of the monthly inflow rates for the Oroville Reservoir is necessary for better management of the Oroville Reservoir and the California Water Project. Currently, predictions are provided on February 1st for the entire water year (October 1 - September 30) and updated monthly through May 1st. Figure 5 shows the April to July forecast results for the October 1972 to September 1973 year.

This figure points out several interesting phenomena all of which indicate the potential need for more and better information on which to base forecast runoff. From the diagram, it is apparent that forecast accuracy does not improve from month to month as might be expected. Also it is seen that eighty percent confidence bound diverges from the actual runoff with each new forecast up to April and apparently does not begin to converge until actual runoff data are available. The error in this forecast runoff is plotted in Figure 6 so that the relationship between forecast error and date of prediction may be evaluated. Figure 5 raises one very interesting question: Why does added information gathered in February and March cause

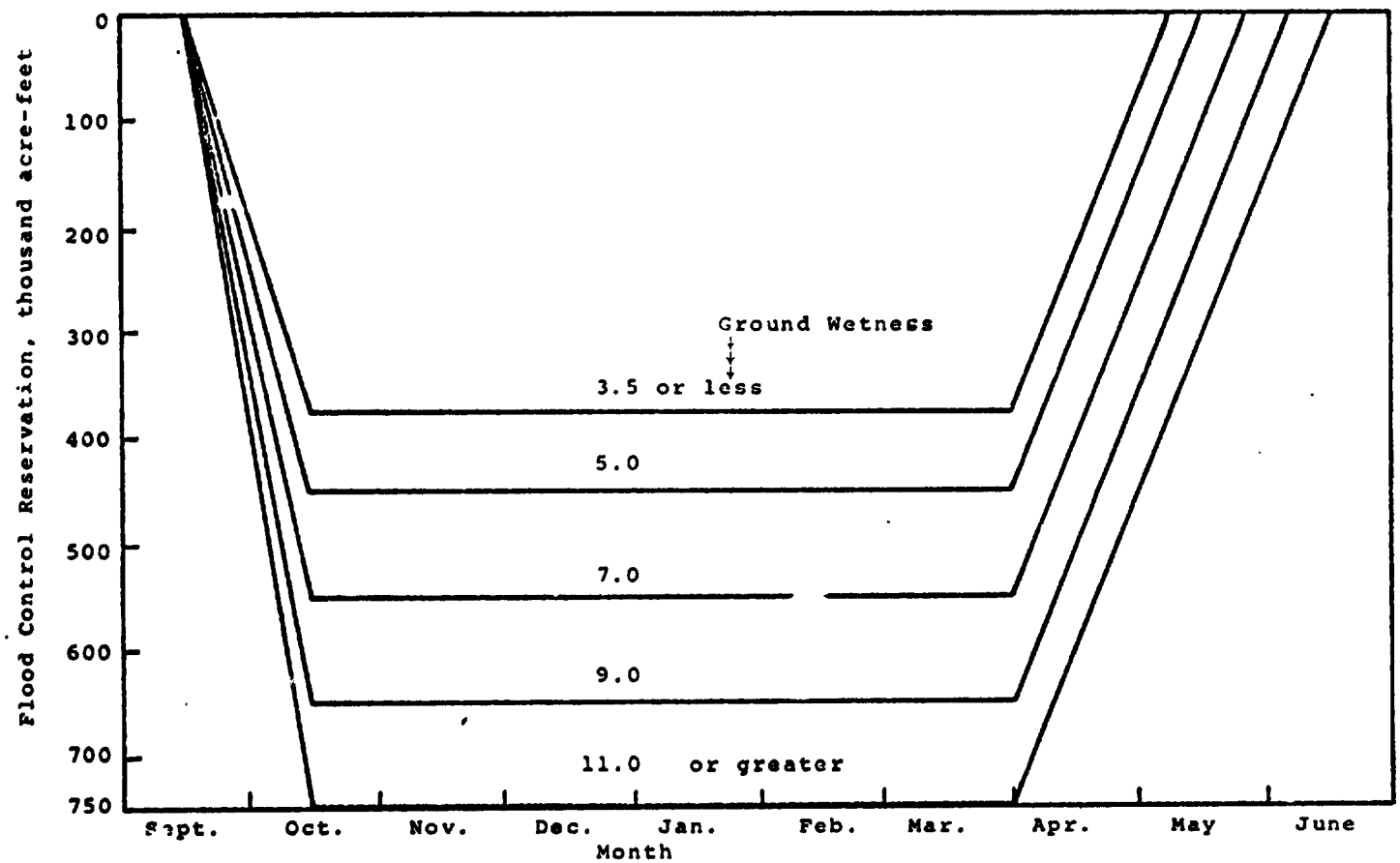

Figure 4 Schedule of Required Unfilled Flood Control Volume by Ground Wetness Index for Oroville Reservoir

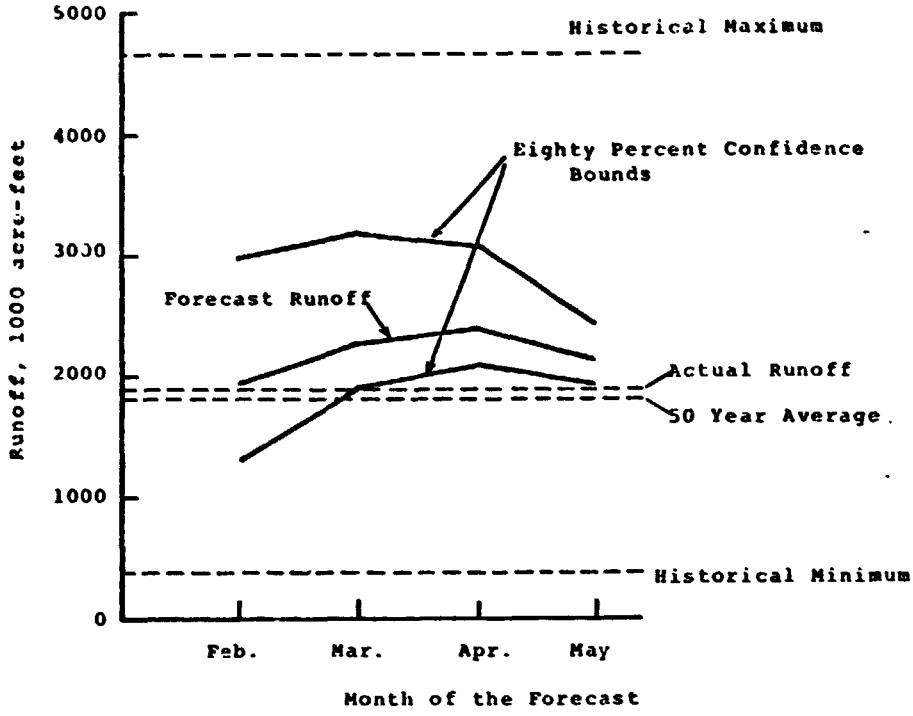

Figure 5 Unimpaired Runoff into Oroville Reservoir for the Period 1 April 1973 - 31 July 1973: Predicted vs. Actual (Without ERTS)

the forecast accuracy to decrease? This question, although it will not be addressed in this report, most definitely highlights the fact that not only is the prediction model lacking in accuracy but that it may have even more serious problems since new information does not seem to improve the accuracy of prediction. It may also imply that present (no ERTS) information patterning techniques are seriously inadequate.

Figure 7 shows the accuracy of the monthly inflow as predicted in March. From the data presented in this diagram, it is again apparent that prediction errors are of the same magnitude as shown previously, that is, ten to twenty-five percent, and furthermore that short term predictions (one month lead time) are not more accurate than longer term predictions.

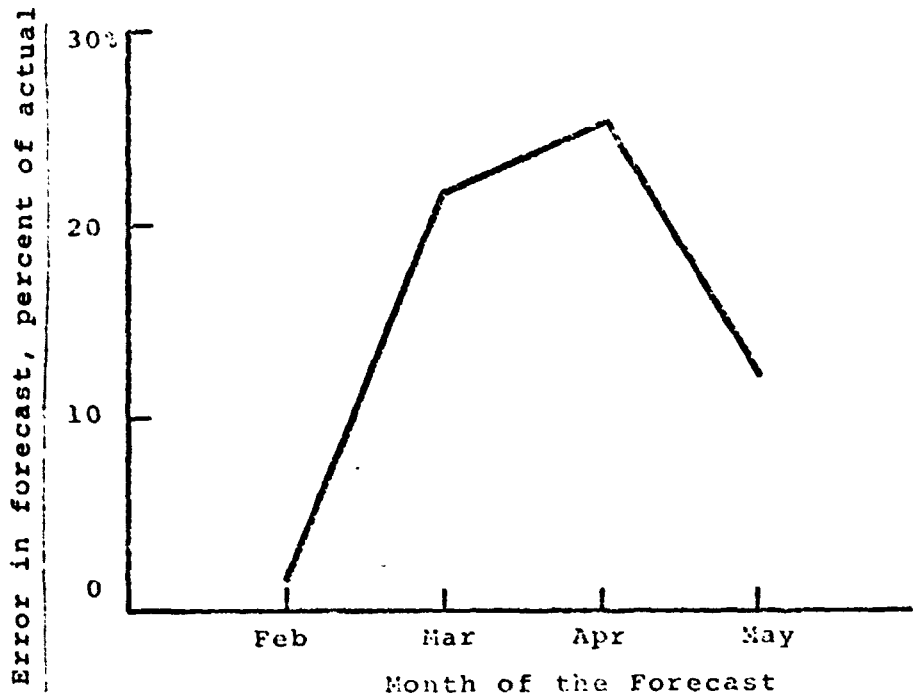

Figure 6 Error in Forecast of Runoff into Oroville Reservoir for the Period 1 April 1973-31 July 1973 (Without ERTS)

The problem of current prediction's accuracy and timing leads one to question the process by which information is gathered and related to the forecast runoff. Current predictions are based on historical years of similar magnitude leading one to assume that flow rates from year to year are similar in nature. However, as shown by Figure 8, different years can produce substantially different flow patterns, thereby limiting the accuracy of using historical records to predict future runoffs. Also, in support of this assertion is Figure 9 which plots the historical runoff rates for another area of California State Water Project. From the "typical" example it is apparent that any attempt to work with an average year would produce large prediction errors. It is necessary therefore to take a much closer look at the mechanics of runoff and its prediction.

Current predicting techniques provide accuracy to within approximately twenty-five percent for both short term

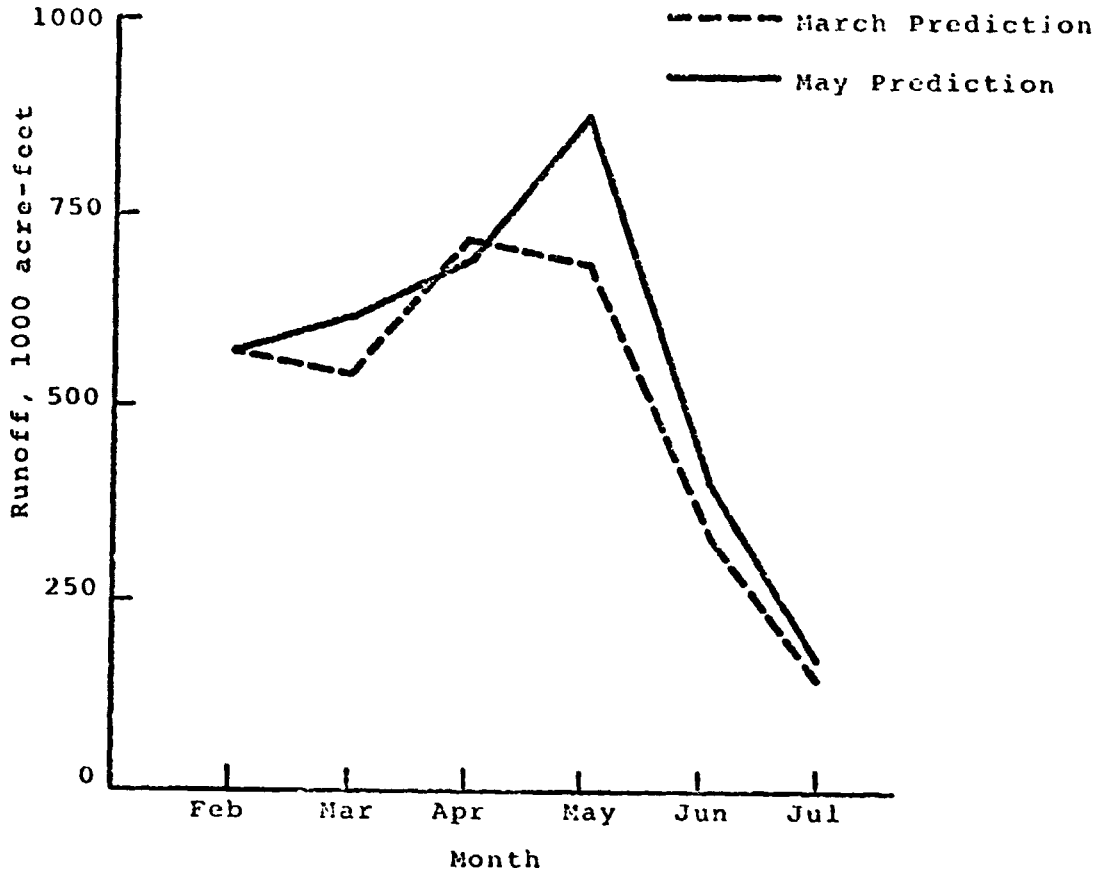

Figure 7 Monthly Inflow Values to the Oroville Reservoir for the Period 1 February 1973-31 July 1973 (Without ERTS)

and long term predictions. The uncertainty of the "correctness" of these predictions is an important factor in the supply of economic water and can in itself either provide significant quantities of economic water or for very poor predictions, limit the supply drastically. Currently, the uncertainties seem excessively large (note the eighty percent band on Figure 5) and much fruitful work could be done on obtaining improved data and methods of prediction. The investigation of remote sensing (ERS) applications to the management of the Feather River, therefore, holds great promise.

From Figure 9, it is clear that there is a large variation in the April to July runoff, with the average runoff for the lowest of the trimodal peaks being less than a third of the value of the highest of the trimodal peaks. If ERS can predict early enough each year which one of these peaks is the relevant one for that year, a large economic benefit would result.

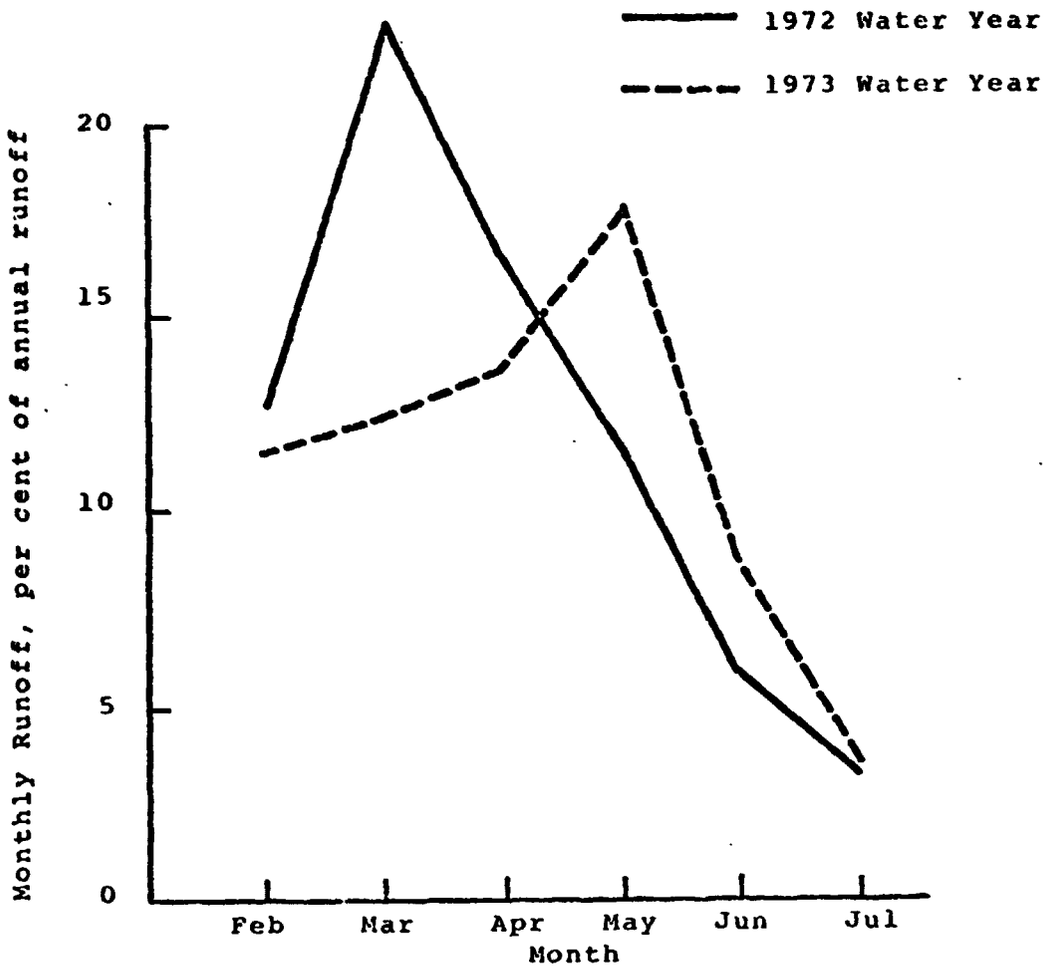

Figure 8 Comparison of Monthly Runoff at Oroville Reservoir for 1972 and 1973 (Without ERTS)

F.5 Economic Analysis

The direct activities that benefit from improved ERS information are shown by Figure 10. With or without ERS information, the Oroville Dam will be managed in such a way as to insure, with virtual certainty, the absence of flooding. Better water management will not show up directly in terms of flood control, but will be effected in the other economic activities shown in Figure 10. Therefore, the value of ERTS information in flood control of the Feather River can be treated as zero.

Water that is used for hydroelectric power generation subsequently can be used for other activities such as recreation, navigation, residential, industrial, and

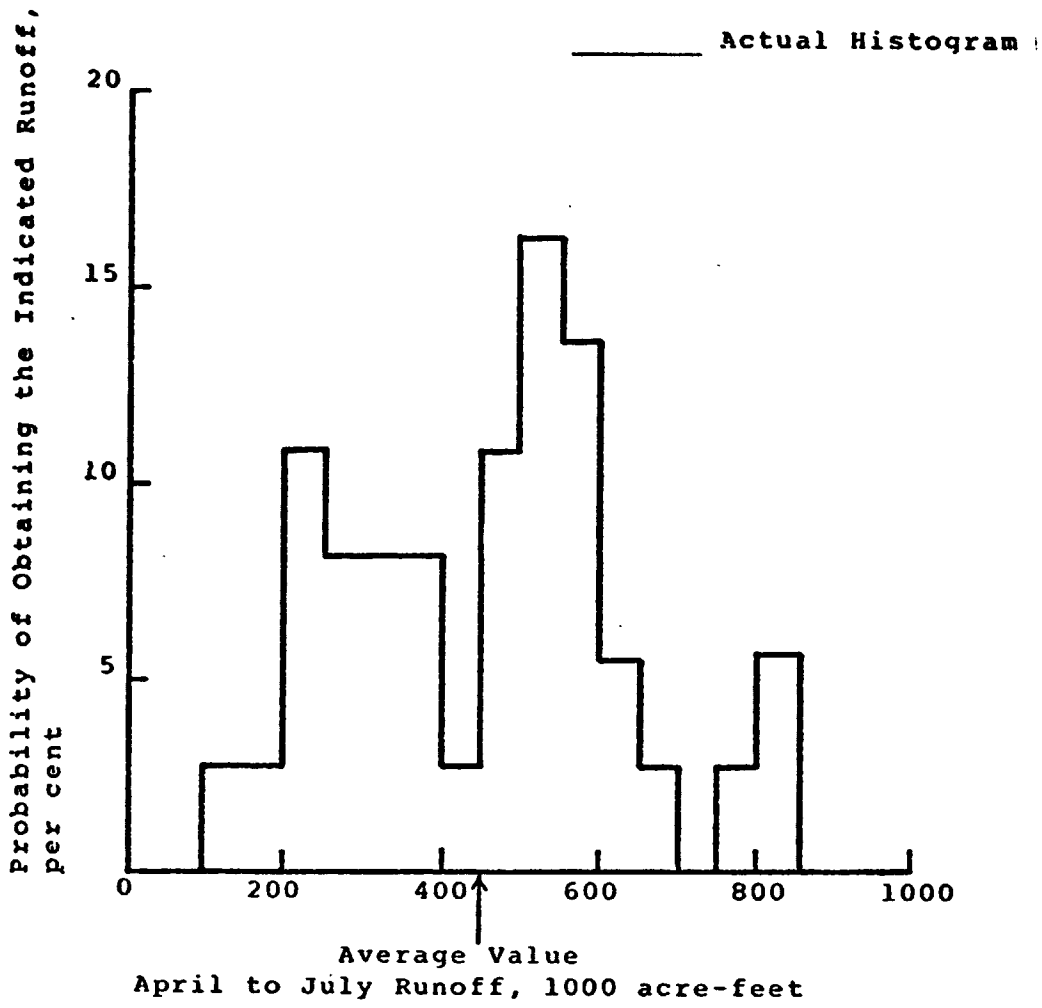

Figure 9 Historical Probability Distribution of Water Inflow of a Typical River of the California State Water Project (Sacramento River Basin)

agricultural programs. The bulk of this water, about 90%, is used for agricultural purposes, both in the Feather River System and for the U.S. in general.

Current and improved operations due to better information can be illustrated partly by Figure 11. Instead of managing the water level in the absence of ERS information such that the expected water level at the dam is at point C, with ERS information, the water level can be managed such that the expected water level is at point B. Both cases provide the same degree of safety, but with ERS information, an additional amount of water (given by the distance BC) is available. The

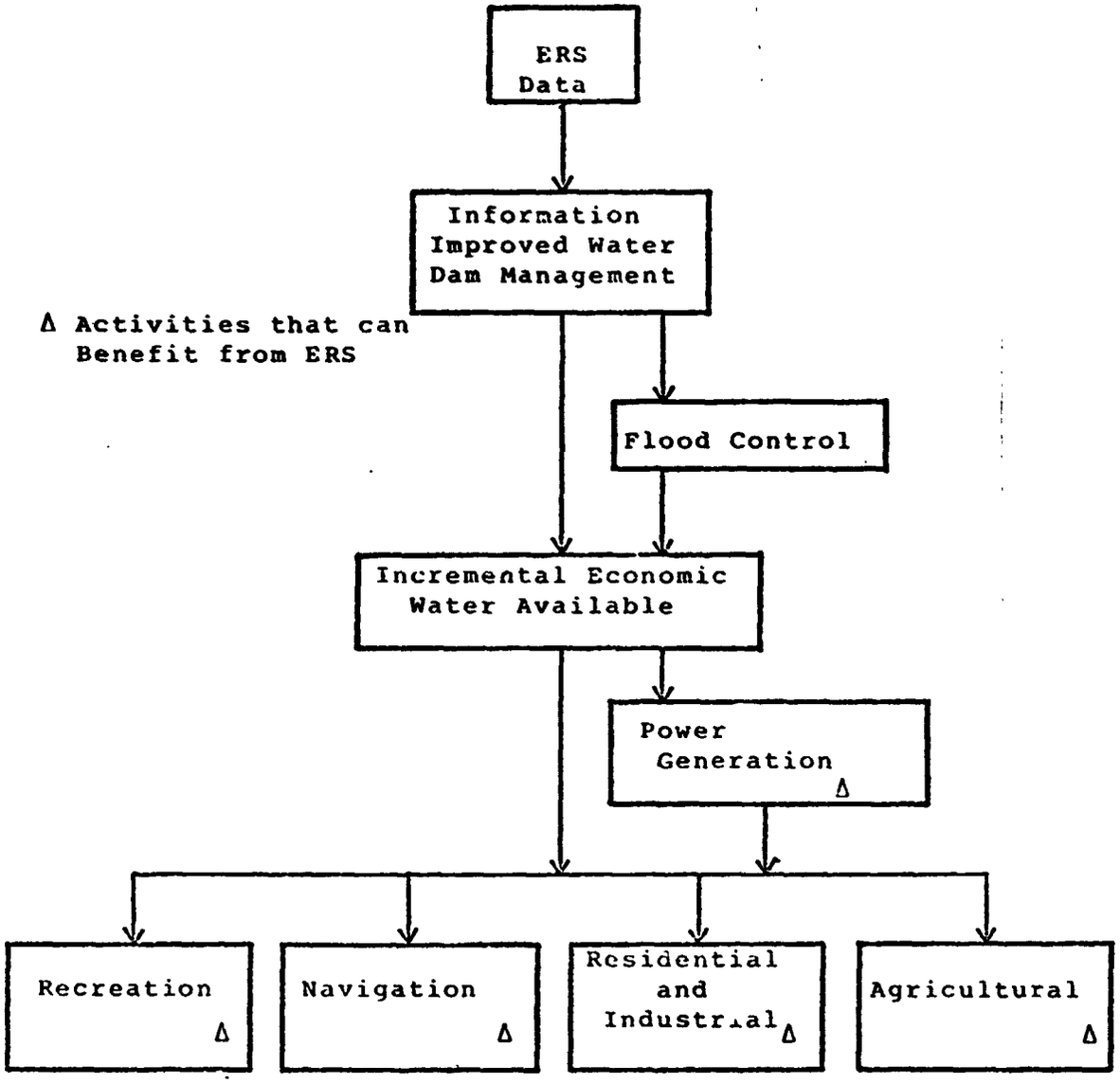

Figure 10 Activities That Benefit From Improved Water Management

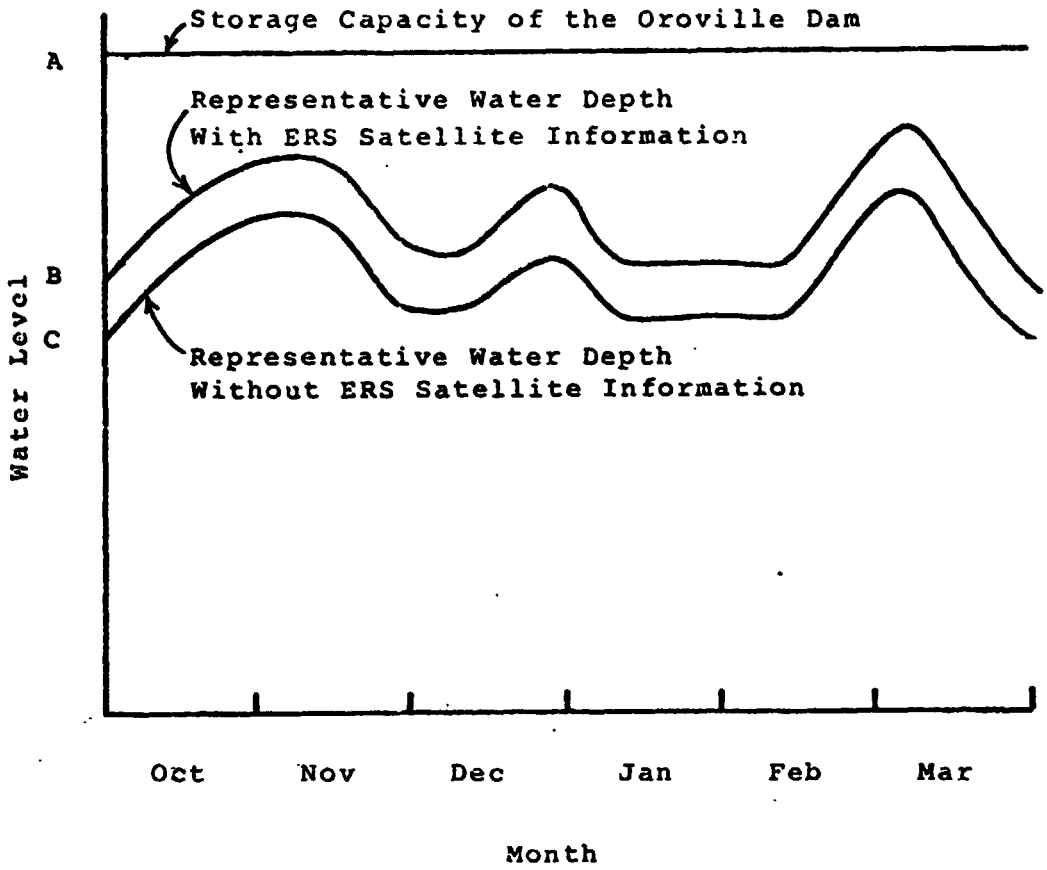

Figure 11 Effect of Improved Information on Steady State Water Levels

distance A minus C corresponds to some specified level of required unfilled flood control water volumes given by Figure 4. For example, level C may represent a flood control reservation of 550,000 acre-feet, which corresponds to a ground wetness level of 7.0. Information as to the estimated annual distribution of ground wetness is not available to us, so it is assumed that a ground wetness of 7.0 is representative of average conditions. The additional amount of water permits better distribution during the year, as illustrated by Figure 12. Instead of the present flow, a more even and economically more valuable flow of water can be obtained.

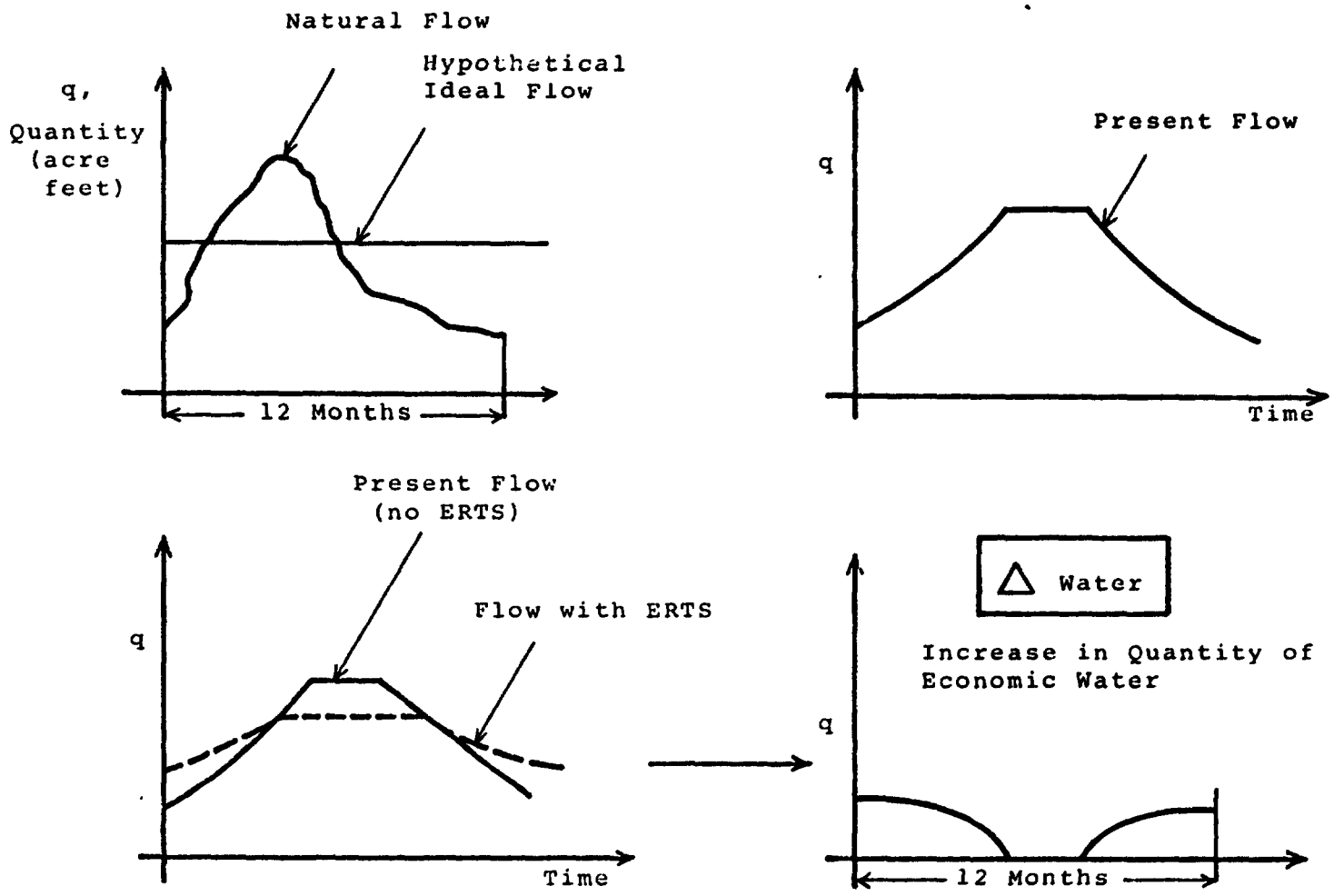

Figure 12 Water Flow (at Dam) Due to Water Management and Added Information

F.6 Water Management Models

In California, two basic water management models are used for forecasting purposes, the River Forecast Center (RFC) Model and the primary California Cooperative Snow Surveys (CCSS) Model. The RFC Model is used to make short-run forecasts (i.e., 6, 12, 18, 24 hour forecasts) while the "primary" CCSS Model is employed for longer term water management planning. A "dynamic" CCSS Model also exists for short-run forecasting purposes.

Because of its 18-day cycle, a single earth resources satellite would be much more valuable in longer term water management planning than in short-run forecasts. This would be true even if 3 earth resources satellites were in orbit. This position is supported implicitly by the University of California Study* and by the EarthSat report.** Therefore, the CCSS Model will be examined here in brief detail, but not the basic RFC Model.

F.7 The CCSS Model

The primary CCSS Model can be represented by the following set of equations:

$$W_1 = a_1A_1 + a_2B_1 + a_3C_1 + a_4D + a_5E_1$$

$$W_2 = a_1A_2 + a_2B_2 + a_3C_2 + a_4D + a_5E_1$$

$$W_3 = a_1A_3 + a_2B_2 + a_3C_2 + a_4D + a_5E_1$$

$$W_4 = a_1A_1 + a_2B_2 + a_2C_2 + a_4D + a_5E_2$$

where

W_1 = February forecast of April to July volume of water runoff

W_2 = March forecast of April to July volume of water runoff

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* An Integrated Study of Earth Resources in the State of California Using Remote Sensing Techniques, Space Science Laboratory, University of California, Berkeley, semi-annual progress report, 31 December 1973, pp. 2-26.

** Snow Mapping and Runoff Forecasting: Examination of ERTS-1 Capabilities and Potential Benefits from an Operational ERS System, Interim Report of Water Resources Management, Case Study Team, March 13, 1974, performed for United States Department of Interior, Office of Economic Analysis, Contract No. 14-08-001-13519.

W_3 = April forecast of April to July volume of water runoff

W_4 = May forecast of April to July volume of water runoff

A_1 = Conversion of February 1st snow pack index into the April 1st snow pack index

A_2 = Conversion of March 1st snow pack index into the April 1st snow pack index

A_3 = April 1st snow pack index

B_1 = Actual precipitation from October to January plus average historical precipitation in February and March

B_2 = Actual precipitation from October to February plus average historical precipitation in March

B_3 = Actual precipitation from October to March

C_1 = Actual runoff from October to February plus average historical runoff in March

C_2 = Actual runoff from October to February plus average historical runoff in March

C_3 = Actual runoff from October to March

D = Previous year's snow pack index

E_1 = Average historical precipitation from April to June

E_2 = Actual precipitation in April plus average historical precipitation from May to June.

The coefficients of these equations have been determined from the statistical technique of regression analysis. These equations therefore are based on statistically analyzed historical data and represent the average relationship between the dependent variable, April to July volume of water runoff,

and the five independent variables. With information developed from the regression analysis, statements can be made about the "goodness of fit," the degree of confidence in the coefficients, and the degree to which each independent variable contributes towards "explaining" the April to July volume of water runoff. Even without such information, we can make qualitative statements about "errors of measurement" associated with each independent variable. It can be assumed that the water precipitation variables have less "measurement error" than the snow pack variables. Thus, a more accurate estimate of snow pack, at least from a "measurement error" standpoint, should contribute more to an accurate forecast than a more accurate estimate of precipitation.

While the primary CCSS Model is used for prediction purposes, this model apparently is not used for purposes of regulation and management of water. However, since the CCSS Model takes into account some major influences not captured by the current model used for water management (described below), it would be surprising if better water management decisions did not occur by incorporating some aspects of the primary CCSS Model into the current water management model.

F.8 Estimate of Increased Accuracy with ERS Information

If ERS data cuts the information and modeling error by 20%, then an additional 110,000 acre-feet of water are available, as represented by the distance BC on Figure 11. That an ERS system can perform to this degree appears to be supported by the recent reports of a number of ERS principal investigators. Some of these principal investigators are Alexander, Burgy, Cooper, Hoffer, Holgren, and Meier. A description of their reports is given in this volume, Appendix G.

From another standpoint, it can be stated that ERS will improve forecasting accuracy. The sampling error of information obtained is given by the formula

$$e = \frac{b}{\sqrt{N}}$$

where

e = percent sampling error

b = a function of resolution, technique used, etc.

N = number of distinct large areas of snow or ground wetness sampled

If, for a given constant b in the above formula, ERS provides a coverage of snow and ground wetness that is 16 times greater than that currently monitored by aircraft, then, by using ERS, the sampling error in the snow cover and ground wetness information content is reduced by 75%.

Of course, snow cover and ground cover information is only part (but a major part) of the information required to make accurate runoff forecasts. Accuracy of forecasts also will be degraded by inaccuracies in the runoff model. In the EarthSat Report on Water Management*, estimated benefits presented in their tables are based on a 25%, 50%, and 75% increase in forecasting accuracy. Therefore, a 20% increase in the accuracy of forecasts is a conservative estimate, given the proven capabilities of ERS, the likely extent of increase in area coverage by ERS, and the estimates used in the EarthSat Report on Water Management.

F.9 Irrigation

Agricultural studies analyzing the value of water for irrigation were conducted by Brown and McGuire in 1967. Using demand functions fitted to two different sets of data, one from the California study for districts served by the Kern County Water Agency (KCWA), they obtained estimates of approximately $19 per acre-foot for the first set of data and $15 per acre-foot for the function fitted to the farm budget study. For the Feather River Area the total equivalent unit charge per acre-foot is $13.46, which is low in comparison to the rest of the state. Table 83 presents the marginal values of water in the districts of the KCWA. The value of water for non-agricultural purposes is typically higher than for agricultural purposes.** Therefore, applying the value of agricultural water to all other uses (except hydroelectric power generation) gives a conservative estimate of the additional value of water due to ERTS information.

Is there enough currently fallow but potentially irrigable land available in the Feather River Basin? The answer is affirmative, as indicated by Figure 13.

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* Snow Mapping and Runoff Forecasting: Examination of ERTS-1 Capabilities and Potential Benefits from an Operational ERS System, Interim Report of Water Resources Management, Case Study Team, March 13, 1974, performed for United States Department of Interior, Office of Economic Analysis, Contract No. 14-08-001-13519.

** If there were a completely free market for water use, and its quality were uniform across all users, then the marginal values for water would be identical across all uses.

Table 85: Prospective Marginal Values of Water in the Irrigation Districts of KCWA under Optimum Allocation

District	Annual delivery 1,000 acre-feet	Delivered price (= marginal) value) per acre-foot, $ (1967)	
		Case 1	Case 2
Belridge, W.S.D.	206	18.20	$14.60
Lost Hills, W.D.	168	14.50	10.85
Rosedale-Rio Bravo W.S.D.	70	19.20	15.55
Semitropic W.S.D.	127	17.70	14.05
W. Kern County W.D.	3	22.50	18.85
Antelope Plain W.D.	59	23.20	19.55
Wheeler Ridge-Maricopa W.S.D.			
No. 1	142	23.30	19.65
No. 2	29	28.75	25.10
Kern River Delta & Others	309	18.00	14.35

Source: Brown and McGuire, A Socially Optimum Pricing Policy for a Public Water Agency. Water Resources Research, Vol. 3; No. 1, 1967, pp. 33-43.

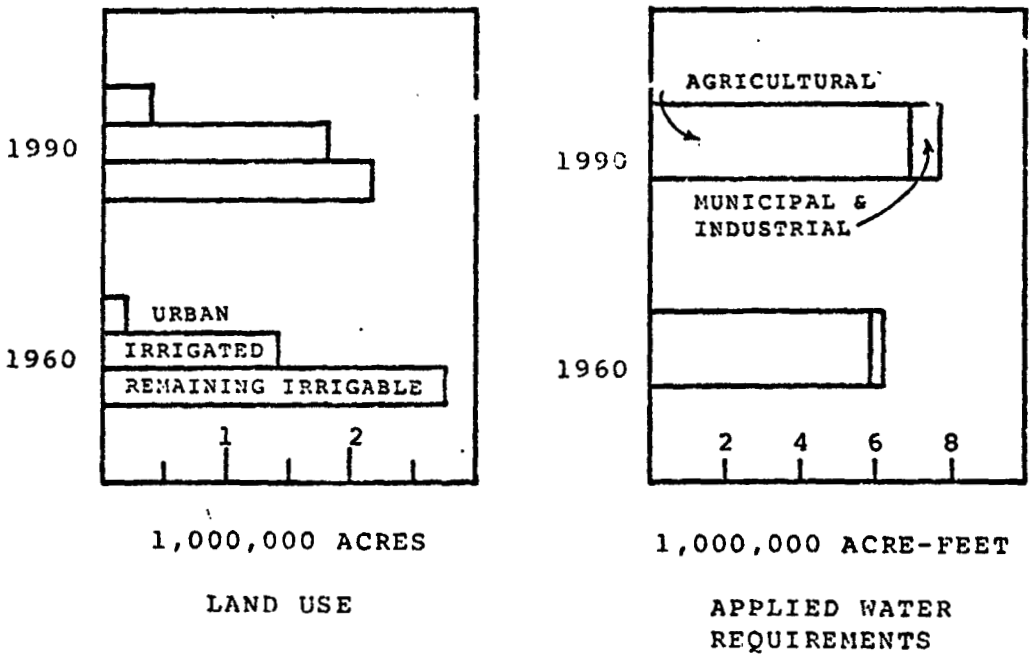

Figure 13 Sacramento Basin Hydroelectric Area Statistics (includes Feather River)

Source: Bulletin No. 160-66, Implementation of the California Water Plan, March 1966, State of California, Department of Water Resources

The value of 110,000 additional acre-feet of water at $13.46 per acre foot is $1,480,600 per annum. Since the price of crops has increased by at least 50% since 1967, when the value of $13.46 per acre-foot of water was calculated, an increase of 40% for the value of water is conservative. Multiplying the value per acre-foot by the number of acre-feet yields the annual benefit from increased water for irrigation and other non-hydroelectric power purposes in 1973 dollars of $2,072,840.*

For these estimated benefits to be valid on an annual basis, the variation in annual runoff into the Feather River Basin must be high relative to the estimated increase in the "steady state" water level. For the snowmelt period of the year (i.e., April 1 to July 31), the runoff in acre-feet for the years 1969-1973 was:

Year	Runoff	Difference in Runoff
1969	13,228,000	....
1970	4,462,800	-8,765,200
1971	10,803,200	6,340,400
1972	4,762,000	-6,041,200
1973	7,620,000	2,858,400

The difference in runoff from year to year is on the order of several million acre-feet, which is large relative to the 110,000 acre-feet increase in the steady-state water level.

The other reservoirs in the California State Water Project have a combined capacity that is approximately two-thirds of Lake Oroville. Therefore, an additional $1,380,000 per annum can be assigned to irrigation benefits in California.** From the EarthSat Report on Water Management

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* An alternative procedure is to calculate the net present value of the increase in land under irrigation. The calculation would involve taking the present value of the difference between the value of irrigated and nonirrigated agricultural land per acre multiplied by the expected increase in the amount of irrigated land. This procedure has a number of problems, particularly in obtaining an up-to-date value of the land per acre and in obtaining the expected increase in the amount of irrigated land.

** To be conservative, irrigation water that does originate from the California State Water Project is not included in the estimated benefits. The major irrigation water not included in California under this conservative general rule is irrigation water from the Colorado River.

(p. 99), the potential net benefit for irrigation activities in California is approximately 40% of the total for ten Western states. Therefore, an estimate of the total benefit from additional irrigation is $8,580,000 per annum.

F.10 Hydroelectric Power Generation

To calculate the value of 110,000 acre-feet of water for power generation, which can be obtained in addition to its value for irrigation, it is necessary to (a) determine the amount of Kilowatt-hours (kwh) that can be generated by this amount of water and to (b) determine the incremental value per Kilowatt-hour (kwh). Potential hydroelectric power is a function of the volume of water and the average height of that water. Given the gross static-head at Oroville of 615 feet, and a gross static-head of 103 feet at Thermalito, and using a power conversion efficiency of 90%, an acre-foot of water at Oroville-Thermolito is equivalent to 658 Kilowatt-hours of electricity. The total amount of additional hydroelectric power is therefore 72,400,000 kwh.*

Because of the highly regulated nature of the utility industry, a serious problem arises in determining the true incremental economic value of a kilowatt-hour. According to the EarthSat Report, the additional power generated can be used for peak power generation, where the value of a kwh is much higher than for off-peak power generation. The value of this power is equal to the value of such power generated by the least expensive alternative means. This value, based on the latest available information, appears to be at least two cents per kwh.

Data on the revenue and output (kwh) of privately owned electric utilities is published in Electric Power Statistics.** For the twelve-month period ended April 1973, the average price per kwh was $.0175.*** This price was 13.4% higher than the preceding twelve-month period. Applying this percentage to the next twelve-month period gives a price of

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* This estimated power generation is conservative since the Thermolito plant has a pumpback capability which permits "cheap" off-peak water to be pumped back for use as "expensive" peak-hour water.

** Electric Power Statistics, Federal Power Commission, April, 1973.

*** A subsidized price of only $.0077 per kwh was charged in 1972 to utility companies by the State of California for hydroelectric power from the Feather River.

$.02 per kwh. Because of high interest rates, tight credit, and the energy crisis, the price per kwh has increased considerably more than 13.4%. However, to be conservative, a $.02 per kwh price is used in our estimation procedure. This price is also conservative because it is a weighted average of the peak and off-peak price of electricity. Since the peak-hour cost is higher than off-peak-hour cost, a price that reflected only peak-hour cost would be higher than a price that reflected the weighted average of peak and off-peak cost. The annual value of this hydroelectric power is therefore equal to or greater than $1,450,000.

In order to calculate the potential increase in hydroelectric power for the U.S., based on the Feather River results, an examination was made of those major U.S. drainage basins where snowmelt would be an important determinant of water runoff. The following drainage basins, shown on Figure 14 met this criterion: North Pacific, South Pacific, Great Basin, Colorado River, Missouri River, and Ohio River. Within these drainage basins, only large hydroelectric power plants (i.e., those with a generating capacity over 100,000 kw) were included in the calculation. It is estimated from data available from the Federal Power Commission that these hydroelectric plants generated, on a conservative basis, 107 billion kwh of electricity in 1973.

The Oroville-Thermalito power plants generated an annual average of 2.45 billion kw of electricity in the years 1971 and 1972 (i.e., 3.264 billion in 1971 and 1.635 billion in 1972). This average represents 2.29% of the estimated total production of large hydroelectric plants in the six designated drainage basins in 1973.* Therefore, scaling up the hydroelectric power results for the Feather River by a factor of 43.6 gives an annual nationwide benefit of $63,000,000.** However, to be conservative, it is assumed that only two thirds of these large plants in the six designated river basins benefit from FRS. This adjustment yields an annual benefit for the U.S. of $42,000,000.

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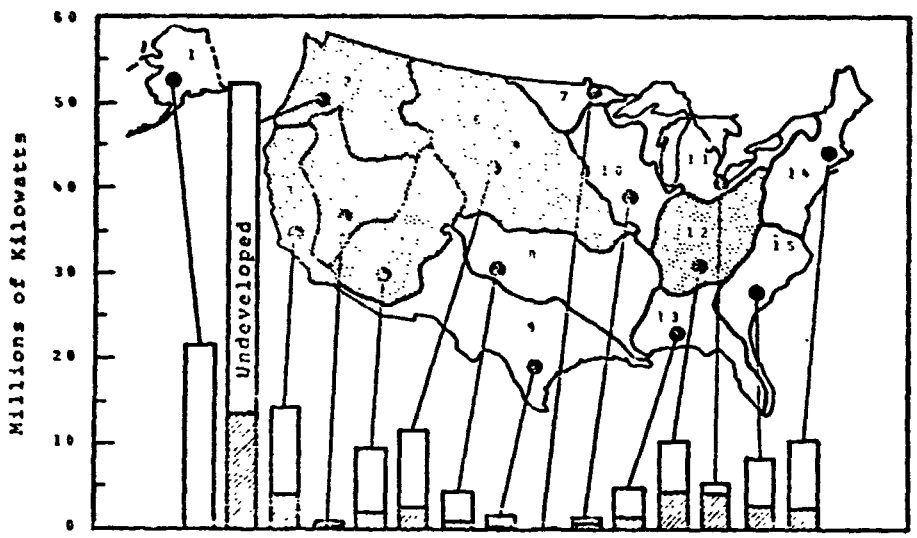
* Bulletin 132-69 published by the Department of Water Resources, State of California, June, 1969, estimates the average annual generation of 2.3 billion kwh, which represents 2.15% of our estimated total large hydroelectric power plant production. If this percentage were used in our calculations, the scale-up factor would be 46.5

** This calculation excludes projected increases in installed capacity. Based on historical data, these increases are likely to increase installed capacity by at least a third by 1985.

By combining the value of added economic water for irrigation and hydroelectric power generation, a lower bound estimate of annual benefits attributable to improved (ERS) information of $50.6 million is obtained.



1. Alaska
2. North Pacific
3. South Pacific
4. Great Basin
5. Colorado River
6. Missouri River
7. Hudson Bay
8. Lower Mississippi River
9. Western Gulf
10. Upper Mississippi River
11. Great Lakes St. Lawrence River
12. Ohio River
13. Eastern Gulf
14. North Atlantic
15. South Atlantic

Figure 14 Developed and Undeveloped Hydroelectric Power by Major Drainages January 1, 1964

APPENDIX G:

ABSTRACTS OF RECENT REPORTS ON UNITED STATES INLAND WATER RESOURCES BY ERTS PRINCIPAL INVESTIGATORS

This appendix contains current information on ERTS principal investigators, including addresses, telephone numbers, affiliations, summaries of progress reports and accomplishments.*

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* This appendix excludes principal investigators whose recent reports are primarily on Coastlands, Wetlands, and Estuaries and also excludes principal investigators whose recent reports do not include areas of the United States.

Source: A merging of information from three current NASA computer printouts.

Table 86: List and Appendix Location of ERTS Principal Investigators

Principal Investigators	Page
ALEXANDER, R.H.	G-4
BARNES, James C.	G-4
BAUMGARDNER, Marion F.	G-6
BELON, Albert E.	G-7, 11, 45
BLANCHARD, Bruce	G-8
BRYAN, M.L.	G-9
BURGY, R.	G-10, 15
CARLSON, Robert F.	G-11
CAST, Larry D.	G-12
CHASE, P.	G-12
CLARK, R.	G-13
COLLINS, R.	G-14
COLWELL, R.N.	G-14, 15
COOPER, Saul	G-16
COULBOURN, W.C.	G-18
DETHIER, B.E.	G-18
DREW, James V.	G-18
ERB, R. Bryan	G-19
GARCIA, Luis	G-20
GOETZ, A.F.H.	G-20
HIDALGO, John U.	G-21
HIGER, Aaron L.	G-21
HOFFER, Roger	G-22
HOLLYDAY, Este R.	G-22
HOLMGREN, B.	G-23
JAIN, R.K.	G-23
JELACIC, Allan	G-24
KNEPPER, Daniel H., Jr.	G-25
LANDGREBE, David A.	G-25
LIND, A.O.	G-26
MACDONALD, William R.	G-28
MARK, Herman	G-29
MEIER, Mark	G-30
MORRISON, Roger B.	G-33
MYERS, Victor	G-34
PAULSON, Richard W.	G-34
PERRIER, Raymond	G-35
PLUHOWSKI, Edward J.	G-35
POLCYN, Fabian C.	G-36
REEVES, C.C.	C-37
ROGERS, Robert H.	G-38
SATTINGER, I.J.	G-38
SCHMANN, Herbert H.	G-39
SEREBRENY, Sidney M.	G-40
SHOWN, Lynn M.	G-41

Table 86: List and Appendix Location of ERTS Principal Investigators (Continued)

Principal Investigators	Page
STOECKELER, Ernest G.	G-41
THORLEY, G.A.	G-43
WEAVER, Kenneth	G-44
WELBY, Charles W.	G-44
WELLER, Gunter	G-44
WELLS, T.	G-46
WEZERNAK, C.T.	G-46
WIEGAND, Craig L.	G-47
WIESNET, Donald R.	G-47
WOBBER, Frank J.	G-49
WOODMAN, Raymond G.	G-49
YARGER, Harold L.	G-49

ALEXANDER, R. H.
U.S.G.S.
National Center
Room 2722
Mail Stop 115
Reston, VA.
22092
GSFC ID 1125A-IN02A-C
Phone 703-860-6345

TITLE:

Central Atlantic Regional Ecological Test Site

REPORT A:

This is a preliminary attempt to establish empirical relationships between infiltration, runoff, sediment yield, and water quality on the one hand and land use patterns and change on the other.

BARNES, James C.
Environmental Research & Technology
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Lexington, Massachusetts
02173
PI Telephone: 617-861-1490

DISCIPLINES: Water Resources -- Snow Surveys

TITLE: To Evaluate The Application of ERTS(A) Data For Detecting and Mapping Snow Cover

ABSTRACT 201:

ERTS-A data will be examined and the optimum spectral interval selected for snow mapping. Snow mapping will be conducted in the mountainous areas of the Sierra Nevada region, the Upper Columbia River Basin, and the Salt River Project area in Arizona. Flat terrain snow mapping will be accomplished in the Upper Mississippi and Missouri River Basins. All satellite-derived results will be compared to results achieved using conventional observations and data sources.

REPORT A:

In two cases analyzed for the salt-verde watershed in Arizona, good agreement is observed between the location of snow lines as mapped on ERTS imagery and aerial snow cover

charts. More detail usually exists on ERTS-derived charts. Time required to make an aerial snow survey chart is six hours. ERTS data permits mapping of watershed snow cover in two hours. These results indicate that snow extent can be mapped from ERTS data on a cost-effective basis.

REPORT B:

Considerable detail is observable in glaciers located along the West and East coasts of Greenland. Detectable features include medial moraines, terminal moraines, crevassed areas, and limits of snow cover of glacial ice.

REPORT C:

Results from snow mapping in the Southern Sierra and Central Arizona Mountains indicate that snow extent can be mapped from ERTS imagery in more detail than is depicted on aerial cover survey charts. The agreement between percentage snow cover as determined from ERTS data and from aerial snow charts is of 5% for most cases. Moreover, it appears that areas of significant snow cover can be mapped as accurately from ERTS imagery as from aircraft photography.

REPORT D::

Dynamic snow cover changes on Banks Island in the Canadian Archipelago have been observed from ERTS-1. On 26 July 1972, ERTS MSS imagery shows the Island is snow-free. In the 4 September observations, snow covers only the higher elevations in the central part of the Island. On 21 September, the entire island is snow covered.

REPORT E:

Labrador Lake appears sharply in Band 3, faintly in Band 2, and disappears in Band 1. Surrounding lakes are relatively unaffected.

Note: Lake in question is Umiakovic at 570 23.2' N., 620 50.0' W.

BAUMGARDNER, Dr. Marion F.
Lab. for Appl. of Remote Sen.
Purdue University
1220 Potter Drive
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47907

TITLE: Purdue/Larsys Crop and Soil Characterization and Mapping Using ERTS CCTS

REPORT A:

The surface water resources of Lynn County, Texas, were examined. Water was separated spectrally from all other categories for three ERTS overpass dates. It was found that many of the playas containing water on 9 October (1078-16524) contained no water on 14 November (1114-16532) and many with no water on 14 November had water on 2 December (1132-16532). Precipitation records support these general water surface area observations. The following is an estimate of the water surface area for the three dates: 9 October, 4374 points, 1924 hectares; 14 November, 3735 points, 1643 hectares; 2 December, 1520 points, 2253 hectares; (total area - 197683 hectares).

REPORT B:

A study of water quality and surface area in Tahoka Lake (Lynn County, Te. s) using time sequential ERTS MSS digital data produced four major types of classes: 1) classes which were not water on any of the three days, 2) classes which were water for all three days, 3) classes which were water on only two days, and 4) classes which were water on only one day. By analyzing the arrangement of points, changes in water surface area can be observed and deep and/or clear water can be distinguished from shallow and/or turbid water by comparing class means.

REPORT C:

Analysis of computer compatible tapes of ERTS scenes including the Devon Reservoir, Collins County, Texas, indicates that three categories of water can be delineated. These categories correspond to areas of relatively deep water, relatively shallow water, and shallow water containing many dead trees and stumps.

REPORT D:

Analysis of computer compatible tapes of ERTS scenes including the Devon Reservoir, Collins County, Texas, indicates that three categories of water can be delineated. These categories correspond to areas of relatively deep water, relatively shallow water, and shallow water containing many dead trees and stumps.

REPORT E:

Ten spectral classes representing different land features and eight spectral classes of water in the Lavon Reservoir area of Collins County were mapped. The different water categories were the result of differences in depth, turbidity, sediment load, and algae growth. For example, in the Southwest part of the Lake, a distinct spectral class proved to be shallow water interspersed with a high population of dead tree stumps. Other spectrally identifiable features included cotton, wooded areas, and grazing.

REPORT F:

Analysis of computer compatible tapes of ERTS scenes including the Devon Reservoir, Collins County, Texas, indicates that three categories of water can be delineated. These categories correspond to areas of relatively deep water, relatively shallow water, and shallow water containing many dead trees and stumps.

BELON, Albert E.
Geophysical Institute
University of Alaska
Fairbanks, Alaska
99701

TITLE: Grant From Office of University Affairs

REPORT:

ERTS image 1029-20383 of Big Delta, Alaska, taken August 21, 1972, showing a characteristic dashed and zigzag line in old terminal moraines, suggests that the Mt. Hayes Glacier, which is now retreating, was once a surging glacier.

BLANCHARD, Bruce
HARTMAN, Monroe
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DISCIPLINES: Water Resources -- Watershed Surveys

TITLE: Use of Space Data in Watershed Hydrology

ABSTRACT 011: This study will determine how effectively ERTS MSS data can be used to characterize watershed runoff. Where success in this endeavor is obtained, the ERTS-derived parameters will be injected into a hydrologic model and the performance of the model compared when satellite data is used versus when it is not. If improved performance of the model is noted when satellite data is used, the model will be modified to routinely accept satellite data.

REPORT A:

It has been found that MSS Bands 1, 2, and 4 in linear combination offer the best discrimination between wet and dry conditions on small watersheds (less than 10 square miles) in the Washita drainage area. It seems at this point that separate linear equations for each season of the year. The range in spectral response in all bands is reduced under wet conditions.

REPORT B:

The difference in MSS mean spectral response between watersheds with widely varying runoff characteristics is extremely small for dormant scenes. The variance around the mean spectral response for a given watershed decreases when wet conditions prevail.

REPORT C:

It has been found that MSS Bands 1, 2, and 4 in linear combination offer the best discrimination between wet and dry conditions on small watershed (less than 10 square miles) in the Washita drainage area. It seems at this point that separate linear equations for each season of the year. The range in spectral response in all bands is reduced under wet conditions.

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HORVATH, Robert
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LEGAULT, Richard R.
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DISCIPLINES: Water Resources -- Lake Ice Surveys

TITLE: Application of ERTS(A) Imagery to Lake Ice Survey

ABSTRACT 072:

Intercomparison will be made between ERTS Vidicon, Multispectral and IR Data and aircraft measurements with multispectral scanner, synthetic aperture radar and IR for intended use of lake ice surveillance for eastern Lake Superior and southern Lake Huron during fall and winter. Ice parameters of importance include location, extent, leads, barriers, thickness and strength. Surface water temperature of 4 degrees C. critical for ice formation forecasts, will be mapped.

BURGY. R.

DISCTEST:

Water Resources
Watershed Surveys

AREA:

California and Nevada
Northern Coast of California

PLATFORM:

ERTS A

SENSOR:

Multispectral Scanner

REPORT A:

Band 6 (Infrared) is the best for delineating water features, while Bands 4 and 5 are best for determining conditions of water itself. Band 5 provides the best combination of ground resolution and detection of in-water details. Color composites are useful for delineating streams, lakes and ponds, but are best used to evaluate general characteristics of watershed i.e , land use, vegetation types, moisture distribution, etc.

REPORT B:

Changes in flood water stages from one pass to another have been observed. (Band 6 is the most useful in that respect). Sediment flow out of test site is observed by tone difference in several sloughs draining the area. Band 5 allows best underwater detail recognition and shows greater tonal difference between water of different qualities (principally in terms of sediment concentration).

REPORT C:

Band 6 (Infrared) is best for delineating water features while bands 4 and 5 are best for determining conditions of water itself. Band 5 provides the best combination of ground resolution and detection of in-water details. Color composites are useful for delineating streams, lakes and ponds, but

are best used to evaluate general characteristics of watershed i.e., land use, vegetation types, moisture distribution, etc.

REPORT D:

Variations in water levels (of reservoirs, lakes, rivers, etc.) are detectable from ERTS-A imagery by observations of: Change in shape, in position of water line and appearance of a bright line along shore (in Band 4 and 5) denoting a denuded area are detectable from ERTS-A imagery by observations of: Change in shape in position of water line and appearance of a bright line.

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WENDLER, Gerd, Dr.
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BELON, Albert E.
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DISCIPLINES: Water Resources -- Watershed Surveys

TITLE: Break-Up Characteristics of Chena River Basin

ABSTRACT 110-05:

Use ERTS-A imagery to observe the extent of snowmelt in a watershed by three-stage sampling--no snow on ground, melting snow on surface, non-melting surface snow. Obtain indication of snow depth before and during melt through interpretation of emergence of vegetation.

REPORT A:

No significant results.

REPORT B:

ERTS imagery has been used to monitor snow melt in central Alaska. From ERTS it was possible to observe that snow cover increased at high altitudes from mid-February to the beginning of May. At low altitudes there was an increase from 19 February to 27 March, but a decrease to 2 May as melting started. It was also noted that snow cover increased with increasing altitude as well as with a northerly exposure.

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80225
PI Telephone: 303-234-4179

BOWMAN, James W.
U.S. Bureau of Reclamation
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Denver, Colorado
80225

GUDGEL, David F.
U.S. Bureau of Reclamation
Region 7, Federal Center
Denver, Colorado
80225

DISCIPLINES: Water Resources -- Reservoir Monitoring

TITLE: Remote Sensing of Reclamation Projects

ABSTRACT 208:

Study areas are: completed Colorado-Big Thompson Project, partially completed Frying Pan-Arkansas Project, soon to be constructed narrows unit and front range unit under study. Specific objectives are: detection of water leakage from canals and reservoirs; detection of algae growth, pollutants and siltation in reservoirs; location of geologic contacts, structure and faults in front range unit and land use study of this area.

CHASE, P.

DISCTEXT:

Water Resources

* Watershed Surveys
** Lakes

AREA:

Michigan

PLATFORM:

ERTS A

SENSOR:

Multispectral Scanner

REPORT A:

Four distinct types of lake reflectance identified in test lakes: shoreline, shallow water and two deep water types of reflectance.

REPORT B:

Minimum size lake identifiable by use of 10x glass and positive transparency was 500 ft. by 650 ft.

REPORT C:

Seven density slicing levels were determined for Orchard Lake, Michigan, in the 27 March 1973 scene (1247-15474), Band 5. The 28 September 1972 scene of the same lake yielded only 4 levels. The shoreline, shallow water and deep water areas of the 27 March band 5 CCT agree quite well with aerial photography taken from a C-130. There is, however, more information on the deep water areas in the MSS imagery.

CLARK, R.

DISCTEXT:

Water Resources
* Flood Assessment and Prediction
** Seasonal Repetition of Flood Conditions

AREA:

Arizona

PLATFORM:

ERTS A

SENSOR:

Multispectral Scanner

REPORT A:

Map of watershed oundaries i: Cochise Co., Arizona constructed from combined ERTS and U-2 imagery. Preliminary areas of flood inundation were locally determined. This contributes to implementation of Arizona House Bill 2010. A detailed set of watershed configurations for the Cochise County area had not been available prior to this project.

COLLINS, R.

DISCTEXT:

Water Resources
* Ground Water Surveys

AREA:

Oklahoma-Texas

PLATFORM:

ERTS A

SENSOR:

Multispectral Scanner

REPORT A:

MSS imagery reveals many areas that are known to be underlain by shallow aquifers.

COLWELL, Robert N., Dr.
Space Science Lab
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Berkeley, California
94720
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DISCIPLINES: Water Resources -- River Monitoring

TITLE: Analysis of River Meanders from ERTS-A Imagery

ABSTRACT 317-04:

ERTS imagery will be assessed for its utility in predicting river discharge rates by statistical analysis of meander patterns. Data from ongoing studies of U.S. rivers by aerial photography will be used in validating lower cost satellite-recovered data of potential value in the control and inventory of water resources over large, undeveloped regions of the world. Establishment of new criteria for determining meander pattern stability and assessing river controls will be attempted.

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KNIGHT, Allen W.
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STORM, David R.
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University of California
Davis, California
95616

DISCIPLINES: Water Resources - General

TITLE: Use of ERTS-A To Aid in Solving Water Resource Management Problems in California

ABSTRACT 317-02:

Use of ERTS data will be tested for the solution of certain water resource management problems. California sites will be monitored to: (1) characterize water yield predictions

and melting rates indicated by snowpack imagery; (2) test application of ERTS data in multiple management of a large, regulated river system; and (3) detect and assess gross water quality changes in an estuarine water system. Emphasis will be given to demonstration by ground verification of ERTS data utility.

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N.E. Div.
U.S.A. Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts
02154

BOCK, Paul, Dr.
University of Connecticut
Storrs, Connecticut
06268

DISCIPLINES: Water Resources - Reservoir Monitoring

TITLE: The Use of ERTS Imagery in Reservoir Management and Operations

ABSTRACT 089:

The major objectives will be to determine the feasibility of using space-relayed data and space photography in reservoir regulation and management. 25 platform sites will be selected to monitor (thru space-relay) precipitation, water quality, tide, etc. A systems engineering approach will be used and cost benefit studies produced that quantitatively evaluate the ERTS space relay system. RBV and MSS imagery will be used in studying the areal distribution of floods, water quality, etc.

REPORT A:

23 out of 27 DCP's have been installed and data are being received in near real-time. The data has been used in an operational mode during the spring floods in Maine as well as during the recent floods in New Hampshire and Vermont that occurred at the end of June. In terms of the percentage of good reports received versus the total received, the percentage is very frequently over 95% for individual DCP's. For U.S. Army Corps of Engineers purposes the DCS performance is judged to be satisfactory.

REPORT B:

Analysis of ERTS frames E-1024-15055 and E-1024-15062 on 16 August 1972 and E-1096-15056 on 27 October 1972 suggests the possibility that actual flood patterns at different stages may be determined with some accuracy. In addition, the imagery may be useful in checking expected flood patterns along the lengths of rivers against the flood configuration that actually occurred.

REPORT C:

ERTS-1 imagery has been found useful for flood plain and wetland management. Extensive flooding along Connecticut and Merrimack Rivers after flooding in spring. A procedure for using ERTS imagery, topographic maps, and other information has been developed to evaluate storage capabilities of flood plains and wetlands.

REPORT D:

Adjacent frames taken on 6 and 7 January 1973 provide a dramatic example showing Lake Winnipesaukee in New Hampshire in the process of freezing over.

REPORT E:

In the vegetation and mountainous regions of New England the snowline boundary can be fixed to within one or two miles. Satellite imagery in conjunction with conventional information provides improved snow contour maps. Using overlap on pictures taken on successive days (6 and 7 April) very large changes in stations on the Merrimack Basin show a commensurate increase in riverflow.

REPORT F:

Using MSS band 3 (0.7--0.8 micrometer) and 4 (0.8--1.1 micrometers) imagery all lakes mapped on U.S.G.S. quadrangle maps (1:125,000) covering the Shetucket and Quinnebaug River basins have been located including unnamed lakes. New dredging ponds, inlet configurations, river sediment patterns, and other surface water features not on the maps have been identified. Water features 300 feet in diameter can be readily identified. Useful interpretations of drainage features, drainage divides and hydrologic complexes can be made for basins as small as 25-50 square miles.

COULBOURN, W.C.
Grumman Ecosystems Corporation
Bethpage, New York
11714
GSFC ID 1589A-PR07D-C-A000
Telephone: 516-575-2473

TITLE: Determine the Boundaries of A/C & S/C Data Within Which Useful Water Quality Information can be Extracted

DETHIER, B.E., Dr.
Department of Agronomy
Box 21 Emerson Hall
Cornell University
Ithaca, New York
14850
GSFC ID 1159A-UN01A-C-A000
Telephone: 609-256-3034

TITLE: Phenology Satellite Experiment (Greenwave NE-69)

REPORT A:

Wetland areas such as bogs and heaths can be seen readily on ERTS MSS imagery. Bogs and heaths ranging in size from ten to several hundred hectares were noted and found to coincide with boundaries on existing USGS Quadrangle maps. ERTS-1 frame 1040-14545 over Portland, Maine, area also permits the delineation of tidal and mud flats in Casco Bay with good accuracy.

REPORT B:

Band MSS-7 used in flood extent evaluation. Flooding along Wabash and White Rivers apparent. Inundated lands identifiable bordering rivers.

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GSFC ID 1020A-UN01C-C-A000
Phone: 402-472-2875

TITLE: Mapping and Managing Soil and Range Resources in the Sand Hills Region

REPORT A:

ERTS imagery, limited to August, 1972 shows that certain lakes in the Nebraska sand hills area reflect individual wavelength bands differently from the majority of lakes in this area. Reasons are not yet determined; limited evidence indicates no correlation between reflectance and water properties such as ph, total alkalinity, total solids (turbidity), and ppm of several ions (both positive and negative) commonly found in lake water.

REPORT B:

Continuing investigations of lakes in Nebraska sand hills now reveal that generally the greater the total amount of ions in the water the greater the reflectance. MSS Band 6 appears to be more sensitive to this relationship than Band 7. With densitometry measurements, the lakes can be separated into 3 quality classes with Band 6 imagery, into 2 classes with the Band 7 imagery. Potential significance of these classes to the use and management of the lakes is yet to be determined.

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TITLE: Utilization of ERTS A & B Data for Application in Test Site 175

REPORT A:

The ERTS-1 coastal analysis team at JSC has determined that a greater number of spectral clusters identifying water can be separated when data from the coastal land areas are excluded from the data processed. An isoclustering computer run with the edited data yielded 4 distinct groupings of spectral values of the water features.

REPORT B:

Changes in water turbidity were found to cause detectable changes in water reflectance as recorded by all bands of the ERTS-1 multispectral scanned (MSS). This was not expected in data from Band 7. A portion of the data was selected for

enhancement by rating relative brightness of scene features as arbitrary colors on the CRT of a data analysis station. Water brightness varied from values of 1 to 4 on the grayscale. In contrast, land brightness had grayscale values of 21 or greater. Discernable brightness variations were observed in portions of the image identified as water inflow points, where high values of turbidity would be expected.

REPORT C:

A graymap printout from ERTS-1 data of Lake Somerville in South Central Texas described a lake outline that was not consistent with available maps of the shoreline. Field examination revealed that the actual level of the lake was about 6 feet below that for which the map was drawn. The lake as it currently stands agrees in shape and relative size with the ERTS-1 printout.

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TITLE: Research and Land-Use in Soil Erosion, Deficit, Deforestation and Floods; Geologic Mapping and Tectonic Structure Delineation

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TITLE: Application of ERTS and EREP Images to Geological Investigation of Basin and Range-Colorado Plateau Boundary in Arizona

REPORT A:

Near Flagstaff, Arizona, a set of northwest-trending lineaments that converge toward a north-trending lineament of the Oak Creek fault was discovered on ERTS frame 1014-17375 of August 6, 1972; and it may mark an area structurally favorable for the location of water in paleozoic sediments that underlie the basalt cap.

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TITLE: Preliminary Study of Lake Pontchartrain and Vicinity Using Remotely Sensed Data from ERTS

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DISCIPLINES: Water Resources -- Flood Assessment and Prediction

TITLE: Develop Data Relay System for Monitoring Hydrologic Conditions in South and Central Florida

ABSTRACT 272:

The Water Resources Division, USGS, proposes the joint use of ERTS imagery and on-site data collection platforms to monitor specific climatological and hydrologic conditions in south Florida. Experiments are planned to test this approach for the following problems: (1) management of water resources; (2) monitor discharge of heated salt water into Card Sound; and (3) the study of land-water botanical distribution dynamics in south Florida.

REPORT A:

All 13 data collection platforms are installed in three conservation areas of the water management model and are measuring rainfall and water level. Water storage can be determined mechanically using a combination of ERTS imagery for area and DCP's for water depth. Water storage data is being provided daily to the Corps of Engineers who are using the data in their operations.

REPORT B:

ERTS imagery of Lake Okeechobee has been used to

determine water circulation patterns in the lake by detecting turbidity distribution. This is important in analyzing the effect and distribution of outflow from various water sources as they contribute to lake pollution and eutrophication.

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TITLE: Interdisciplinary Evaluation of ERTS for Colorado Mountain Environments Using ADP Techniques

REPORT A:

The area of the Animas watershed was estimated using computer techniques and 1.12 acre per element. The error was 1.4% as compared to USGC measurements. Snow cover was estimated by classification techniques and it was concluded that it provided a rapid area measurement of the snowpack.

REPORT B:

The area of the Animas watershed was estimated using computer techniques and 1.12 acres per element. The error was 1.4% as compared to USGC measurements. Snow cover was estimated using computer classification techniques and it was concluded that it provided a rapid area measurement of the snowpack. Primary attention on this project is being devoted to statistics related to winter wheat production with Finney County, Kansas as a test area. Wheat has been successfully identified and acreage estimates have been prepared for a ten county area in southwestern Kansas. Alfalfa has been identified and mapped in Finney County. Data on the extent and distribution of irrigation and strip cropping in Kansas have been extracted from the imagery.

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DISCIPLINES: Water Resources -- Watershed Surveys

TITLE: Basic Characteristics Extracted from ERTS Data for Improving Regression Est. of Streamflow

ABSTRACT 342-06:

Extraction of relevant characteristics in satellite data as observed over the Piedmont and coastal plain in Delaware and Maryland will be attempted. These characteristics will be used in regression analysis involving streamflow records. The results will be compared to regression results derived using conventional observations and standard techniques.

HOLMGREN, B.

REPORT A:

ERTS data provides entirely new information on break-up characteristics of extensive drainage basins, showing removal of snow by wind, overflow on rivers, the development of drainage patterns, the retreat of snow cover, snow drifts, and the majority of ice fields after snow melt. Road systems between oil camps, airfields, etc. are readily visible and are useful in the study of the ecological effects of man on the tundra environment.

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TITLE: Evaluate Effects of Construction & Staged Filling of Reservoirs on Environment & Ecology

REPORT A:

Ground truth progress: 4 vegetation areas; 5 micro-climate stations were established. Insect and animal inventories were completed. Water quality at 13 sites was completed.

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DISCIPLINES: Water Resources -- Lake Ice Surveys

TITLE: The Interdependence of Lake Ice & Climate in Central North America

ABSTRACT 113:

The primary objective is to correlate the freezing and thawing of central North American lakes with climatic variations using ERTS-A imagery and local weather records. A secondary objective is to determine if any feedback effects occur in the local weather from the lake freezing or thawing processes.

COMMENTS:

1. Retrospective order is restricted to lakes within the test site area.

2. Data analysis plan accepted January 30, 1973

REPORT A:

Latitude migration of lake ice boundary during October and November 48 and 33 km per day respectively. Transition zone is oriented NW-SE. Upper latitude cyclones tend to move along a path within transition zone.

REPORT E:

ERTS-1 has proven to be an exceptional platform from which to conduct a lake survey. Of a total 411 candidate lakes, 260 were chosen as study lakes. Resolution limits of ERTS imagery have restricted surface characteristics identification on lakes less than 250 mm. Synoptic coverage by satellite has enabled the lake freeze transition zone to be viewed over large areas in space at a single instant in time. Results identified are (1) freeze/thaw transition zone can occupy same geographical location during freeze season from year to year; (2) orientation of transition zone boundaries independent of time of year or geographical location. TZ boundaries usually are oriented Northwest-Southeast. Satellite based studies of lake freezing cycle appars to present opportunity of increasing knowledge of lake/atmosphere interaction.

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TITLE: Geologic and Mineral and Water Resources Investigations in Western Colorado Using ERTS-A Data

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TITLE: A Study of the Utilization of ERTS-A Data from Wabash River Basin

REPORT A:

Spectral analysis and classification was performed on water resources test sites in ERTS frame 1016-16050 on August 8 over southern Indiana. Four spectral classes were found in samples from the Wabash River, Wabash Ohio River Junction, the Ohio River, and several lakes. Classification results showed that whenever the visible bands were used, either by themselves or in combination with the near-infrared channels, the water classes were easily separated.

REPORT B:

Computer processing led to a minimum of three distinct water quality classifications derived from images of area water reservoirs and rivers. Observation from low flying aircraft did not disclose visible differences in these waters. Differences which appear in ERTS imagery are believed to result from variations in sediment content. Algae growth was also detectable from space.

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DISCIPLINES: Water Resources -- Estuary & Wetlands Surveys

TITLE: Environmental Study of ERTS-A Imagery, Lake Champlain Basin

ABSTRACT 347:

Visual analysis relating tone, color, texture, pattern in ERTS images to ground data for Lake Champlain and environs; Objectives: Identify major land use classes; note distribution of superficial geologic deposit (sands-gravels); aquatic vegetation zones-distribution and changes; lake level and shoreline changes; surface roughness, and turbidity patterns; pollution effects; influence of environment on Lake region

C-5

resources; extension of ongoing research program in limnology.

REPORT A:

Within Lake Champlain and parts of Vermont to the East, it has proved possible to identify the following features in ERTS RBV imagery taken between July 29 - 31, 1972: Boundary between turbid and clear northern waters in the lake (by tonal differences between Bands 1 and 2); wetlands areas around mouths of several rivers; trends of two moraine-like glacial deposits; outline of the former shoreline of the Champlain Sea near St. Albans; meander scars associated with river flood plains; and three major categories of land use--wooded areas, open land, and built up areas in the vicinity of Burlington, Vermont.

REPORT B:

Comparison of ERTS images covering Lake Champlain made in October and twice in April 1973 shows large measurable changes in shoreline position at water levels of 95.1.,100.4, and 99.4 feet. The delta of the Lamoille River, nearly completely submerged on April 10, emerges partly on April 25. Shorelines around Otter Creek, Dead Creek display less pronounced changes owing to the steeper slopes above the banks. This information will assist the Lake Champlain Commission in assessing effects of springtime flooding on agriculture, resort activities and wildlife habitat management.

REPORT C:

Within Lake Champlain and parts of Vermont to the East, it has proved possible to identify the following features in ERTS RBV imagery taken between July 29 - 31, 1972: Boundary between turbid and clear northern waters in the lake (by tonal differences between Bands 1 and 2); algal blooms in southern part of lake; variations in bottom topography in lake (best in Band 2); wetlands areas around mouths of several rivers; trends of two moraine-like glacial deposits; outline of the former shoreline of the Champlain Sea near St. Albans; meander scars associated with river flood plains; and three major categories of land use--wooded areas, open land, and built-up areas in the vicinity of Burlington.

REPORT D:

Within Lake Champlain and parts of Vermont to the East, it has proved possible to identify the following features

in the ERTS RBV imagery taken between July 29 – 31, 1972; Boundary between turbid and clear northern waters in the lake (by tonal differences between Bands 1 and 2); Algal blooms in southern part of lake; variations in bottom topography in lake (best in Band 2); wetlands areas around mouths of several rivers; trends of two moraine-like glacial deposits; outline of the former shoreline of the Champlain Sea near St. Albans; meander scars associated with river flood plains; and three major categories of land use--wooded areas, open land, and built up areas in the vicinity of Burlington, Vermont.

REPORT E:

Within Lake Champlain and parts of Vermont to the East, it has proved possible to identify the following features in ERTS RBV imagery taken between July 29 – 31, 1972: Boundary between turbid and clear northern waters in the lake (to tonal differences between Bands 1 and 2); algal blooms in southern part of lake; variations in bottom topography in lake (best in Band 2); wetlands areas around mouths of several rivers; trends of two moraine-like glacial deposits; outline of the former shoreline of the Champlain Sea near St. Albans; meander scars associated with river flood plains; and three major categories of land use--wooded areas, open land, and built-up areas in the vicinity of Burlington, Vermont.

REPORT F:

A pollution plume in Lake Champlain near Burlington, Vermont, has been recognized in ERTS MSS Bands 1 (0.5 – 0.6 micrometer) and 2 0.6 – 0.7 micrometer) images. The plume, seen visually now for the first time, correlates closely with sodium concentration, conductivity, and dissolved oxygen content determined previously from measurements in the lake. The source of the plume is a paper mill on the New York shoreline. The state of Vermont is using this ERTS observation as evidence in legal action.

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DISCIPLINES: Water Resources -- Glacier Surveys

TITLE: Cartographic Application of ERTS/RBV Imagery in Polar Regions

ABSTRACT 149:

Develop a real-time glaciological study on regional scale including living ice sheets as entities, seasonal variations and annual life cycles. Compare long-term trends of regional features and interrelationships. Develop modern cartographic products, i.e., pictoral record of ice conditions at a known instant of time for long-range scientific requirements of U.S. polar research program. Develop Doppler System for positioning data.

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TITLE: ERTS CATA for Lewis Research Center

REPORT A:

ERTS-1 MSS imagery of the North Shore of the Central Basin of Lake Erie on September 9, 1972, was studied to compare turbidity patterns with calculated currents. The calculated currents that were predicted as a result of the North winds on September 9 indicate that the large amount of turbidity along the north shore of Lake Erie in the neighborhood of Long Point

was probably caused by strong upwelling created by the north winds. (This presentation was made at the interagency conference on marine science and engineering for the Great Lakes, Ann Arbor, Michigan, December 13-15, 1972).

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DISCIPLINES: Water Resources--Snow Surveys

TITLE: Evaluate ERTS Imagery for Mapping and Detection of Change of Snowcover on Land and on Glaciers

ABSTRACT 342 H:

This investigation will seek to use high resolution ERTS imagery for providing a large scale synoptic picture of changing mountain snow cover in several different environments. Both the areal extent of snow cover and snowline altitude will be studied. Successful mapping results will be related to macroscale and mesoscale meteorological conditions and glacier mass balances.

REPORT A:

A limited number of ERTS-1 images of mountains in Alaska, British Columbia and Washington show that the snow line on land can be readily distinguished, except in heavy forest. Imagery from MSS Bands 1 (0.5 - 0.6 micrometer) and 2 (0.6 - 0.7 micrometer) shows the snow line most clearly. The distinction between snow on large snowfields and stratus-type clouds is very difficult, but can be made fairly easily where either the snow pattern or the clouds show definite structure. MSS Band 3 (0.7 - 0.8 micrometer) appears to be advantageous for distinguishing snow from clouds.

REPORT B:

Snow cover on the Thunder Creek drainage basin near

New Halem, Washington was determined by video slicing techniques to be 61.4 square kilometers, or 22.6 percent of the basis area. Their study indicates that fully automatic mapping of snow cover in mountainous terrain appears impossible. Some interpretation and man interaction is needed because of the many variables involved.

REPORT C:

The standard error of measurement of snow covered area in major drainage basins in the Cascade Range, Washington, using simple measurements of ERTS-1 images, was found to range from 11% (April) to 7% (30 Sept.) during typical melt season, but was as high as 32% per midwinter. A typical basin snow-cover diminishes at approximately 1.5% per day during the melt season, thus, these techniques cannot provide useful data at time intervals less than 14-22 days. More frequent ERTS-1 passes would be advantageous to overcome coverage problem.

REPORT D:

A new technique has been developed for measuring snow-covered area or snowline altitude semi-automatically. This variable contour overlay method involves superimposing an ERTS-1 image on a monitor with a registered series of contour masks which are rapidly cycled, thus permitting the snow cover to be matched efficiently to the best fit contour of altitude. Repeatability of 60M in altitude is readily obtained.

REPORT E:

The area of snow cover on 10 individual drainage basins in the north Cascades has been determined for 7/29, 9/2, 10/8/72, 5/30, and 9/12/73. Snow cover on many of these basins has been measured on 9/14/72 and 1/6, 2/12, 4/7, 5/12, and 8/11/73. A semi-automatic radiance threshold technique was employed. The result is: 1) A unique record of changing water storage as snow in these hydrologic units, 2) Dilution of waste and heat, 3) Support of salmon migration, 4) irrigation. This data will allow a new type of hydrologic modeling which permits more accurate forecast of streamflow.

REPORT F:

Changes in snow cover in areas as small as 3 x 5 km can be determined from ERTS images by both optical and electronic methods. A large medial structure in the accumulation area of the Hubbard Glacier was discovered for the first time

using ERTS-1 imagery in spite of abundant aerial photography and existing detailed maps. Knowledge of this structure adds to our understanding of the drainage basin and dynamics of this huge glacier which threatens to close off Russell Fiord and endanger the salmon canning industry near Yukatat, Alaska.

REPORT G:

World data center-A for Glaciology (National Academy of Sciences) in Tacoma, Washington, is acquiring ERTS-1 images for an area 4500 km long and 320 km wide from Mt. Rainier to Mt. McKinley in the Alaska Range. The data are available for viewing in the library.

REPORT H:

Snow lines on glaciers can be found easily. It appears possible to rapidly determine the accumulation area ratio from a large number of glaciers using ERTS imagery.

REPORT I:

Dust bands and medial moraines can be readily observed on glaciers using ERTS. These observations have given clues to the mechanism causing the Bearing Glacier to surge. These Clugas can be provided easily by ERTS, but are unrecognizable from the ground or aircraft because of the necessity of wide-area coverage. Surging glaciers can be distinguished from others by the wiggly, folder moraines easily distinguished on ERTS.

REPORT J:

Worldwide inventory of glaciers is possible by analyzing ERTS-1 imagery. Glaciers can be monitored for such features as dammed lakes, embayments, and movement (surging glaciers). ERTS-1 imagery has provided the materials for map compilation in a total elapsed time of 1.5 hours, of the Lowell Glacier after a recent surge.

REPORT K:

The motion of the Yentna Glacier during the concluding phase of its surge was successfully measured by a "flicker" technique using images of 2 dates. It appears that displacements as small as 100 to 200 miles can be measured, which is very close to the resolution limit for a single ERTS-1 image.

REPORT L:

Motion of the Tweedsmuir Glacier was measured using ERTS-1 images enlarged to 1:50,000 using the facilities of the Geophysical Institute, University of Alaska. Changes detected include a shock wave moving down the glacier, the margin expanding the moraine pattern deforming, and the marginal valley deepening. Velocities measured at 9 places in time and space ranged from 2-88m. per day. These clearly show the increase and decrease in speed as the surge wave passed. These measurements have been confirmed by independent studies conducted by a Canadian glaciologist.

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TITLE: ERTS Application to Accelerated Erosion and to Monitor Future Erosional Changes in Arizona Region

REPORT A:

Images taken immediately after moderate rains show soil differences especially well.

REPORT B:

Important flood effects have been determined for the Gila River. These include extent of innundation and areas of severe sediment deposition and erosion.

REPORT C:

Local anomalous drainage patterns recognized on ERTS imagery appear to reflect underlying bedrock topography. This occurs despite glacial overburden of up to 200 feet. In addition, preliminary color additive studies reveal trends which also may relate to topographic-geologic boundaries of the bedrock units.

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TITLE: Effective Use of ERTS Multisensor Data in the Great Plains Corridor

REPORT A:

Eroded shale soils located along the Missouri River reservoirs in South Dakota above the Ft. Randall and Big Bend Dams are clearly visible on the IR Bands of ERTS scene 17 August 1972. By being able to delineate these soils ERTS is marking areas of potentially high sediment contribution to these reservoirs. Care must be exercised since different sediment source areas will appear different in tone. Nevertheless, ERTS appears to be a tool for monitoring attempts to control erosion.

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DISCIPLINES: Water Resources -- Watershed Surveys

TITLE: Near Real-Time Water Resources Data for River Basin Management

ABSTRACT 190:

This investigation will provide an operational test of the ERTS Data Collection System in the management of the Delaware River Basin. Data will be collected from 20 stream gauges, ground water observation wells, and water quality monitors and relayed to the Delaware River Basin Commission. Flood inundation, storm damage, water pollution, etc., will hopefully be delineated in the ERTS imagery on a routine basis.

REPORT:

On a daily basis, data from six water-quality monitors, eight stream gauges, and three ground-water observation wells are computer processed and released to the Delaware and Susquehanna River Basin Commission and Delaware River Master and the Trenton USGS Office.

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TITLE: Use of DCS to Operate a Network of Remote Hydrological and Climatological Stations

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DISCIPLINES: Water Resources - Limnology

TITLE: Dynamics of Suspended Sediment Plumes in Lake Ontario

ABSTRACT 342-04:

Short period (greater than 1 week) and seasonal changes in the areal extent of sediment plumes associated with the Niagara and Genessee Rivers will be studied using ERTS imagery. It is hoped that the relationship of the plumes to runoff regimen and wind direction and intensity can be better understood because of the synoptic and repetitive coverage provided by the satellite observations.

REPORT A:

Suspended sediment plumes generated by the Welland Canal and the Genessee River are identifiable in ERTS-1 MSS imagery. The Oswego River was not visible during low-flow periods, but was identifiable following storms. The Niagara River plume was not visible in any of the ERTS-1 frames. Numerous examples of shore line erosion were evident in the December 7, 1972 imagery of Western Lake Ontario.

REPORT B:

Spatial and temporal variation in sediment plumes from the Niagara River, the Welland Canal, Oswego River, Genessee River ,and the Diversion Channel by Port Dalhousie River have been delineated by ERTS. This imagery shows that the Welland Canal and the Port Dalhousie Canal are the principal sources of suspended matter entering Lake Ontario during the shipping season. The plumes come from oil spillage, ship and pleasure craft wastes, dredging, and the resuspension of fine grained bottom materials.

REPORT C:

The mechanism by which large quantities of nearshore suspended sediments are swept out into Lake Ontario is revealed by imagery obtained on July 11, 1973. Sediment laden water moving from east to west along New York shoreline toward the Niagara River jet is directed far offshore due to force of jet. As the surface spreading Niagara River discharge gradually loses velocity in the quiescent lake, much of the suspended matter settles to the bottom of the lake.

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TITLE: Hydrologic Problems of Lake Ontario Basin for IFYGL

REPORT:

Mosaics of the Lake Ontario Basin have been constructed in both the 0.5 - 0.6 μm and the 0.8 - 1.1 μm bands. The 0.5 - 0.6 μm band shows land use and sedimentation patterns. The 0.8 - 1.1 μm band shows the areal extent of surface water.

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DISCIPLINES: Water Resources - Limnology

TITLE: Water Budget of Texas High Plains Plaza Lakes

ABSTRACT 342-03:

Time space relationships of precipitation, runoff, infiltration, evaporation, transpiration to the geology-morphology of 3 West Texas lakes will be studies to evaluate the water budget associated with such areas. Spatial distribution

of soils, plants, and time-space distribution of soil moisture and ponded storage volume are to be correlated with absorbance-reflectance data obtained via repetitive, multispectral satellite imagery.

REPORT A:

Regional viewing of ERTS-1 imagery around Playa Lake test sites shows that storm paths can be accurately traced (band 3 MSS, 0.7 — 0.8 micrometer, E-1006-16522) and a count made of the number of intermittent lake basins filled by the storm. During wet periods ERTS imagery can be used to conduct a reliable count of the tens of thousands of natural lake basins on the southern high plains which contain water.

REPORT B:

A wet lake census over the southern high plains, West Texas and Eastern New Mexico was completed. It was estimated that these basins contained at least 182,561 acre/feet of available fresh water and perhaps as much as 580,098 acre/feet. The Panhandle Regional Planning Commission has expressed considerable interest in having an inventory made of the intermittent lake basins of West Texas using ERTS-1 imagery.

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TITLE: Utilization of ERTS(A) Data to Monitor and Classify Eutrophication of Inland Lakes

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TITLE: Planning of Land Use Utilization in the Detroit Metropolitan Area

REPORT:

ERTS-1 photos derived from multispectral scanner data (observation ID 1067-15643 of September 28, 1972) shows that different spectral bands differentiate various types of land surface features. Lakes and water area are revealed

in MSS bands 3 (0.7 — 0.8 micrometer) and 4 (0.8 — 1.1 micrometers). Roads and wooded areas show clearly in bands 1 (0.5 0.6 micrometer) and 2 (0.6 — 0.7 micrometer). The conclusion is that ERTS MSS data is useful for land use planning.

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DISCIPLINES: Water Resources -- Flood Assessment and Prediction

TITLE: Applications of the ERTS Data Collection System in the ARETS

ABSTRACT 184:

Establish 6 DCP stations in South Arizona to supply continual data flow to aid interpretation, testing and evaluation of aircraft and spacecraft remote sensing methods to environmental and early resources problems in ARETS. Parameters measured include stream stage, precipitation and snow water content, solar radiation, and air and soil temperature.

REPORT A:

2 DCP's have been installed in association with 2 stream gauging stations on the Black and Verde Rivers and are receiving data.

REPORT B:

For Verde River site, this permits computation of average daily streamflow rates including useful information for peak flow periods.

REPORT C:

On 2/21/73, the large potential for serious flooding in the Salt River Valley and a partial failure of the SRP microwave telemetry system precipitated an emergency request from the SRP to the USGS for DCS streamflow data for the Verde River, and data was furnished in near real time. The data enabled USGS to furnish water management with key streamflow information to assist the SRP in the operations of reservoirs on the Salt River within 26 minutes from the time of transmission to the satellite.

REPORT D:

On March 15, 1973, on a near-real time basis, data on watersheds for use in management and operation of SRP reservoir system was requested by SRP. At the request of the geological survey the data was furnished directly to the Salt River project twice daily from 3/15 - 5/22/73. Using a special procedure for rapid manual conversion of DCS data into engineering units, SRP was able to utilize the DCS data operationally in near-real time.

REPORT E:

The DCS water-stage data from the USGS streamflow-gauging station on the Verde River furnished information sufficient for the accurate computation of daily mean flow rates. DCS data agreed with those computed from the digital-recorder data within ± 5 percent during periods of rapidly changing high-flow.

REPORT F:

The SRP was furnished with near-real time DCS information on snow moisture content and streamflow rates for use in management and operation of the multiple-use reservoir system between 3/15 and 5/22/73. By prudent water management and the use of hydrologic data, the SRP was successful in anticipating the amount of flow into the Salt and Verde Rivers and in the subsequent release of water rates that did not create flooding in metropolitan Phoenix. As a result, the losses due to flooding were far smaller than those of the winter and spring of 1972-1973.

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TITLE: Time-Lapse Data Processing for Dynamic Hydrologic Conditions

REPORT:

Area measurements accuracies of ± 2% within a specific drainage basis were obtained by utilization of photographic enlarger and an integrating photometer. This is better than ± 5% accuracy which is believed to be required to make meaningful streamflow estimates.

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DISCIPLINES: Water Resources -- Watershed Surveys

TITLE: Determine Utility of Imagery in Preparation of Hydrologic Atlases of Aridland Watershed

ABSTRACT 234:

Evaluate ERTS imagery for delineating watersheds over 10 sq. miles and then define vegetation-type boundaries within and topographic position (bottom land or gentle slope/steep upland) of these watersheds to provide data for hydrologic atlas. Second objective is to compare geology, vegetation, relief, drainage-density, shape and use of four large rangeland watersheds in Montana, New Mexico, Wyoming and Utah. Standard photointerpretation techniques supported by A/C and field data.

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DISCIPLINES: Water Resources -- Watershed Surveys

TITLE: Develop a Land Use-Peak Runoff Classification System for Highway Engineering Purposes

ABSTRACT 203:

Land use and peak runoff classifications for the state of Maine will be used by the highway commission and land engineers to evaluate the effects of highway construction on water tables and runoff. They expect to collect information of watershed area, slope, channel characteristics, runoff factors, water storage area and land use. Comparison will be made with existing air photo coverages.

REPORT A:

Coverage taken during fall shows the yellow pattern of the swamp hardwoods because of high contrast with the magenta pattern of the adjacent upland hardwoods. Perimeters of swamp hardwood sites, which are effective water storage areas, are very difficult to delineate accurately in an undulating or gently rolling terrain where the surrounding environs are covered by upland hardwood forest.

REPORT B:

Useful data obtained from this study are maps of flooded areas along the Penobscot River. A current study conducted by the Maine Department of Transportation Bridge Division will use this new information.

REPORT C:

Useful information has been derived from ERTS-1 imagery. For this report, a hydrologic study was performed with results compatible to other methods. The area, major stream length, and watershed storage areas were measured with accuracy. This area is not ideally suited for hydrologic study from ERTS-1; significant relief was limited to eastern portion of basin. Mountainous watershed basins are better suited for measurement

from ERTS-1. In study area repetitive coverage, high spring water levels in storage areas and some knowledge of local agriculture allowed good results to be obtained.

REPORT D:

Geological survey using 1:250,000 enlargements of ERTS-1 in a stratigraphy study in western Maine. Other agencies interested in applications in Maine are Department of Forestry, inland fisheries and game, sea and shore fisheries and coastal planning.

REPORT E:

Estimations of snow depth can be made from ERTS-1 imagery. The low bush of the S.E. Meadow of Sunkhaze Bog averages between 6 and 2 inches. 300 yards from the stream the bush becomes taller so that they are about 5.5 feet 75 yards from the stream. As snow accumulates, varying amounts of bush are covered. As the bush becomes covered, the snow color changes from a greyish white to pure white; e.g., on 2/10/73 image, ID 1202 14552, the Sunkhaze meadows have a greyish white color and on 2/28/73 image, ID 1202-4553, the Meadows are pure white, indicating enough snow fell between the imagery dates to cover the bush to a depth greater than one foot. A check of precipitation showed 12 inches of snow fell between these dates.

THORLEY, G.A.

DISCTEXT:

Water Resources
* Watershed Surveys
Water Resources
* Limnology

AREA:

California and Nevada

PLATFORM:

ERTS A

SENSOR:

Multispectral Scanner

REPORT A:

Post fire mapping of burned wildland area on ERTS preliminary results is feasible. The use of sequentially procured ERTS-1 data can provide superior post-fire maps at more frequent intervals and with reduced manpower requirements and costs.

REPORT B:

The total time required for imagery interpretation, including resource type classification, has been estimated to be seven times greater on imagery acquired by high altitude aircraft than on ERTS-1 imagery, giving a projected cost ratio on a per acre basis of 7:1.

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TITLE: Research and Investigation of Geology, Mineral and Water Resources of Maryland

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TITLE: Use of ERTS-A in Geological Evaluation, Regional Planning, Forest Management and Water Management

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DISCIPLINES: Water Resources -- Snow Surveys

TITLE: Survey of the Seasonal Snow Cover of Alaska

ABSTRACT 110-04:

The three distinct climatic regions of Alaska reflect differences in depositional history, amount, characteristics, and duration of snow cover. Remote sensing can identify 1) appearance, 2) disappearance, 3) amount of snow present in a spatial and temporal frame. A single band of RBV imagery and digital tapes will be processed to plot maps and print out tables of iso-density areas representing snow-covered terrain.

REPORT A:

ERTS imagery, air and surface photography, radiation and climatological data are used to describe characteristics of snow and ice breakup in a 30 km along north-south transect across the Arctic Slope. Data from ERTS demonstrate a number of accumulation as well as ablation features for the hydrology of the Arctic Slope.

REPORT B:

No significant results.

REPORT C:

The variation of the extent of snow cover in climatic zones spanned by North-South transect across Alaska can be described in detail using ERTS imagery. Snow line elevations in a transect across Alaska, Wrangell and Chugach Mountains have been determined with ERTS imagery and topographic maps. ERTS data appears to offer a means of recording snow and ice build-up from year to year over wide expanses. This is a

useful capability for studying climatic trends, particularly in Alaska where the station network density is too low to permit interpolation between stations.

WELLS, T.

DISCTEXT:

Environment
* Pollution Surveys
** Lake and River Pollution Surveys

AREA:

Lake Erie

PLATFORM:

ERTS A

SENSOR:

Multispectral Scanner

REPORT A:

State of Ohio has demonstrated the use of ERTS-1 imagery in water quality and coastal zone management. This demonstration has shown how ERTS-1 imagery could contribute to localized (metropolitan/urban), multicounty, and overall state land use and water quality monitoring needs.

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TITLE: Application of Remote Sensing to Water Quality Monitoring

REPORT A:

Preliminary analyses of aircraft and ERTS data of August 16, 1972 clearly show distribution of an acid waste discharge, sewage sludge dump, and major suspended sediment inputs into New York Bight area. Surface drift patterns of waste inputs are also shown. Acid waste disposal provides suspension which tends to remain in distinct patterns for extended times.

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TITLE: Reflectance of Vegetation, Soil and Water

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DISCIPLINES: Water Resources -- Limnology

TITLE: Evaluation of ERTS Data for Certain Hydrological Uses

ABSTRACT 109:

Analysis and evaluation of ERTS data for certain hydrologic uses in the eastern Great Lakes and Sierra Nevada, California. The study will address snow mapping, i.e., boundary delineation and amount of precipitation delineation and amount and identification of frozen surface, e.g., ice ground truth, aircraft and other satellite data will be utilized for intercomparison. Point hydrologic measurements will be extended to maps.

REPORT A:

Mosaicking of U-2 imagery over the Feather River watershed taken on March 6, 1972 (Flight No. 72-036) has been completed.

REPORT B:

Airborne and NOAA 2 VHRR visible and thermal data are being analyzed in the Lake Ontario basin. VHRR is in digital format and daily, thus, permitting a means of evaluating the

effectiveness of the ERTS-1 18 day cycle to measure changes in snow pack extent.

REPORT C:

ERTS-1 imagery over Lake Erie was examined to determine ice melting conditions. The ice field in MSS 4 had high reflectance, but lacy appearance characteristic of rotten ice. A pronounced decrease in reflectance is noted in MSS-7. This indicates melting conditions. Air temperatures both before and after the ERTS-1 pass confirm melting conditions. NOAA-2 VHRR confirms a uniform lake temperature at the same time.

REPORT D:

The following ice features have been identified from 17-18 February and 8 March 1973 ERTS-1 MSS images of Lake Erie and Lake Ontario Shuga, light and dark milas, fast ice, icefoot, ice breccie, brash ice, fracturing, ridging, rafting, sastrugi, thaw holes, rotten ice, ice islands, dried ice puddles, hummocked ice leads. This allows ice condition features characteristic of thawing conditions to be detected. ERTS-1 is the most outstanding lakes ice reconnaissance platform yet devised. The detailed images of lake ice features exceeds any prior sensor platform combination in terms of interpretability and information content. By using it in conjunction with NOAA-2, it ought to revolutionize the ice forecasting ability of NOAA's lake forecasters.

REPORT E:

U-2 aircraft imagery and AOCM transfer scope are being used to map snow cover in the Feather River watershed at a scale of 1:250,000 in order to develop a method for analyzing ERTS-1 data.

REPORT F:

Mapping of snow cover using ERTS-1 proved to be six times faster than that done from U-2 photography in the American and Feather River Basins in California. ERTS-1 maps can be used to provide a reliable check or calibration standard for daily VHRR data from NOAA-2 over the same area. NOAA-2 VHRR snow maps are about as economical to make as ERTS-1 snow maps, but not as accurate. VHRR maps are usually with 5% of the ERTS-1 and its cartographic fidelity make it outstanding as a snow mapping satellite. It has no peer in this respect.

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TITLE: Exploitation of ERTS Imagery Using Snow Enhancement Techniques

REPORT:

Since investigation depends on snow cover in subject area, direct studies have not yet begun. However, investigators have done necessary preliminary work, including setting up network of snow depth reporters and acquisition of supporting maps, air photos, and radar imagery, preliminary field work in Massachusetts has been done. MSS pictures of snow-free areas have been studied.

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TITLE: To Map the Distribution of Glaciofluval Deposits and Associated Glacial Landforms

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DISCIPLINES: Water Resources -- Reservoir Monitoring

TITLE: Study of Monitoring Fresh Water Resources

ABSTRACT 060-10:

Study the feasibility of monitoring algal growth and silting in Kansas reservoirs by correlating water color as determined from ERTS imagery with ground measurements of suspended solids, chlorophyll concentrations, and content of potassium, phosphate and nitrate ions.

REPORT A:

Samples involving ten stations have been collected on both Perry and Tuttle Creeks during four overflights in this report period. Most images of Perry and Tuttle Creek Reservoirs have been level sliced on idecs, and density measurements corresponding to sample stations are being compared with results of sample analysis. All data are being placed on computer cards for use. Initial coverage indicates strong qualitative correlation between film density and turbidity.

REPORT B:

Correlations of reflectance versus secchi disk depth and total suspended solids have stayed about the same although new data have been obtained since report given at 8/73 ERTS-1 symposium. Total suspended solids relationships are usable up to approximately 75 ppm.

REPORT C:

Work performed during the six-month period is reported. Two different sensor products have been compared with ground-truth information. Level sliced MSS images of Kansas reservoirs have been used in constructing graphs which show the relation between total suspended solids and gray level. Similar graphs have been made using CCT output. The two techniques all compared by normalizing the gray level graphs to fit the CCT derived graphs. It is concluded that a level-slicing technique can reliably duplicate results obtained from CCT's.