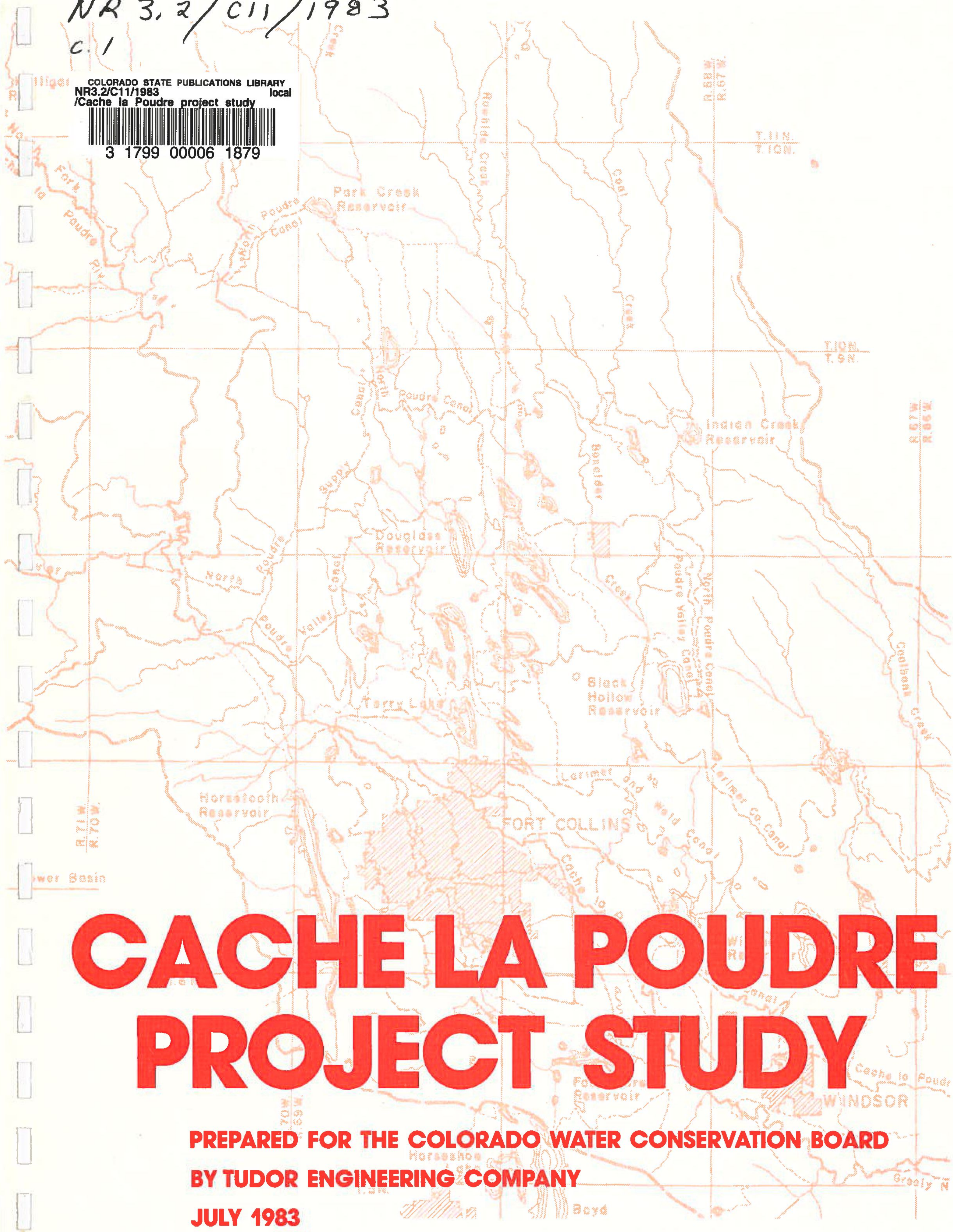

CACHE LA POUDRE PROJECT STUDY

PREPARED FOR THE COLORADO WATER CONSERVATION BOARD

BY TUDOR ENGINEERING COMPANY

JULY 1983

CERTIFICATE OF ENGINEER

CACHE LA POUDRE PROJECT STUDY

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The technical analyses, material and data developed in this study were prepared under the supervision and direction of the undersigned, whose seal as a professional engineer is affixed below.

Nelson James Jacobs

Nelson James Jacobs
Registered Professional Engineer
State of Colorado

EXECUTIVE SUMMARY

A. AUTHORITY

In 1981, the Colorado General Assembly authorized the Colorado Water Conservation Board (CWCB) to conduct studies of four potential water resources development projects. Among them was "the Cache la Poudre Project - an integrated project upstream of the town of Fort Collins on the Cache la Poudre River" (Section 7, S.B. 439).

The CWCB retained Tudor Engineering Company to perform the Cache la Poudre study. Expenditures were limited by S.B. 439 to $300,000. In addition, S.B. 439 specifies that future funding "... is contingent upon a showing that additional funding is justified based on competent engineering and economic data."

B. STUDY OBJECTIVE

The objective of the Cache la Poudre Project Study was: to evaluate, at a reconnaissance level of detail, the engineering and economic feasibility of alternative projects which could develop new water supplies, improve the management of already developed water and provide hydroelectric power production. The alternative projects consisted of one or more storage reservoirs together with all appurtenances and associated features including hydropower facilities.

Reconnaissance-level studies (such as the Cache la Poudre Study) are not intended to provide specific data or designs from which construction can proceed. The intent of these studies is to investigate major concepts and to identify and evaluate various alternative project configurations. An evaluation of such alternative projects provides a preliminary indication of project viability and is the basis for decisions of whether or not to proceed with more detailed feasibility-level studies.

Consistent with the legislative intent of S.B. 439 and the constraints imposed by time and budget limitations, this study did not analyze a non-structural alternative nor evaluate the environmental and recreational impacts of any of the alternative projects under consideration. Rather, this study was limited to addressing the threshold questions of whether there appears to be any project which may be feasible from an engineering and economic point of view. Subsequent, detailed feasibility studies will, should they be undertaken, need to thoroughly address all impacts, both beneficial and adverse, of any potential project.

C. STUDY CONTENT

The reconnaissance-level investigations for this study included the following major elements:

- Analyses of the water supply and flood hydrology and sedimentation characteristics of the Cache la Poudre Basin.

- An assessment of existing water supply entities and facilities and of the operation of these facilities.

- An assessment of the operation of the Cache la Poudre water rights system and of significant conditional decrees which could impact a potential project.

- Geologic and geotechnical investigations of site suitability for construction of potential facilities.

- Analyses of existing and projected water and power demands.

- Formulation of alternative projects to include one or more major reservoirs.

- Reconnaissance-level designs and cost estimates for proposed facilities.

- Reservoir operation studies for preliminary facility sizing and to provide a preliminary indication of project outputs.

- Economic comparisons of costs with potential benefits.

- Preliminary financial evaluations of total and annual costs under two different financing assumptions and the projected impact of cost inflation.

D. FORMULATION OF ALTERNATIVES

The formulation, evaluation and selection of alternative projects was an iterative process in which an initial "universe" of possible development options was narrowed to eight preliminary alternatives in Phase I of the study and subsequently narrowed further to four selected alternatives in Phase II. Alternatives were developed to provide storage in the upper basin to meet the objectives of improved management, development of new water supplies and hydroelectric power production using the following concepts as guidelines for project formulation:

1. All potential reservoir sites would be located upstream of the City of Fort Collins as required by S.B. 439.

2. Potential reservoir sites would be situated to control, to the maximum extent possible, the total flow in the upper basin.

3. All potential projects would include a storage reservoir primarily for conservation purposes. This terminal reservoir would store and regulate flows to meet agricultural, municipal and industrial water demands in the lower basin.

4. Potential projects could include storage reservoirs in the upper portion of the basin for the purpose of regulating flows for hydroelectric peaking power production as well as for additional conservation storage.

5. A number of potential reservoir sites would be considered individually and in various combinations as alternative projects which would exhibit a wide range of possible development.

Potential reservoir sites were identified from previous planning studies, by analysis of topographic maps and by site visits. Seven major reservoir sites appeared to be the most promising locations for storage in the upper basin, they are:

Grey Mountain Reservoir on the mainstem (conservation storage).

New Seaman Reservoir on the North Fork (conservation storage).

Elkhorn Reservoir on the mainstem (conservation storage or peaking power production).

Indian Meadows Reservoir on the mainstem (peaking power production).

Idylwilde Reservoir on the mainstem (peaking power production).

Rockwell Reservoir on the South Fork (peaking power production).

Upper Poudre Reservoir on the mainstem (peaking power production).

The seven potential reservoir sites represent possible storage locations that could be linked together to form potential projects to serve the functions of conservation storage and hydroelectric power generation. The development concepts listed above were applied to the potential reservoir sites to formulate a broad range of alternatives.

The formulation process was initiated with the development of a "universe" of conceptual projects ranging from a single reservoir for conservation storage purposes to large, multiple reservoir systems with connecting tunnels, conduits, diversion dams and power plants to produce peaking hydropower as well as provide conservation storage.

Very preliminary analyses indicated that the entire "universe" of conceptual projects could be represented by six basic configurations which would illustrate the full range of possibilities for the development of the power potential in the upper basin as well as a spectrum of change in the present use of the streams in the upper basin. The six basic configurations initially selected for evaluation as preliminary alternatives in Phase I of the study were:

Preliminary Alternative No.	Major Features
1	Grey Mountain Reservoir
2	Grey Mountain Reservoir-Idylwilde Reservoir
3	Grey Mountain Reservoir-Elkhorn Reservoir
4	New Seaman Reservoir-Indian Meadows Reservoir-Rockwell Reservoir
5	New Seaman Reservoir-Indian Meadows Reservoir-Rockwell Reservoir
6	Grey Mountain Reservoir-Indian Meadows Reservoir-Rockwell Reservoir-Upper Poudre Reservoir

Comments received from the study advisory committee and from the public, at public meetings held to explain the study, resulted in the addition of two alternatives which would have a lesser degree of impact on existing development in the canyon. These two alternatives were:

Preliminary Alternative No.	Major Features
7	New Seaman Reservoir-Elkhorn Reservoir
8	Elkhorn Reservoir

E. EVALUATION OF ALTERNATIVES

Two sets of evaluation factors, monetary and non-monetary, were used in evaluating the eight preliminary alternatives in Phase I of the study. The monetary factors consisted of: (1) initial investment costs, (2) benefit-cost ratios, (3) net direct economic benefits and (4) cost effectiveness expressed in terms of project costs per kilowatt of installed generation capacity and costs per acre-foot of storage. The non-monetary factors used were: (1) geologic conditions, (2) impacts from inundation at each reservoir site and (3) increased water yield of "new water" developed as a result of project implementation. These evaluation factors were selected in accordance with the study mandate which was to assess the engineering and economic feasibility of a potential Cache la Poudre Project.

At the completion of Phase I, the CWCB selected Alternatives 1, 2, 7 and 8 for further analysis in Phase II of the study. The four selected alternatives represent two important development concepts. Alternatives 1 and 8 represent single reservoir systems which provide storage primarily for conservation purposes (agricultural, municipal and industrial water demands and the improved management of existing water supplies). Alternatives 2 and 7 represent multiple reservoir systems with an upper reservoir primarily for peaking hydropower production and a lower, or terminal reservoir, for reregulation and conservation storage.

The cost estimates for Phase II were revised somewhat from Phase I to reflect refinement of design layouts to a reconnaissance level of detail. The total capital cost estimates (in 1982 dollars) for the single reservoir systems ranged from $110 million to $131 million while the multiple reservoir systems ranged from $354 million to $401 million.

The evaluation of the Phase II alternatives utilized both monetary and non-monetary evaluation factors as in Phase I. For the Phase II analyses, however, the evaluation factors were revised and expanded to include preliminary financial projections and additional physical impacts.

The Phase II economic evaluations included benefit-cost ratios and net annual benefits for the single reservoir systems (Alternatives 1 and 8) and the economic value of peaking power production for the multiple reservoir systems (Alternatives 2 and 7). The economic analyses indicated that none of the alternatives would be feasible at the present time using a 7 1/2 percent discount rate.

Sensitivity analyses were also performed using discount rates of five percent and ten percent for the economic evaluations. The five percent analysis provided a preliminary indication of economic feasibility while the ten percent analysis indicated very unfavorable conditions of economic feasibility.

It should also be noted that, due to time and budget constraints, the systems formulated for these alternatives were not optimized. It is conceivable that optimization would result in smaller reservoirs with more favorable benefit-cost relationships.

The preliminary financial evaluations projected total investment requirements and annual costs under two different financing approaches: (1) the state funding approach and (2) the revenue bonding approach. The state funding approach assumes a project would be funded from the CWCB construction fund and that capital costs would be amortized at five percent for forty years. The revenue bonding approach assumes the issuance of tax-exempt revenue bonds by a political subdivision of the state with capital costs amortized at twelve percent for thirty years. Interest during construction (i.e., the cost of short-term construction financing) and cost of issuing bonds were added to capital costs under the revenue bonding approach.

An additional element of the financial evaluations was the calculation of the cost burden on peaking power for the two multiple reservoir systems (Alternatives 2 and 7). The cost burden is defined here as the value that peaking power would have to attain, along with the estimated revenues from all other project purposes, to retire the total project costs for the multiple reservoir systems.

The financial evaluations are summarized on the following table. The base data section of the table displays the total capital costs and the annual operation, maintenance and replacement costs (in 1982 dollars) for each alternative along with the projected on-line date of the alternative assuming that planning activities begin in mid-1983 and are followed by design and construction.

The total capital costs were escalated for inflation throughout the assumed planning, design and construction period. The escalated costs were then used to estimate total investment costs and the annual cost of assumed debt retirement.

The table illustrates the total investment cost (capital costs escalated for inflation) and the annual costs (the annual amortization requirement plus operation, maintenance and replacement) under the two funding approaches. The table also provides the estimated cost burden on peaking power (in 1982 dollars). The cost burden is expressed as a composite value of the peaking power output including both a capacity and energy component. It is expressed both as a cost per kilowatt-hour of energy production and as a cost per kilowatt-year based on installed capacity.

The numbers displayed on the table clearly demonstrate the impact of inflation and the difference in costs under the two financing approaches. The two financing approaches were selected to illustrate two extremes of a broad range of potential financial arrangements which would have to be investigated further in more detailed feasibility studies.

F. CONCLUSIONS AND RECOMMENDATIONS

The present study has developed useful information about large storage reservoirs in the upper Cache la Poudre Basin. Although the uncertainties associated with both the future demand for peaking power and the need for new reservoirs prevent one from arriving at firm conclusions as to what would or would not be feasible 10-15 years from now, the projects examined in this study appear to have been sufficiently analyzed for the present.

On the other hand, given the limitations placed upon the geographical scope of this study, many questions remain unanswered concerning the future water resources needs of the Cache la Poudre Basin and the alternative means available to meet various water resource development and management objectives. Questions regarding future water and power demands, the future of irrigated lands, the condition of the existing plains reservoirs and alternatives to large new storage projects in the canyon (which alternatives may include smaller capacity reservoir project(s) in the upper basin) all need to be addressed before decisions can be reached on what future projects and management actions might be feasible and desirable.

The best means of addressing these questions would be a carefully designed study of basin-wide scope (upper and lower basin) formulated with the participation of all interested parties in the basin. In March 1983, the Board recommended that the General Assembly authorize the expenditure of not more than $15,000 from the CWCB construction fund for the preparation by the Board of a detailed proposal for a basin-wide study of the Cache la Poudre. This authorization would cover operating costs for a public information program, consultation with interested parties and the printing and distribution of pertinent materials. The intent of the recommendation was that a detailed plan of study would be submitted to the General Assembly in 1984 for consideration and action as the legislature would deem appropriate.

In June 1983, House Bill 1102 was enacted by the Colorado General Assembly. Section 3 of H.B. 1102 contained the following provision relating to the Cache la Poudre Study:

> "The General Assembly recognizes that further resource development opportunities exist in the upper and lower Cache la Poudre River Basins. The Board is further authorized to study the development and management of the water resources of all or any portion of the Cache la Poudre River Basin should any agency, entity, or organization provide funds to the Board for that purpose; provided, however, that any such study or studies shall not include consideration of water development projects which would be located upstream from Kinikinik or upstream from the Rockwell Damsite."

CACHE LA POUDRE PROJECT
FINANCIAL SUMMARY

	Single Reservoir Systems		Multiple Reservoir Systems	
Base Data	Alternative 1 Grey Mountain Only	Alternative 8 Elkhorn Only	Alternative 2 Grey Mountain-Idylwilde	Alternative 7 Elkhorn-New Seaman
Total Capital Costs (1982 dollars) 1/	$130,800,000	$109,600,000	$400,800,000	$354,300,000
Annual Operation, Maintenance and Replacement Costs (1982 dollars)	200,000	235,000	1,690,000	1,160,000
Projected On-Line Date	1994	1994	1998	1998
State Funding Approach (5%, 40 years)				
Total Investment Cost at On-Line Date 2/	$292,000,000	$224,000,000	$1,166,000,000	$1,032,000,000
Annual Cost at On-Line Date 3/	17,500,000	14,800,000	73,700,000	64,100,000
Annual Cost in 1982 Dollars	7,800,000	6,600,000	25,000,000	21,800,000
Cost Burden on Peaking Power (1982 dollars)				
Per Kilowatt-Hour	n/a	n/a	100 mills	94 mills
Per Kilowatt-Year	n/a	n/a	$177	$196
Revenue Bonding Approach (12%, 30 years)				
Total Investment Cost at On-Line Date 4/	$399,000,000	$335,000,000	$1,680,000,000	$1,485,000,000
Annual Cost at On-Line Date 3/	44,000,000	37,000,000	189,000,000	166,000,000
Annual Cost in 1982 Dollars	19,900,000	16,700,000	65,700,000	51,600,000
Cost Burden on Peaking Power (1982 dollars)				
Per Kilowatt-Hour	n/a	n/a	323 mills	312 mills
Per Kilowatt-Year	n/a	n/a	$569	$649

1/ Total capital costs include estimated costs of planning, design and construction. They do not include interest during construction.

2/ Total investment costs are capital costs escalated for inflation plus interest during construction.

3/ Annual cost is the sum of the annual amortization requirement (debt service) plus operation, maintenance and replacement.

4/ Total investment costs are capital costs escalated for inflation plus interest during construction and costs of revenue bonding.

CACHE LA POUDRE PROJECT STUDY
RECONNAISSANCE REPORT
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ACKNOWLEDGEMENTS

In the conduct of the Cache la Poudre Project Study and the preparation of this report, Tudor Engineering Company wishes to acknowledge the assistance and input received from many sources. These include, but are not limited to:

- The staff of the Colorado Water Conservation Board for their guidance in scoping the study, their assistance in establishing guidelines and criteria to be used, their review of various analyses during the two phases of the study, their assistance in seeking out sources of data pertinent to the study, their arranging meetings and conferences with affected and interested individuals and organizations and their assistance in preparing the interim and final reports.

- The Advisory Committee for their useful input in helping to establish guidelines and criteria, their review of the results of the analyses, and their assistance in selecting alternative projects for evaluation in each phase of the study. A list of the members of the Advisory Committee is included on the following page.

- The various publics for voicing opinions and concerns at public meetings, thereby providing valuable input regarding overall scope of the study and selection of alternative projects for study.

- The office of the State Engineer; and, in particular, the Water Commissioner of former Water District 3; for assistance in providing data on water rights and historic flows and an insight into the operation of the complex water supply system in the Cache la Poudre basin.

- Several Federal agencies, including the U.S. Bureau of Reclamation, U.S. Geological Survey and the U.S. Forest Service, for providing information on previous studies related to the development of water resources of the Cache la Poudre River.

- The various water users organizations, both municipal and agricultural, for discussion and insight into the present and projected water use in the Cache la Podure Basin and the potential economic effects associated with that water use.

- The Colorado Public Utilities Commission, Public Service Company of Colorado, Tri-State Generation and Transmission Association and Platte River Power Authority for discussions and insight into the present and projected loads and resources of the integrated regional power systems.

- The several consultants and subcontractors who provided valuable input into the study; including Dr. Al Stevens of Boulder on hydrology, Dr. Kenneth Nobe and Mr. William Gardner of Colorado State University on agricultural economics and recreational aspects, Resource Consultants, Inc. of Fort Collins on an inventory and description of the water supply facilities in the Cache la Poudre Basin and their operation.

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CHAPTER I
INTRODUCTION

A. AUTHORITY

In 1981, the Colorado General Assembly authorized the Colorado Water Conservation Board to conduct studies of four potential water resources development projects. Among these was "the Cache la Poudre Project -- an integrated project up-stream of the town of Fort Collins on the Cache la Poudre River" (section 7, S.B. 439).

Expenditures for each of the studies was limited to not more than $300,000. In addition, S.B. 439 specifies that future funding for the potential projects ". . . is contingent upon a showing that additional funding is justified based on competent engineering and economic data."

B. STUDY OBJECTIVE

The objective of this Cache la Poudre Project study was: to evaluate, at a reconnaissance level of detail, the engineering and economic feasibility of alternative projects which could develop new water supplies, improve the management of already developed water, and provide hydroelectric power production. The alternative projects may consist of one or more storage reservoirs together with all appurtenances and associated features, including hydropower facilities.

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Consistent with the legislative intent of S.B. 439 and the constraints imposed by time and budget limitations, this study did not analyze a "non-structural" alternative nor evaluate the environmental and recreational impacts of any of the alternative projects under consideration. Rather, this study is limited to addressing the threshold questions of whether there appears to be any project which may be feasible from an engineering and economic point of view. Subsequent, detailed feasibility studies will, should they be undertaken, need to thoroughly address all impacts, both beneficial and adverse, of any potential project.

C. STUDY AREA

The Cache la Poudre River Basin lies in north-central Colorado on the eastern slope of the Continental Divide of the Rocky Mountains. The Cache la Poudre River Basin, totalling about 1,850 square miles in area, is composed of two distinctly different geographical units. The mountainous upper basin, some 1,050 square miles in area, is primarily the water yielding area; while the lower basin, some 800 square miles in area, is the area of water use. Figure I-1 is a map of the basin showing the upper and lower basins separated by a dotted line which intersects the River at the mouth of the canyon.

The study examined such projects as would be located on the mainstem of the Cache la Poudre River or its tributaries (i.e., the North or South Forks) upstream from Fort Collins. Although segments of the mainstem and South Fork are under study for possible inclusion in the national wild and scenic rivers system, those segments were not excluded from consideration for reservoir sites in this study. Likewise, the existence of designated wilderness areas was not taken as a constraint on the siting of potential reservoirs or any other potential project features.

D. STUDY MANAGEMENT

Pursuant to the proper statutory procedures, the Colorado Water Conservation Board selected Tudor Engineering Company to perform the study. Under the general guidance of the Colorado Water Conservation Board's staff, Tudor was responsible for carrying out all aspects of the study and for the preparation of all necessary study documentation and reports. Final decisions concerning the scope and conduct of the study, the evaluation criteria employed at each stage of the study and the recommendations made at the conclusion of the study were the responsibility of the Colorado Water Conservation Board.

E. CONDUCT OF THE STUDY

The study was conducted in two phases. In Phase I of the study, it was originally intended that four to six preliminary alternative projects would be selected for evaluation. Fourteen potential alternative projects were identified, evaluated and then screened down to six preliminary alternative projects. As a result of discussion with the Advisory Committee and input received during public meetings, two additional preliminary alternative projects were added for preliminary evaluation. These eight preliminary alternative projects were analyzed and evaluated during Phase I of the study. The results of Phase I were presented in the "Interim Report on the Cache la Poudre Project Study" and an addendum to that report in July 1982.

In the original scope of work, it was intended that one or two alternative projects would be selected for evaluation at reconnaissance level in Phase II of the study. Following completion of Phase I, the decision of the Colorado Water Conservation Board was to investigate four alternative projects during Phase II of the study. The four selected alternative projects were analyzed and evaluated during Phase II of the study. The results of both Phase I and Phase II of the study are presented in this report.

The decision to investigate eight preliminary alternative projects instead of four to six during Phase I and four alternative projects instead of one or two during Phase II necessitated changes in the scope of work for the study. The additional effort resulting from investigation of a greater number of preliminary alternative projects during Phase I and the evaluation of a greater number of alternative projects during Phase II necessitated a comparable reduction in effort during Phase II due to budgetary limitations. As a result, the reformulation of the four selected alternatives during Phase II was limited primarily to upgrading designs and cost estimates for the major project facilities to achieve reconnaissance level of detail. No additional operation studies were performed during Phase II; therefore, sizing of project reservoirs and power facilities were not optimized as originally envisioned. Preliminary estimates of project benefits were not refined or upgraded from Phase I to Phase II as originally intended. As a result, it is felt that reservoirs are oversized, resulting in an overestimation of project costs, and that project benefits, particularly of peaking power, are underestimated.

F. PUBLIC INVOLVEMENT

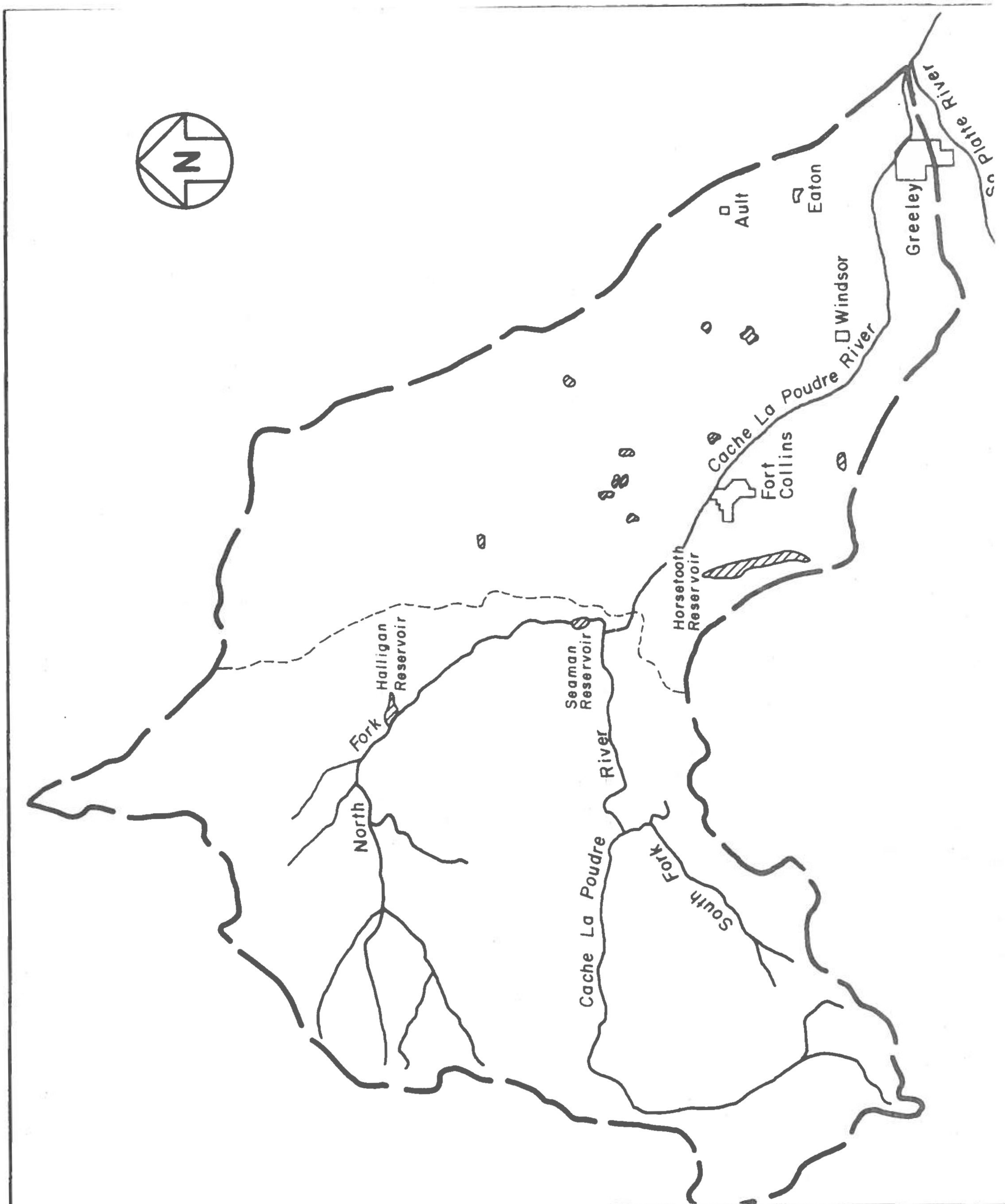
Comment on the study has been actively sought from the outset with the formation of an Advisory Committee composed of knowledgeable individuals representing a wide range of interests in the Cache la Poudre Basin. Functions of the advisors panel included review of written products and advising on the content and conduct of the study, including public participation activities.

A series of public meetings were held in Fort Collins throughout the study to inform the public and to allow public input to the study process. The first meeting was held on June 30, 1982 to acquaint the public with the objectives of the study. At the second public meeting on August 11, 1982, the results of Phase I of the study were summarized and discussed.

At its regular bi-monthly meeting on August 16, 1982, the Colorado Water Conservation Board reviewed the eight preliminary alternatives which were evaluated in Phase I of the study. After hearing public comment, the Board selected four of the preliminary alternatives for further evaluation in Phase II of the study.

A final public meeting was held in Fort Collins on February 23, 1983, to present the results of the Phase II evaluations to the public. On March 3, 1983, the Colorado Water Conservation Board held a special evening meeting in Fort Collins to hear public comment on the Cache la Poudre Study and to adopt a recommendation on the study for transmittal to the General Assembly.

In addition to the public meeting, a series of publications was also made available to the public during the course of the study. Four newsletters were distributed between June 1982 and February 1983 to inform the public of the status of study activities and to announce upcoming meetings. "The Interim Report on the Cache la Poudre Project Study" and the "Addendum to the Interim Report" were distributed following Phase I of the study in August 1982. At the completion of Phase II of the study, the "Cache la Poudre Project Study Draft Summary Report" was distributed.



COLORADO WATER CONSERVATION BOARD

CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

CACHE LA POUDRE
RIVER BASIN

TUDOR ENGINEERING COMPANY FIGURE: I-1

CHAPTER II
BASIN DESCRIPTION

A. INTRODUCTION

This chapter contains a general description of the Cache la Poudre River Basin, including a physical description of the basin and a discussion of the present water use within the basin. It also discusses the existing power system. It is intended to provide an understanding of the present day conditions for comparison to projected future conditions with and without a potential Cache la Poudre Project.

B. LOCATION AND PHYSIOGRAPHY

The Cache la Poudre River Basin lies in north-central Colorado on the eastern slope of the Continental Divide of the Rocky Mountains. The basin is shown on Figure II-1. The Laramie and Medicine Bow mountain ranges form the western boundary of the basin separating it from the Laramie River, Michigan River and Colorado River basins. The Mummy Range and foothills to the east of the Mummy Range form the southern boundary of the basin separating it from the Big Thompson River drainage. The northern boundary develops in the high plateau region of southern Wyoming. The eastern boundary is in the low ridges common to the transition zone between the foothills and plains. Separate ridges divide the Cache la Poudre River basin from that of other South Platte River tributaries, Lone Tree Creek and Owl Creek. The Cache la Poudre River, a major tributary of the South Platte River, discharges into the South Platte River near the City of Greeley.

Elevations in the basin vary from just over 4,600 feet at the confluence with the South Platte River to 13,560 feet on Hagues Peak in the Rocky Mountain National Park. Along the southern boundary of the basin there are five mountain peaks with elevations greater than 13,000 feet.

The mainstem Cache la Poudre River is fed by two major tributaries, the North Fork Cache la Poudre River and the South Fork Cache la Poudre River (known locally as the Little South Fork). The North Fork Cache la Poudre River enters the mainstem at River Mile 60.3; river mileage being measured upstream from the confluence with the South Platte River. The North Fork drainage basin ranges in elevation from about 5,550 feet at its confluence to 11,000 feet on South Bald Mountain. The South Fork Cache la Poudre River enters the mainstem at River Mile 73. Its drainage basin ranges in elevation from about 6,570 feet at its confluence to 13,400 feet on Rowe Peak.

As shown on Figure II-1, the Cache la Poudre River Basin is composed of two distinctly different geographical units. The mountainous upper basin is primarily the water yielding area. The lower basin, in the Colorado Piedmont section of the Great Plains Province, is the area of water use. The mouth of the Cache la Poudre River canyon, about 13 miles upstream from the City of Fort Collins, is roughly the dividing line between the upper and lower basins. The total area of the basin is about 1,850 square miles with some 1,050 square miles in the upper basin and 800 square miles in the lower basin.

C. THE RIVER CORRIDOR

For ease of describing the Cache la Poudre River corridor, the stream has been divided into seven segments as was done in the Cache la Poudre Wild and Scenic River, Draft Environmental Impact Statement [1][1/] and shown in Figure II-2. A brief description of each river segment follows in which the number of acres shown represents the area in the river corridor which covers 1/4 mile on each side of the river. Total recreational use, in 12-hour recreation visitor days, as estimated by the U.S. Forest Service within the seven segments for the year 1980 is summarized on Table II-1. The use of developed recreational facilities within the segments for the years 1967, 1977, and 1981 is shown, in recreation visitor days, on Table II-2. A 1980 estimate of the distribution of the fishing visits by the same segments, was provided by the Colorado Division of Wildlife [2] and is shown on Table II-3.

Segment 1, on the mainstem, is approximately 5 miles in length extending from the eastern boundary of Roosevelt National Forest to the west side of the village of Poudre Park. It contains approximately 1,600 acres. The community of Poudre Park and some additional residential development along with the Fort Collins water treatment plant are located in this segment. State Highway 14 parallels the river throughout its length. Lands are approximately 80 percent privately owned. This segment receives heavy recreation use despite a lack of developed facilities because of the proximity of Fort Collins. Fishing use is heavy with the lower four miles of this segment being managed as a quality fishing area for artificial lures only. More than half the boating use in the total corridor occurs in this segment because of its suitability for rafting [3]. The Grayrock Trail provides a popular hiking opportunity.

Segment 2, on the mainstem, is approximately 10 miles in length starting from the west side of Poudre Park and extending to the confluence with the South Fork. It contains approximately 3,200 acres in which the noted features are several campgrounds, the gorges of the Little and Big Narrows, and the Mishawaka settlement. State Highway 14 continues to parallel the river throughout this segment. Approximately 10 percent of the land is privately owned and it contains about half of the total corridor's campground and picnic area development. Dutch George Flats is one of three potential areas for future campground development. This segment is actively fished and there is limited hunting and boating use.

1/ Bracketed numbers throughout the report indicate specific references listed in the back of the report.

TABLE II-1
CACHE LA POUDRE PROJECT
TOTAL 1980 RECREATION USE
IN THE CACHE LA POUDRE RIVER CORRIDOR

	12-Hour Recreation Visitor Days		
Recreation Activity	Mainstem (Segments 1-4)	Mainstem (Segment 5)	South Fork (Segments 6-7)
Automobile Travel	279,500	100	9,100
Bicycling	2,000	0	0
Horseback Riding	1,500	0	0
Hiking and Walking	14,100	2,000	3,300
Boating	2,000	0	200
Fishing	35,200	3,300	10,100
Hunting	8,000	300	0
Camping	75,900	11,000	15,700
Picnicking	20,700	2,700	4,800
Winter Recreation	1,300	1,000	2,200
Total 12 Hour Recreation Visitor Days	440,200	20,400	45,400
GRAND TOTAL			506,000

TABLE II-2
CACHE LA POUDRE PROJECT
USE OF DEVELOPED RECREATION FACILITIES
IN THE CACHE LA POUDRE RIVER CORRIDOR

SITE NAME	RECREATION VISITOR DAYS 1967	1977	1981
RIVER SEGMENT 1, Mainstem from National Forest Boundary to Poudre Park			
Grayrock Trail Head			7,300
RIVER SEGMENT 2, Mainstem from Poudre Park to South Fork			
Poudre Park Picnic Ground	800	4,400	2,100
Mishawaka Picnic Ground		2,300	1,700
Diamond Park Picnic Ground	5,000	6,400	2,200
Ansel Watrous Campground/Picnic Ground	10,300	14,800	12,600
Stove Prairie Landing Campground		6,000	3,100
Upper Landing Campground		2,200	1,500
Stevens Gulch Campground		3,900	2,600
Narrows Picnic Ground	1,800	6,000	1,700
Narrows Coop Campground		4,200	2,400
Dutch George Flat Campground		6,100	6,100
TOTAL	17,900	56,300	36,000
RIVER SEGMENT 3, Mainstem from South Fork to Indian Meadows			
Mountain Park Campground/Picnic Ground	15,300	24,700	47,300
Kreutzer- Mt. McConnel Trail Head			800
Kelly Flats Campground	3,100	11,300	10,000
Eggars Picnic Ground		2,400	2,200
Indian Meadows Campground		1,700	1,500
Home Moraine Interpretive Site	200	1,600	400
TOTAL	18,600	41,700	61,200
RIVER SEGMENT 4, Mainstem from Indian Meadows to Joe Wright Creek			
Zimmerman Crown Point Trail Head			500
Kimnikinic Rest Area			
Big Bend			6,400
Tunnel Campground		1,600	1,700
Sleeping Elephant Campground		3,800	6,000
Big South Trail Head		1,200	600
TOTAL	0	6,600	15,200
RIVER SEGMENT 5, Mainstem from Joe Wright Creek to Source			
	None	None	None
RIVER SEGMENT 6, South Fork from Mainstem to Beaver Creek			
	None	None	None
RIVER SEGMENT 7, South Fork from Beaver Creek to Source			
Bennett Creek Picnic Ground	400	2,900	1,200
Fish Creek Campground	900	2,900	2,200
Tom Bennett Campground	700	4,100	6,100
Little South Campground		6,200	6,200
TOTAL		16,100	14,700
TOTAL - SEGMENTS 1-7	36,500	120,700	134,400

TABLE II-3
CACHE LA POUDRE PROJECT
FISHING VISITS TO THE
CACHE LA POUDRE RIVER CORRIDOR IN 1980

RIVER SEGMENT	MILES OF STREAM	1980 VISITS	% OF VISITS	VISITS PER MILE
1. Mainstem	6	38,400	30	6,400
2. Mainstem	12	32,000	25	2,667
3. Mainstem	9	25,600	20	2,844
4. Mainstem	17	12,800	10	753
5. Mainstem	18	7,680	6	427
6. South Fork	8	2,560	2	320
7. South Fork	17	8,960	7	527
TOTAL	87	128,000 1/	100	

1/ Differences in fishing use compared to Table II-1 are due primarily to methodology variations between the two agencies, where the Forest Service has converted visits to 12-hour "visitor-day" equivalents.

Segment 3, on the mainstem, is approximately 7 miles in length extending from the confluence with the South Fork to Indian Meadows. It contains 2,240 acres, all of which is publicly owned though there are some privately owned cabins on national forest land authorized by special use permit. State Highway 14 continues throughout its length. Nearly half of the total corridor recreation visitor days on developed sites occurred in this segment. Mountain Park campground, a Fort Collins municipal park, is by far the most heavily used facility in the corridor. Mountain Park Campground is also the site of annual kayak races hosted by the Colorado Whitewater Association. One-fourth of the boating activity is estimated to occur in this segment [3]. Hombres Ranch and Indian Meadows are the sites of the other two potential planned campground developments of the U. S. Forest Service [4].

Segment 4, on the mainstem, is approximately 16 miles in length extending from Indian Meadows to the confluence of Joe Wright Creek with the mainstem. It contains 5,120 acres of which approximately 60 percent is privately owned. Here the corridor becomes a broad glacial valley through which the river slowly meanders. This segment contains the community of Rustic, several private resorts and a state fish hatchery. There are a few developed recreation areas and a limited amount of fishing and kayaking occurs. State Highway 14 continues to parallel the river to the upper end of this segment where it leaves the corridor to continue along Joe Wright Creek and over Cameron Pass.

Segment 5, on the mainstem, is approximately 18 miles in length extending from the confluence with Joe Wright Creek to the source of the mainstem at Poudre Lake in Rocky Mountain National Park. It contains 5,760 acres, most of which lies in the Comanche Peak Wilderness Area or Rocky Mountain National Park, and is 100 percent publicly owned. There are no developed facilities except for limited campground facilities at the Big South Trailhead. Recreational use is limited in this segment by the steep terrain since it is accessible only by trail.

Segment 6, on the South Fork, is approximately 7 miles in length extending from the confluence with the mainstem to Little Beaver Creek. It contains 2,240 acres most of which lies within the Cache La Poudre Wilderness Area. Approximately 10 percent of the land is privately owned, and there are no community developments or developed recreation facilities. Public access is limited by extremely rugged terrain.

Segment 7, on the South Fork, is approximately 11 miles in length and extends from Little Beaver Creek to the source of the South Fork in Rocky Mountain National Park. It contains 3,520 acres of which only about 3 percent is privately owned. The lower portion of this segment is well developed and is paralleled by County Road 131. There are several developed campgrounds, numerous recreation cabins, and the Pingree Park campus of Colorado State University. The upper portion of this segment lies within the Comanche Peak Wilderness Area and Rocky Mountain National Park.

D. CLIMATE

The topography of the Cache la Poudre River basin varies from alpine tundra in the high mountain headwaters to relatively flat plains at the confluence with the South Platte River. This rapid variance, in conjunction with the regions mid-latitude location, results in localized climatic extremes.

Precipitation varies from over 25 inches per year in the high mountain areas to 14.19 inches per year at Fort Collins, and 11.12 inches per year at Greeley. Temperatures range from near arctic proportions in the high mountains of the upper basin to maximums of over 100° F in Fort Collins and Greeley. The mean annual temperatures are 48.1° F, at Fort Collins, 48.3° F, at Greeley, and 35° F in the mountains.

The climate of the upper basin is typical of the Colorado mountain regime. Most of the precipitation occurs as fall and winter snowfall. Average snowfalls exceed 100 inches per year in the high mountains decreasing with elevation to about 48 inches per year at Fort Collins. Occasional scattered summer thunderstorms contribute a small amount to the annual runoff. Mountain valley agriculture, primarily hay and pasture, is limited by a 90-day growing season.

The climate of the lower basin is characterized by low annual precipitation, low humidity, winds, and an abundance of sunshine. This, with a wide range of temperatures, results in high rates of evaporation. The winters are generally mild; however, short periods of severe cold occur. There are usually several heavy snowstorms during the winter; however, snow does not accumulate to a great degree in the lower basin. Spring and summer precipitation usually occurs as thunderstorms, sometimes with strong winds and hail.

Precipitation in the lower basin is usually erratic and unevenly distributed, but is generally sufficient to support a light cover of native grasses, shrubs, and some winter grains. The maximum monthly precipitation usually occurs in May while the minimum usually occurs in the months of December, January and February as light, dry snows. Successful farming is almost wholly dependent on irrigation. The growing season in the lower basin is from 175 to 185 days.

E. FISH & WILDLIFE RESOURCES [1/]

The upper Cache la Poudre Basin has a great abundance and variety of fish and wildlife resources. A reason for the variety of species is the fact that

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1/ The information for this section of the report was obtained from an unpublished report prepared by the Colorado Division of Wildlife in December 1978, for the U.S. Forest Service.

the river flows through four major life zones; Artic-Alpine (above 11,500 feet), Hudsonian (10,500 to 11,500 feet), Canadian (8,000 to 10,500 feet) and Transition (5,500 to 8,000 feet).

These four life zones offer a variety of wildlife habitats which are conducive to abundant populations. Aquatic habitats include the river, tributary streams, lakes, reservoirs, seeps and ponds for fish, amphibians, crustaceans and some reptiles. Terrestrial habitats include alpine meadows, forests, shrubland, grassland and riparian areas for birds and mammals.

There are approximately fifteen species of fish in the waters of the upper basin. Game fish include five species of trout, Kokanee salmon and mountain whitefish. Non-game fish include minnows, shiners and suckers. In addition, there are six species of crustaceans found generally in lakes and reservoirs.

The Colorado Division of Wildlife stocks about 33 miles of the mainstem and 3 miles of the Little South Fork with trout each year. A number of the reservoirs in the upper basin are also stocked with trout. The river provides excellent aquatic habitat with good water quality, desirable water temperatures, a gentle stream gradient, abundant riparian vegetation, adequate reproduction areas and a pool-riffle ratio of about 50:50.

There are approximately 265 species of amphibians, birds, mammals and reptiles in the upper Cache la Poudre basin. The more common species include beaver, chipmunks, coyote, deer, elk, hawks, lizards, magpies, mice, shorebirds, skunk, songbirds and squirrels.

Big game mammals include bear, bighorn sheep, deer, elk and mountain lion. Deer are the most abundant of the large mammals and are found along the entire river corridor. Elk are also numerous and, like the deer, they are found in the higher elevations during the summer months and at lower elevations during the winter. Their winter range extends from about 8,000 feet down to about 6,500 feet.

There are approximately 100 bighorn sheep in the upper basin with the largest herd of about 75 animals located along the north slope of the canyon near Rustic. This herd started with 16 animals introduced in the area in 1946 by the Colorado Division of Wildlife. Their range extends from above Spencer Heights down to Stove Prairie Landing. Smaller bighorn sheep herds are found near the headwaters of the River in Rocky Mountain National Park.

Small game mammals found in the upper basin are cottontail rabbit, snowshoe hare and tree squirrels. Upland game birds include blue grouse, ptarmigan and turkey. Migratory game birds include band-tailed pigeon, mourning dove, waterfowl and shorebirds.

Raptors are common to all habitats along the river corridor. The most common residents include several species of hawks as well as golden eagle, prairie falcon and great-horned owl.

There are a moderate number of furbearers in the area including badger, beaver, marten, muskrat, skunk and long-tailed weasel. Varmints common to the area are coyote, crow, ground squirrel, magpie, marmot, porcupine, red fox, rock squirrel, raccoon, starling and prairie rattler.

Amphibians found in the upper basin are salamanders, toads and frogs. There are eleven species of reptiles, the most common of which are the rock lizard, bull snakes, garter snakes and prairie rattlesnakes.

In addition to the above, there are 29 species of non-game animals and 124 species of non-game birds. The Cache la Poudre Wild and Scenic River Draft Environmental Statement and Study Report lists two species on the Endangered and Threatened Species List: the Peregrine falcon and the greenback cutthroat trout.

F. GEOLOGICAL AND GEOTECHNICAL CONSIDERATIONS

1. Geological Setting

The Cache la Poudre River Basin is located in the geomorphological province known as the Front Range. The Front Range is an uplifted region (horst) which lies adjacent to the down-dropped block (relative to the Front Range) known as the Denver Basin graben.

The upper basin is almost entirely contained within uplifted, very old Precambrian crystalline rocks. These uplifted crystalline rocks form part of the easternmost mountain range in Colorado, referred to as the Front Range. Steeply dipping, younger Paleozoic and Mesozoic sedimentary rocks flank the older crystalline rocks at the eastern edge of the Front Range. At this crystalline-sedimentary contact, the topography changes from steep high mountains to the flat Great Plains. Locally resistant sandstone and limestone beds form hogbacks parallel to the eastern edge of the mountains. These hogbacks give way to relatively flat lying sedimentary rocks that underlie the Great Plains.

2. Seismicity

The Front Range is generally recognized as a low seismic region. The youngest faulting in the area is about 70 miles to the south along the Derby Fault near Denver. The pumping of military arsenal wastes down disposal wells in the middle to late 1960's had caused movements along the Derby Fault, resulting in earthquakes with a maximum magnitude of 5.5 on the Richter scale. In general, the study area is characterized by low seismic activity with Richter magnitudes rarely exceeding 5.0.

G. WATER SUPPLY

The native water supply in the Cache la Poudre River basin is supplied by snowmelt from the perennial snow fields in the high mountains and, to a lesser extent, from rainfall. The bulk of this runoff is from the headwaters of the mainstem and South Fork in the high mountains within and bordering Rocky

Mountain National Park. This high mountain area, comprising only about 15 percent of the upper basin drainage area, produces about 50 percent of the native runoff from the upper basin.

Transmountain diversions from the drainages west of the basin augment the native flows in the basin. These "foreign waters", which form a significant contribution to the total water supply in the basin, also originate primarily from snowmelt in adjacent high mountain watersheds.

H. PRESENT WATER USE

The major use of water in the Cache la Poudre River basin is for irrigated agriculture. There is a small amount of irrigated hay and pasture in the upper basin; however, the developed agriculture is primarily in the lower basin. Although there is some dryland farming, agriculture in the lower basin is largely limited to irrigation farming in lower lying areas accessible to diversion of streamflows. Presently, there are about 225,000 acres of irrigated agriculture in the service area of the Cache la Poudre River.

The service area is comprised of lands in the lower basin and some adjacent areas to the east which are served by diversions from the Cache la Poudre River. The service area has widely diversified agriculture including native hay, alfalfa, corn, sugar beets, potatoes, beans, barley, oats and winter wheat. The principal agricultural industries are general farming, livestock feeding, and dairying. Alfalfa and corn are usually raised for consumption in the area by feeder cattle and sheep.

Rapid population growth in recent years has made municipal and industrial water needs in the lower basin an increasingly important aspect of water use. The metropolitan areas of Greeley and Fort Collins are the major municipal and industrial water users; however, smaller towns such as Windsor are experiencing significant population growth with an accompanying increase in water use. Establishment and expansion of industries such as Ideal Cement Company, Eastman Kodak, and Hewlett-Packard, along with the growth of Colorado State University and the University of Northern Colorado have contributed substantially to this overall population growth.

I. WATER USE ENTITIES AND EXISTING FACILITIES

1. Inventory of Entities and Existing Facilities

Major water use entities in the basin are listed on Table II-4. As shown in the table, the majority of these water users have joined together to form the Cache la Poudre Water Users Association. This organization was formed to coordinate and facilitate the beneficial use of water resources in the basin. The majority of these entities are also participants in the Northern Colorado Water Conservancy District which is the operating entity for the Colorado-Big Thompson Project facilities. A municipal sub-district of the Northern Colorado Water Conservancy District will administer the use of Windy-Gap Project flows through the Colorado-Big Thompson Project facilities. The Windy-Gap Project is presently under construction.

TABLE II-4
CACHE LA POUDRE PROJECT
MAJOR WATER USE ENTITIES
IN THE CACHE LA POUDRE BASIN

- 1/ Arthur Irrigation Company
- 1/ Boxelder Ditch Company
- Boyd Irrigation Company
- Cache la Poudre Reservoir Company
- 1/ Cache la Poudre Irrigating Company
- Colorado Department of Game, Fish & Parks
- 2/ Crestview Water Assoc.
- 1/ Divide Canal & Reservoir Company
- 2/ East Larimer County Water District (ELCO)
- 2/ Eastman Kodak Company
- 1/ B. H. Eaton Ditch Company
- Fisher & Hoffman
- 1/ City of Fort Collins
- 2/ Fort Collins-Loveland Water District
- 1/ City of Greeley
- 1/ Greeley Irrigation Company (No. 3)
- Ideal Cement Company
- William Jones Irrigation Company
- 1/ Jackson Ditch Company
- 2/ Kitchell Reservoir Company
- 1/ Larimer County Canal No. 2 Irrigation Company
- 1/ Lake Canal
- 2/ Laport Water District
- 1/ Larimer & Weld Irrigation Company
- 1/ Larimer & Weld Reservoir Company
- 1/ New Mercer Ditch Company
- 1/ The New Cache la Poudre Irrigation & Reservoir Company
- 1/ North Poudre Irrigation Company
- 2/ North Weld County Water District
- 2/ Northern Colorado Water Association
- 1/ Ogilvy Irrigation and Land Company
- 1/ Platte River Power Authority
- 1/ Pleasant Valley & Lake Canal
- Red Feather Storage & Irrigation Company
- Specht, Nix & Williams
- 2/ Spring Canyon Water & Sanitation District
- 2/ Sunset Water District
- 2/ State Board of Agriculture
- 1/ Taylor & Gill
- Warren Lake Reservoir Company
- 1/ Water Supply & Storage Company
- 2/ West Fort Collins Water District
- 1/ Whitney Irrigation Company
- 1/ Windsor Reservoir & Canal Company
- Woods Lake Farms Company

1/ Member of the Cache la Poudre Water Users Association.

2/ Water supply not obtained directly from the Cache la Poudre River or its tributaries, under separate water rights.

Four major irrigation companies control and utilize 80 to 90 percent of the total flow in the Cache la Poudre River. These are the North Poudre Irrigation Company, the Water Supply and Storage Company, the Larimer and Weld Irrigation Company and, the New Cache la Poudre Irrigation and Reservoir Company.

There are well over 100 storage reservoirs in the Cache la Poudre River Basin. The relationship of the major reservoirs within the total interconnected system can be seen on the schematic shown on Figure II-3 and the larger ones are identified on the maps on Figure II-1 and Figure II-4.

The total number of diversion facilities along the Cache la Poudre River and tributaries is well over 200. In addition to diversion facilities, there are several major reservoir outlet channels which have the capability of returning flows to the river. The relationship of these facilities within the total system can be seen on the schematic shown on Figure II-3 and the major ones are identified on the maps on Figure II-1 and Figure II-4.

There are several facilities which import water into the Cache la Poudre River Basin. The major transbasin import facility is the Hansen Supply Canal which brings water into the lower basin from the Colorado River Basin through the Colorado-Big Thompson Project facilities. The remaining transbasin import facilities bring water into the headwaters of the upper basin from the Colorado River Basin, Michigan River Basin, and Laramie River Basin. The relationship of these facilities can be seen on the schematic shown on Figure II-3 and on the maps on Figure II-1 and Figure II-4.

2. Operation of the Existing System

Diversions from the Cache la Poudre River are practiced on a seasonal basis. Diversions for municipal and industrial uses occur year around; however, these uses require higher diversions during the period from April through October. Diversions for direct irrigation use occur primarily during the period from May through August with lesser diversions continuing into September and October. In addition, some diversion to storage may occur in the spring and fall season provided storage space is available in the lower basin reservoirs. In some years, a small amount of diversion to storage may occur throughout the winter. In comparison to total direct diversion requirements this winter diversion to storage is small.

In the fall, it is customary to fill the reservoirs to a level less than their maximum storage level if water supply is available. This is to prevent damage to the structures by severe winds during the winter and early spring. The reservoirs are then filled to their capacity in the late spring during a short time period by snowmelt runoff. When the reservoirs are filled or when a downstream call for water precludes any diversions to storage, diversion into the ditches continues under direct-flow priorities. Water diverted under direct-flow priorities must be directly applied to farmlands for irrigation and may only be temporarily stored if ditch operations require. It can be stored for only a few days at most.

The principal storage reservoirs in the upper basin are used to store runoff and transbasin diversions for later release to serve irrigation needs in the lower basin. Exceptions are reservoirs owned by the cities of Fort Collins and Greeley. These were originally designed to release flows year around for diversion into the cities water treatment facilities. With the availability of Colorado-Big Thompson Project water, the cities use much of the storage in their upper basin reservoirs for an exchange of waters with irrigation companies.

The major storage capacity in the Cache la Poudre River Basin has been developed in the lower basin in what are commonly referred to as the plains reservoirs. The lower basin reservoirs are owned by various irrigation companies and are located below canals owned by these irrigation companies. These reservoirs are filled with river diversions to storage or storage releases from upper basin reservoirs. Storage from these reservoirs is released during the irrigation season to supply irrigation needs to lands within their service area. In some cases, releases can be made to the Cache la Poudre River to facilitate exchanges within the basin. The lower lying plains reservoirs also collect return flows from irrigation in service areas lying above them.

Since the time of their construction, reservoirs within the Cache la Poudre Basin have been used to accomplish exchanges of water within the basin. These reservoir exchanges, involving both direct flow rights and reservoir storage, were well established prior to the 1920's. One reason for the practice of exchanges is the relative location of the canals and storage reservoirs. Another reason is the distribution of priority dates along the river.

The extent of water exchanges practiced or contemplated can be seen from the resume of Water Court Case No. W-8086-75 which lists some 15 pages of adjudicated exchanges between structures within the basin. In this Case, the Cache la Poudre Water Users Association and its member companies have adjudicated their historic and contemplated exchanges to prevent any future interference with these exchanges by any junior water rights. The structures named in the case are by no means an exhaustive list of all possible exchange combinations, but represent exchanges that either are presently practiced regularly or have been practiced at certain times for certain durations.

There are a large number of minor exchanges practiced in the system that are either made regularly with relatively small amounts of water or which are made infrequently on an irregular basis. An important factor affecting exchanges involving Colorado-Big Thompson Project water is a statutory requirement that Colorado-Big Thompson Project water may not be used outside of the boundaries of the Northern Colorado Water Conservancy District.

J. EXISTING POWER SYSTEM SETTING

Since the specific purchaser for the power and energy generation from a potential Cache la Poudre Project has not been identified at this time, it is necessary to examine the larger interconnected system that would provide a potential market for the power and energy.

The electric power industry has divided the United States into nine electric reliability council regions encompassing the United States and a portion of Canada. The nine council regions are shown in Figure II-5. These reliability councils were formed as a result of great national concern over the ability of interconnected bulk power systems to operate reliably without widespread failures in electric service.

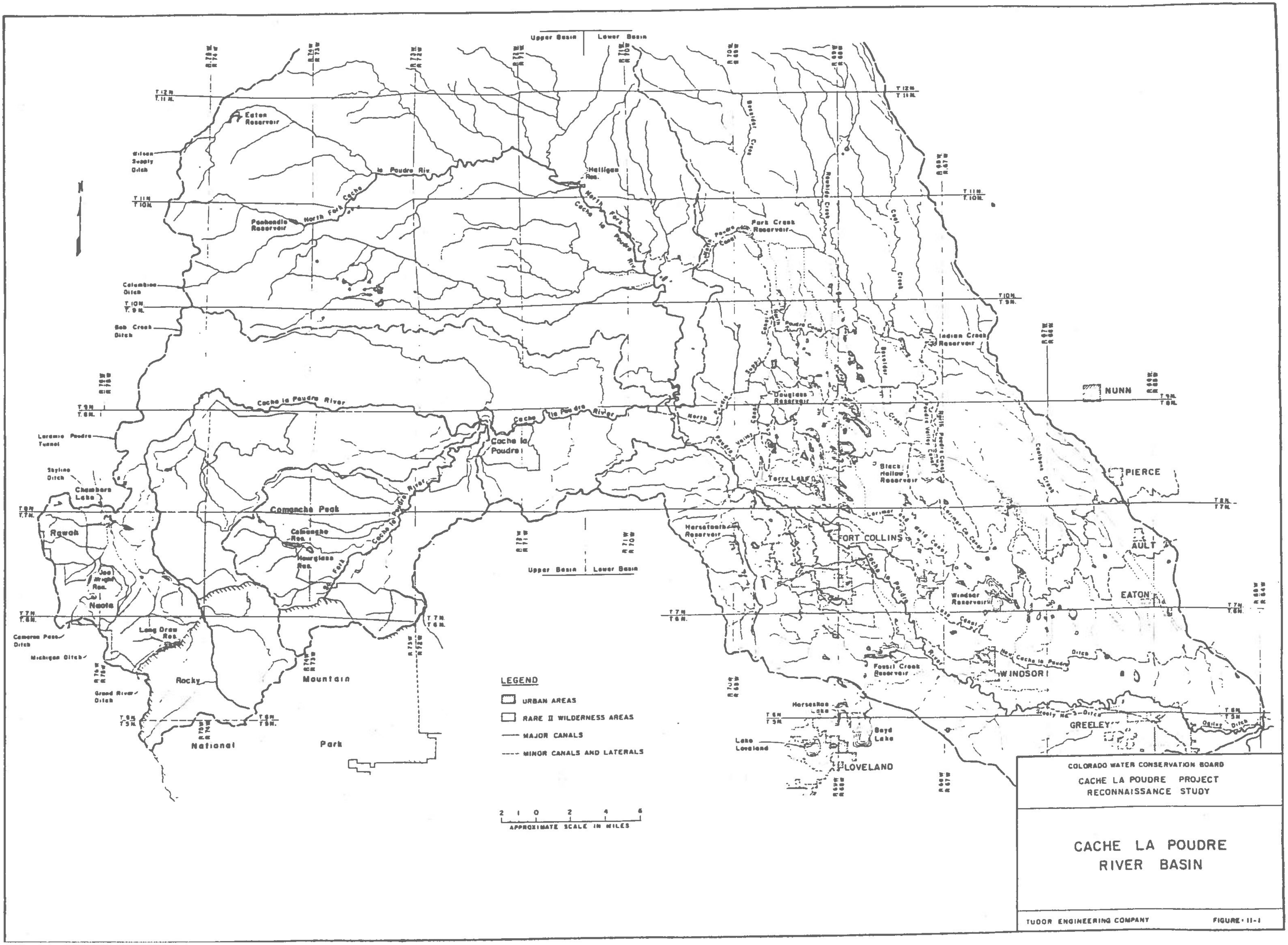
The Western Systems Coordinating Council region, which encompasses the western United States, is divided into four subregions, or general load areas. These reflect concentrations of natural resources and economic activity and the attendant growth of population and industry in certain geographical areas. The Western Systems Coordinating Council region and its subdivisions are shown on Figure II-6.

The greater interconnected system representing the potential market for power and energy production from a Cache la Poudre Project is the Rocky Mountain Power Area of the Western Systems Coordinating Council region. The State of Colorado lies within the Rocky Mountain Power Area.

The three utilities that most likely would be impacted by hydroelectric production from a Cache la Poudre Project; Public Service Company of Colorado, Tri-State Generation and Transmission Association, and Platte River Power Authority are major member utilities of the Rocky Mountain Power Area.

Under the reliability council arrangements, various utilities have joined together into operating pools for coordinated planning and operation to more efficiently match loads and resources. The Inland Power Pool is a formal operating pool with the principal objective of sharing reserve capacity among its members. Members of the Inland Power Pool operate electric generation and transmission systems in Arizona, Colorado, New Mexico, Wyoming, and portions of Utah and Nebraska. The systems are interconnected by 345 kV, 230 kV, and 115 kV transmission lines.

Output from a Cache la Poudre Project would most likely be integrated into the Inland Power Pool. The three utilities mentioned above that most likely would be impacted by the hydroelectric production of a Cache la Poudre Project are all members of the Inland Power Pool.



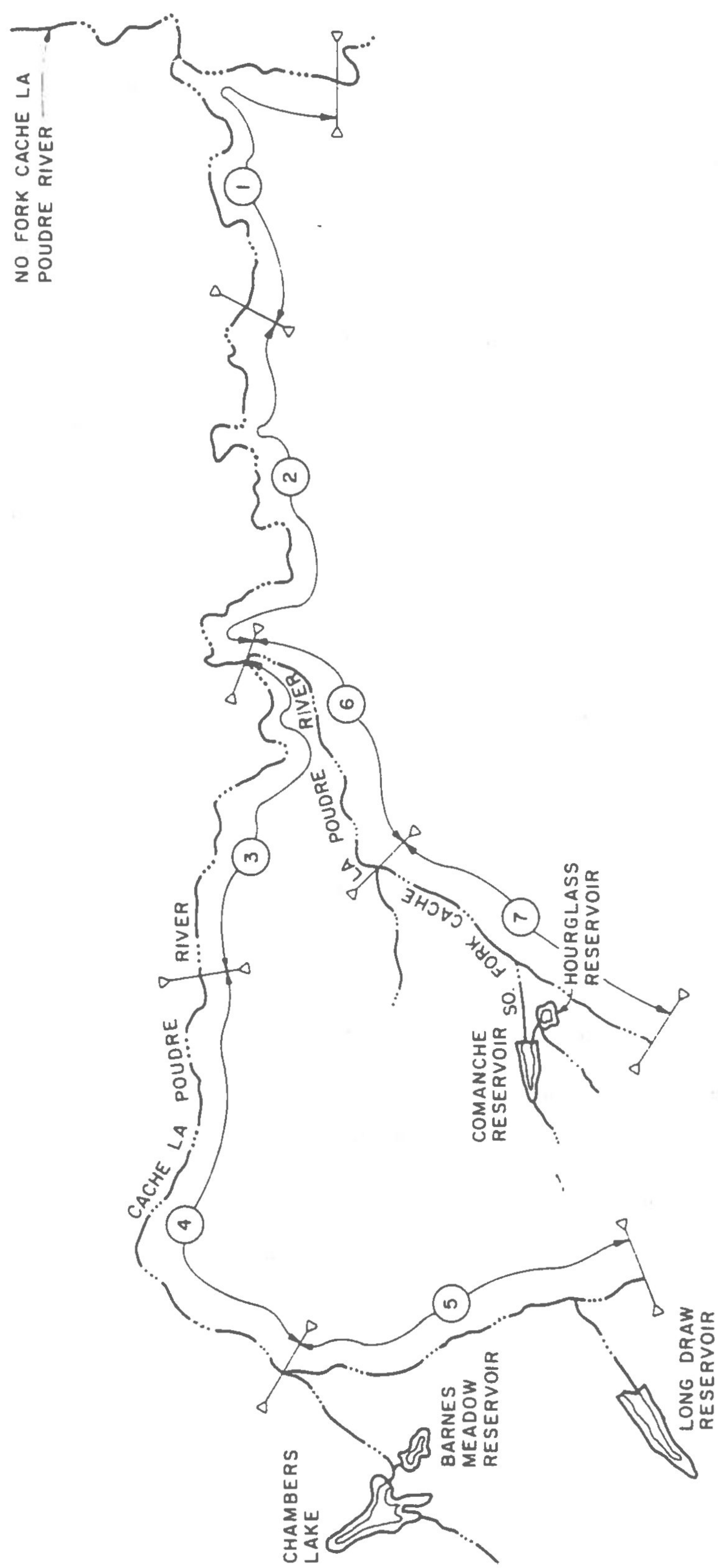
COLORADO WATER CONSERVATION BOARD

CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

CACHE LA POUDRE
RIVER BASIN

TUDOR ENGINEERING COMPANY

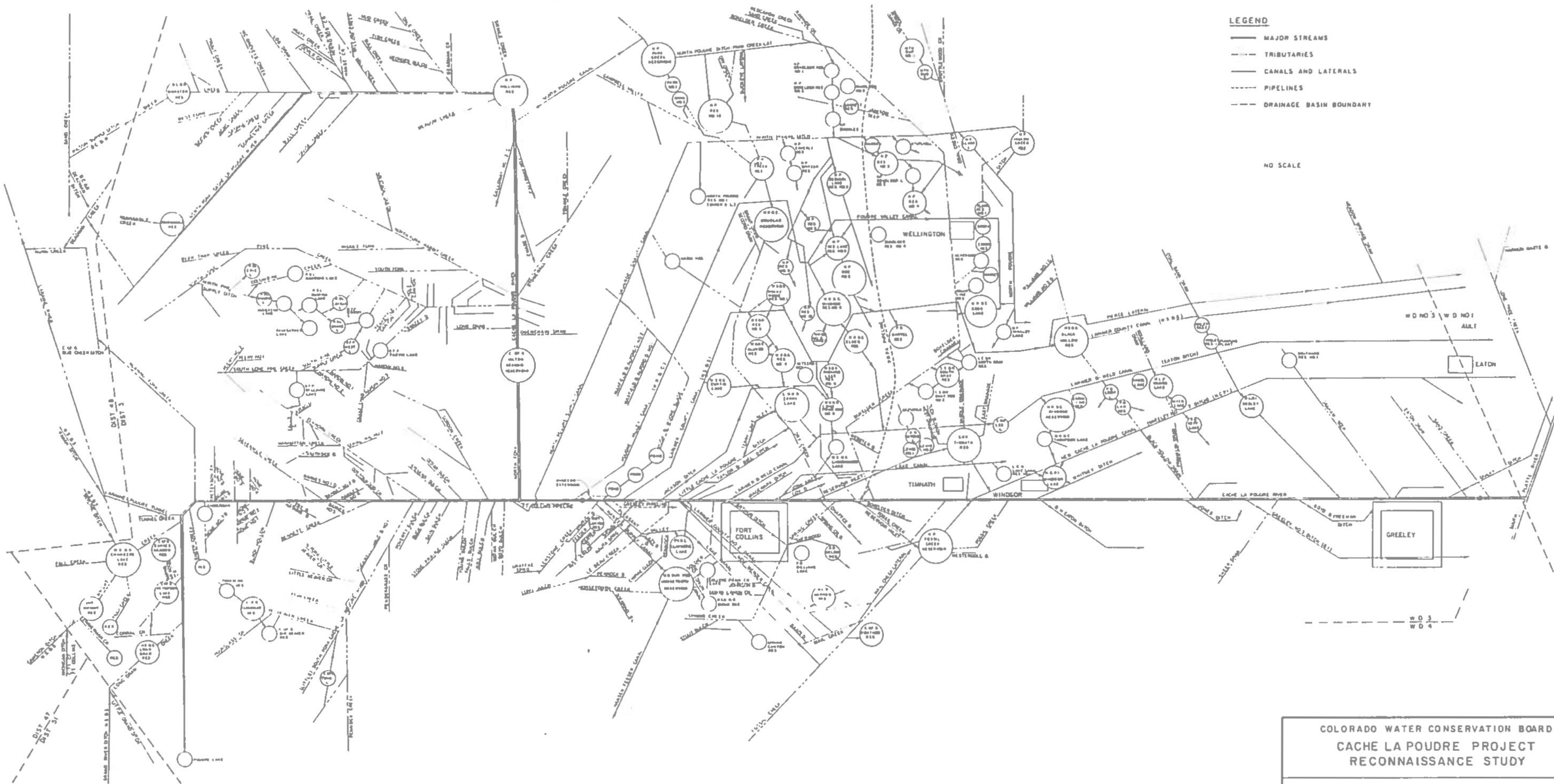
FIGURE II-1



COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

SEGMENTS OF THE
CACHE LA POUDRE
RIVER CORRIDOR

TUDOR ENGINEERING COMPANY FIGURE II 2

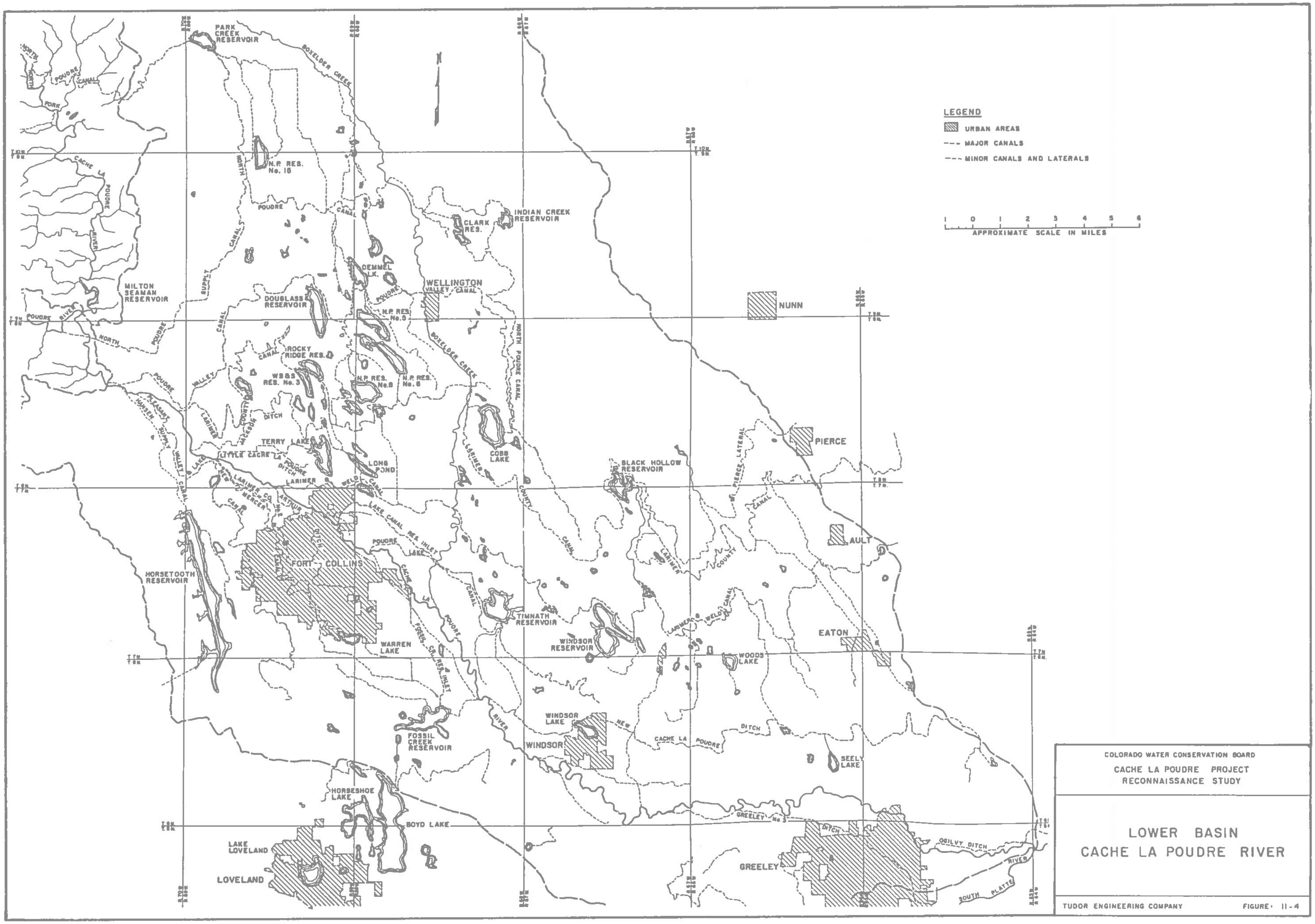


COLORADO WATER CONSERVATION BOARD

CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

SCHEMATIC OF EXISTING
CACHE LA POUDRE
WATER FACILITIES

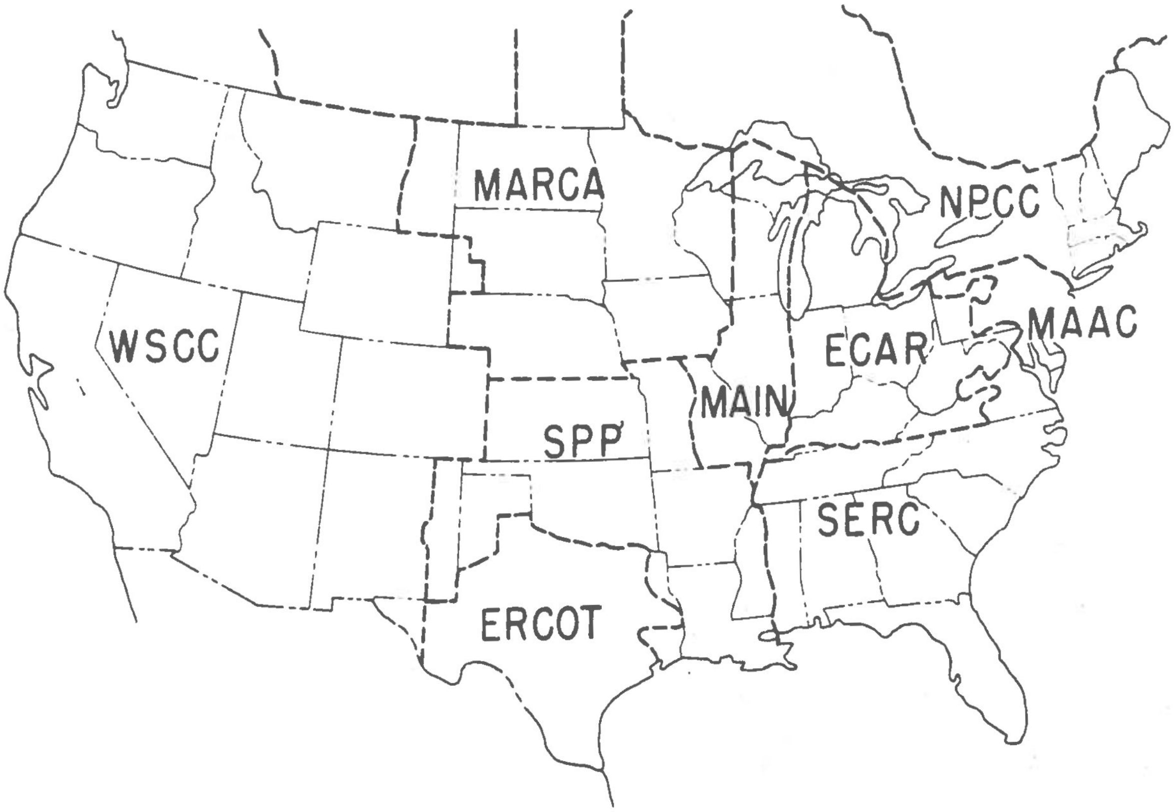
TUDOR ENGINEERING COMPANY FIGURE II-3



COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

LOWER BASIN
CACHE LA POUDRE RIVER

TUDOR ENGINEERING COMPANY
FIGURE II-4



NPCC - NORTHEAST POWER COORDINATING COUNCIL
MAAC - MID ATLANTIC AREA COUNCIL
ECAR - EAST CENTRAL AREA RELIABILITY COORDINATION AGREEMENT
SERC - SOUTHEASTERN ELECTRIC RELIABILITY COUNCIL
MAIN - MID-AMERICA INTERPOOL NETWORK
MARCA - MID-CONTINENTAL AREA RELIABILITY COORDINATION AGREEMENT
SPP - SOUTHWEST POWER POOL
ERCOT - ELECTRIC RELIABILITY COUNCIL OF TEXAS
WSCC - WESTERN SYSTEMS COORDINATING COUNCIL

COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

RELIABILITY
COUNCIL REGIONS

TUDOR ENGINEERING COMPANY FIGURE: II-5

COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

WESTERN SYSTEMS COORDINATING COUNCIL REGIONS

TUDOR ENGINEERING COMPANY FIGURE: II-6

CHAPTER III
HYDROLOGY AND WATER RIGHTS

A. INTRODUCTION

This chapter contains a discussion of the hydrology of the water supply for the Cache la Poudre River Basin, as well as inflow design flood estimates and sediment production estimates which are essential to the planning of facilities for a potential Cache la Poudre Project. It also contains a discussion of the water rights considerations involved in the management of the water supply. This material is intended to provide a basis for projecting future water supply and its management with and without a potential Cache la Poudre Project.

B. WATER SUPPLY HYDROLOGY

1. General

Hydrology is the study of the occurrance and distribution of water and is used in the planning, design and operation of water resource projects. As part of this study, a hydrological analysis was performed with historic precipitation, streamflow, and reservoir operation records for the purpose of estimating the future availability of water within the basin.

As noted in Chapter II, the bulk of the total water supply for the Cache la Poudre Basin is produced by native waters from rainfall and snowmelt in the upper basin catchment area and by importation of water from adjacent river basins. The remaining water supply is produced by rainfall and snowmelt in the lower basin and by groundwater inflow into the lower basin. The availability of water from the upper basin as measured at the mouth of the canyon represents the developable flows for a potential Cache la Poudre Project.

The catchment area of the upper basin of the Cache la Poudre River above the mouth of the canyon is shown on Figure III-1. The location and periods of record of all gages used in the analysis of the upper basin catchment; including streamgages, gages on transbasin import facilities and gages on the major diversion facilities in the upper basin, are also shown on Figure III-1.

2. Recorded Annual Flows

a. Mouth of the Canyon

A plot of the annual streamflows as measured at the mouth of the canyon is shown on Figure III-2. The measured streamflows include effects of transbasin imports, diversions out of the upper basin, consumptive uses in the upper basin, and regulation due to existing storage reservoirs. Referring to Figure III-2, a period of high flows is evident, beginning in 1890 and ending in 1923. Following this period the average annual recorded streamflow diminished greatly to a period of lower flows during the years from 1924 through 1980.

b. Transbasin Imports

The plot of the annual imports of Laramie, Michigan, and Colorado River Basin water to the upper basin is shown in Figure III-3. The total annual imports increased rapidly from zero in 1894 to a peak of 68,000 acre-feet in 1938. Then imports decreased drastically and rapidly to a much lower level in 1940. The lower levels were due to decreased facility capacity caused by reduced maintenance of these facilities. The average of all trans-basin imports to the headwaters of the Cache la Poudre River Basin has been only 37,000 acre-feet per year since 1953, when the Colorado-Big Thompson Project first imported water to the Cache la Poudre system. The Colorado-Big Thompson Project has imported, on the average, 89,300 acre-feet per year into the lower basin for the period 1953 through 1981 as shown in Figure III-4.

c. Major Upstream Diversions

An estimate of the total annual recorded flows from the four major diversions in the upper basin which divert water from the upper basin above the mouth of the canyon are shown in Figure III-5. The diversions into the irrigation canals are recorded only during the irrigation season. In some years a minor amount of unrecorded flow is diverted to storage in lower basin reservoirs outside the irrigation season. This winter diversion is minor in comparison to the total annual flow.

d. Consumptive Uses

The major man-made consumptive uses of water in the upper basin which affect the recorded streamflows are due to the evaporation from reservoirs and irrigation along the floodplains and terraces. It is estimated that the increased consumptive use due to man-made lakes and irrigation in the upper basin is less than 5,000 acre-feet per year, which is considered to be minor in comparison to annual flows.

e. Effects of Regulation

Effects on the annual streamflows due to upper basin reservoir regulation were estimated through an analysis of available reservoir operation records. The analysis of major upper basin reservoir regulation records demonstrated their use to be one of retaining spring runoffs and imported waters for use later in the irrigation season. Therefore, the effect on the measured annual streamflow due to such regulation was determined to be minor.

3. Derivation of Annual Native Flows

An estimate of the annual native flow at the mouth of the canyon was made by adjusting the recorded streamflow by adding the measured amount diverted from the upper basin via the North Poudre Canal, North Poudre Supply Canal, Poudre Valley Canal, and the Fort Collins Pipeline and subtracting the amount imported into the upper basin through the transbasin import facilities to the west. The consumptive uses and effects of regulation assumed to be minor were not included in the adjustment. The resulting flows are plotted in Figure III-6.

The derived annual native flows exhibit the same general trends as do the recorded annual flows discussed earlier in this Chapter. The early period, prior to 1905, is "wet". Then the records move through a transition to a dryer period beginning in 1925. The estimated native flows for the dryer period, represented by the 56-years from 1925 to 1980, averaged 271,000 acre-feet per year.

4. Selection of the Hydrologic Study Period

It appears that the Cache la Poudre River is still in a period of a long cycle which is "dryer" than normal. As long-term climatic changes are not predictable, it is prudent to select the long, dry period as the norm for any study. Thus, the statistics for the estimated native flow at the mouth of the canyon from 1925 through 1980 have been assumed in this study to represent what future native flows from the upper basin will be.

Since a 56-year record is exceedingly long for the purposes of reconnaissance level reservoir operation studies, a shorter period, 1949 through 1971 was selected as representative of the long term conditions. Called the hydrologic study period, this 23-year portion of the total record also has an average annual estimated native flow of 271,000 acre-feet. Along with the average annual flow, the shorter 23-year hydrologic study period exhibits other statistical characteristics similar to the longer 56-year period. The hydrologic study period also contains the driest year of record, 1954, for which the estimated native flow at the mouth of the canyon was only 121,000 acre-feet, and the driest four consecutive years of record, 1953 through 1956.

5. Derivation of Monthly Native Flows

Native streamflow at streamgaging stations in the upper basin and at all existing and potential damsites considered in this study were estimated for the hydrologic study period by correlation with the flow records at the streamgages within the basin. The correlations were done using HEC-4, the U.S. Army Corps of Engineers' generalized computer program for streamflow simulation.

The native streamflows were derived as monthly flows and extrapolated as necessary to the length of the study period. In determining the streamflows at the existing reservoirs and potential damsites, consideration was given to the relation between annual precipitation; the size, shape, orientation and elevation of the watershed; and direction of storm movement. The correlations with the HEC-4 model produced monthly values for the length of the study period for each existing reservoir and potential damsite. The monthly flow records and results of these derived streamflows are available in computer files.

6. Future Water Supply

The future water supply developable by a potential Cache la Poudre Project will consist of native flows at the mouth of the canyon and upper basin transbasin imports. The total future surface water supply available for conservation purposes in the lower basin will consist of these developable flows, transbasin imports delivered through the Colorado-Big Thompson Project facilities, useable return flows, some Big Thompson River flows, rainfall and snowmelt in the lower basin, and groundwater inflow into the lower basin.

An average of 271,000 acre-feet per year of developable native flows is estimated to be available in the future from the upper basin catchment. An estimate of these native flows at the mouth of the canyon was made on a monthly basis using historic data for the hydrologic study period as described earlier in this Chapter.

An average of 37,000 acre-feet per year of developable flow is estimated to be available in the future from upper basin transbasin imports. It was assumed these flows would be available on the same monthly basis as were historic flows during the hydrologic study period. Transbasin imports into the upper basin could be increased in the future with rehabilitation of the two ditches not now in operation, increased maintenance of the other ditches or the development of additional storage. It is estimated that such an increase could add from 5,000 to 10,000 acre-feet per year to the water supply in the Cache la Poudre Basin. This possibility is primarily one of economics of maintaining the ditches or building the storage, and was not considered as part of the future water supply during this study.

Water deliveries through the Colorado-Big Thompson facilities are assumed to continue along with the future supply from the Windy Gap Project presently under construction. The Windy Gap Project is scheduled for completion in this decade. Discussions with officials from the U.S. Bureau of Reclamation indicate that an annual average of 115,000 acre-feet of water will be delivered into the lower basin from these two projects in the future. It was assumed that this water would be available on demand on a monthly basis according to historical agricultural and municipal and industrial uses.

Return flows from the Fort Collins treatment plant will continue to be available for subsequent uses. The amount available is estimated to average 65 percent of the total supplied to the city. The Rawhide Power Plant uses will be fully supplied by this water with the remainder available for agricultural uses according to the historic monthly use pattern. Return flows from the City of Greeley pass out of the basin and, therefore, are not considered as part of the future available supply.

The cities of Windsor and Greeley have water rights for use of water from the Big Thompson River. In 1981 the City of Greeley used approximately 9,000 acre-feet of water from the Big Thompson River. It is anticipated that as the City of Greeley grows an increasing amount of water will be available to them from this source on a monthly basis.

The amount of rainfall and snow melt in the lower basin is small in relation to the total water supply and is accounted for in this study as being available to meet future agricultural uses directly.

Discussions with U.S. Geological Survey staff indicate that ground-water flow into the lower basin is minimal and, therefore, is not included as a potential future source of water supply in this study.

There is the possibility of additional water being available to the Cache la Poudre River Basin in the future from additional runoff from forest management plans [4]. This has been estimated to be about 2,600 acre-feet per year for that portion of the national forest lying within the basin. Since this additional yield is speculative and minor in comparison to the total basin yield, it was not considered as part of the future water supply during this study.

In summary, the average annual future developable water supply at the mouth of the canyon for a potential Cache la Poudre Project would consist of 271,000 acre-feet of native flows and 37,000 acre-feet of transbasin imports. In addition, the total annual average water supply for the Cache la Poudre service area would include 115,000 acre-feet of water from the combined Colorado-Big Thompson Project and Windy-Gap Project, an increasing amount of return flows from Fort Collins and an increasing amount of water from the Big Thompson River.

C. INFLOW DESIGN FLOODS

The inflow design floods for potential dams considered as part of this study were determined from an envelope curve of flood peak versus drainage area which is shown in Figure III-7. The curve was determined from the record of all measured major flood peaks along the front range and piedmont in Colorado and some inflow design flood values developed for existing reservoirs in the Cache la Poudre area.

By inspecting the information in Figure III-7, an envelope curve with a Creager's C of 150 was chosen for preliminary planning of all potential dam-sites except for the New Seaman Dam and inflow design flood peaks which were estimated based on the area above the potential damsite. (The inflow design flood for New Seaman Dam was developed during recent studies by International Engineering Company [28]). The resulting values were used in sizing and estimating costs of spillways for the potential dams. The difference in the cost of the spillways designed to carry different peak flood discharges (obtained by using different values of C) was determined to be minimal when considering the accuracy of designs and cost estimates at the level of detail being employed in this study.

The inflow design floods for the major reservoirs considered in the study are as follows:

Grey Mountain Dam	- 592,000 cubic feet per second
New Seaman Dam	- 274,000 cubic feet per second
Elkhorn Dam	- 386,000 cubic feet per second
Indian Meadows Dam	- 298,000 cubic feet per second
Rockwell Dam	- 172,000 cubic feet per second
Idylwilde Dam	- 276,000 cubic feet per second
Upper Poudre Dam	- 165,000 cubic feet per second

D. SEDIMENT

The sediment yield from the catchment of the North Fork of the Cache la Poudre River has been collecting in the Milton Seaman Reservoir since 1948 and in Halligan Reservoir since 1910. The catchment area of the former is 566 square miles and the latter 326 square miles. In 1977, it was reported by International Engineering Company that a 1976 study indicated Milton Seaman Reservoir was 25 percent full of sediment. This is a reservoir reduction rate of approximately 0.2 acre-feet per year per square mile of contributing catchment area. Estimates of the sedimentation rate in Halligan were not available.

The sediment yield in the South Fork and mainstem of the Cache la Poudre River is probably less than that of the North Fork. Most of the runoff is from snowmelt in the high country and the mainstem and South Fork catchments are either well vegetated or rocky. An estimate of 0.1 acre-feet per square mile per year was made by the U.S. Bureau of Reclamation in 1965 in the study of the potential Idylwilde Reservoir on the mainstem.

For this reconnaissance study, the following reservoir sedimentation rates have been assumed:

- For large storage dams on the South Fork and mainstem, the sedimentation rate will be 0.1 acre-feet per year per square mile of contributing area.

- For large storage dams on the North Fork, the sedimentation rate will be 0.2 acre-feet per year per square mile of contributing area.

Sediment deposition does not pose a significant problem as a relatively small storage space allocation could be made to permit 100 years of accumulation without impairing planned conservation storage.

E. WATER RIGHTS CONSIDERATIONS

1. General

The right to use surface waters in Colorado is governed, in the first instance, by the Colorado Constitution, which establishes the doctrine of prior appropriation, often described as the principle of "first in time, first in right". This doctrine provides that he who first puts a water source to a beneficial use may establish the first or prior right to its future use.

Water courts then issue decrees which evidence one's right to divert and beneficially use water under a specified priority.

The State Engineer is charged with the administration of the surface waters of the State according to the appropriation doctrine to insure their proper division among the many water users. It is the State Engineer's duty to strictly follow the decrees of the courts and to deliver water to those so entitled under the priority system. All river headgates are supervised, controlled and administered through Division Engineers. Water Division No. 1 encompasses the South Platte River basin. The Cache la Poudre River basin is located in former Water District No. 3 and is still frequently referred to as such.

In the administration of water rights, the State Engineer is charged under state statute with facilitating "maximum water utilization." In addition to adjudicated water rights, the State Engineer is provided with certain administrative options to achieve this. These mechanisms may be utilized to provide administrative flexibility as long as adjudicated water rights are not injured thereby.

2. Storage Decrees

As is shown subsequently in this report, all alternative projects considered in this study provide for a terminal storage facility. This terminal reservoir would have to release water on demand to senior rights downstream.

Several upstream reservoirs were also considered. The upstream facilities would be required to release water to the intervening water rights within the upper basin. It has been assumed for the purpose of this study that bypass flows will be required for fisheries and other environmental purposes in order to obtain various federal permits. Those releases, as a practical matter, may exceed the needs of intervening water rights and thus adequately provide for them. On this basis, all significant water rights implications tend to concern only the operation of the terminal reservoir.

In May 1980, the Cache la Poudre Water Users Association filed for a conditional water right for 220,000 acre-feet of storage at the Grey Mountain Reservoir site and for 180,000 acre-feet of storage at the Idylwilde Reservoir site. Grey Mountain is one of the three terminal reservoir sites analyzed in this study. The other two terminal storage sites, Elkhorn Reservoir and New Seaman Reservoir, have not been filed upon. The Elkhorn and New Seaman sites then would have an appropriation date no earlier than 1983 (assuming the Grey Mountain appropriation would not be transferable to one of these two sites).

With certain exceptions, conditional storage rights for the upstream reservoirs have yet to be obtained as well. Thus, they too could obtain appropriation dates no earlier than 1983 (assuming the Idylwilde appropriation would not be transferable to any of the other upstream sites).

The potential yield derived from the storage of flows surplus to those needed to satisfy existing, more senior rights under such junior priority dates may be relatively small. The yield of these water rights is dependent on the disposition of other, more senior conditional decrees, including those for diversion and storage on the lower South Platte River. Table III-1 lists the more important conditional decrees affecting the project.

The storage yield from the decreed water rights is that water which may be legally stored on its own priority and delivered to new beneficial uses within the basin. It differs from "new water" supply as considered in the operation studies, which is water that may be detained out of priority in project reservoirs and subsequently released to serve existing downstream water rights. Nonetheless, such "new water" detained can still provide hydroelectric power and can potentially be used for exchanges.

When considering the effect of a lower South Platte Project decree, a range of assumptions may be made concerning the possible yield of a terminal storage reservoir. The conservative assumption is that a lower South Platte River reservoir senior conditional decree will be exercised (e.g., the Narrows Project). The optimistic assumption is that the major lower South Platte River reservoir conditional decrees will never be made final. In this preliminary study, it is prudent to make the less optimistic assumption -- that the Cache la Poudre project storage rights will be junior to the storage rights of a major lower South Platte reservoir project. Results of investigations during the study show that the effect of a lower South Platte Reservoir Project on a Cache la Poudre Project would be negligible.

3. Decreed Alternate Point of Storage

The desirability of having water which is now stored in off-channel facilities stored in a terminal storage facility in the future is primarily a function of the geographic location of the off-channel facility. For example, the mountain reservoirs which lie in the upper basin upstream from a potential terminal reservoir are, because of their beneficial position and generally high level of utilization, not considered to be likely sources for a transfer.

Lower basin reservoirs which are filled primarily with direct mountain runoff diverted from the mainstem or the North Fork are prime candidates for transfer to alternate points of diversion and storage. They represent most of the reservoirs with which historic exchanges were originally made. The effective yield of many of these off-channel reservoirs are now limited by sedimentation, canal capacity, seepage, and high evaporation. The majority of these lower basin reservoirs lie on the north side of the river below the North Poudre Supply/North Poudre Canals and above the Larimer and Weld Canal.

On the other hand, lower basin reservoirs which lie below the Larimer and Weld Canal are filled primarily by return flows from irrigation and the City of Fort Collins. They can continue to operate in this manner in the future since this is essential to the efficient management of the basin's water supply.

TABLE III-1
CACHE LA POUDRE PROJECT
IMPORTANT CONDITIONAL DECREES

Structure	Source	Amount (Ac-Ft)	Adjud. Date	Approp. Date	Remarks
SOUTH PLATTE BASIN:					
Narrows Reservoir	South Platte River	718,147	Jul. 1970	Aug. 1957	
Hardin Reservoir	South Platte River	350,570	Mar. 1970	Jun. 1963	Contested
Narrows Reservoir	South Platte River	100,000	Jun. 1978	Jul. 1975	Portion of Larger Scheme; 15 Additional Structures
Hardin Reservoir	South Platte River	841,500	Pending	Dec. 1981	
CACHE LA POUDRE BASIN:					
Little South Fork Reservoir	South Fork Cache la Poudre River	4,550	Dec. 1972	Aug. 1962	Common Site with Rockwell Res

TABLE III-1
CACHE LA POUDRE PROJECT
IMPORTANT CONDITIONAL DECREES

Structure	Source	Amount (Ac-Ft)	Adjud. Date	Approp. Date	Remarks
Rockwell Reservoir	South Fork Cache la Poudre River	4,900	Dec. 1977	Oct. 1951	
Sheep Creek Reservoir	Sheep Creek	532	Aug. 1979	Dec. 1977	Utilizes Exchange Rights
Grey Mountain	Cache la Poudre River	220,000	Pending	May 1980	
Idylwilde Reservoir	Cache la Poudre River	180,000	Pending	May 1980	

For purposes of simulating a Cache la Poudre Project operation, it is preferable to use the concept of decreed alternate points of diversion for lower basin reservoir storage rights rather than an outright transfer. This would permit storage at either the existing or new site at the discretion of the owner, thus allowing him considerable flexibility in handling future physical and water right limitations. With a court decree, a project terminal storage reservoir could be operated as an alternate point of storage or detention in the same manner as the upper basin reservoirs are presently physically administered.

Table III-2 provides a preliminary list of reservoirs lying above the Larimer and Weld Canal which are considered suitable for alternate storage at a project terminal storage reservoir. It is assumed approximately 50 percent, or about 50,000 acre-feet of the approximately 100,000 acre-foot total presented in the table, could be transferred. In addition to the decreed primary capacity listed in the table, many of these reservoirs have conditional refill decrees that could possibly be made absolute under alternate point use.

4. Administrative Options

In addition to decreed storage rights and decreed alternate points of storage, administrative options are available to facilitate maximum water utilization. These include out-of-priority storage, exchanges and substitutions of water. Within the Cache la Poudre Basin, these options have long been used to a high degree of refinement.

5. Assumptions

As a result of discussions with the Assistant Division Engineer and water users in the basin, it was concluded that, for this preliminary level of study, the operation of a Cache la Poudre Project could best be simulated by assuming the concept of administrative options, such as out-of-priority storage and exchanges, would be utilized. The water users indicated that if a Cache la Poudre Project were developed, they would work together to ensure efficient operation within the constraints of the water rights priority system.

The use of this concept in the operation studies results in a yield of "new water" that would be lost to the basin in absence of a project. This yield of "new water" is expected to be greater than the storage yield from decreed water rights for the terminal storage reservoir. Under this concept, all available water would be stored in the terminal reservoir until required to be released to serve water users on demand.

TABLE III-2
CACHE LA POUDRE PROJECT
RESERVOIRS SUITABLE FOR ALTERNATE POINTS OF STORAGE

Reservoir Name	Owner	Capacity Decreed (Ac-Ft)	Capacity Surveyed (Ac-Ft)	Source	Use
1. North Poudre #2 (Demmel Lake)	North Poudre Irrigation Company	3,880	3,910	North Fork & Munroe	Equating Storage
2. North Poudre #3	"	3,613	3,441	"	"
3. North Poudre #4 (Wellington #4)	"	1,781	1,669	"	Equating Storage & Fish & Game
4. North Poudre #5 (Bee Lake)	"	9,412	8,398	Munroe	Release to Larimer County Canal
5. North Poudre #6	"	11,134	9,968	"	"
6. North Poudre #15	"	5,463	5,517	North Fork	Equating Storage
7. Reservoir #8	Windsor Reservoir & Canal Company	10,291	10,281	Mainstem & Poudre Valley Canal	Release to Larimer & Weld Canal
8. Reservoir #8 Annex	"	3,090	3,037	"	"
9. Clarks Lake	North Poudre Irrigation Company	1,096	871	North Fork & Munroe	Equating Storage
13. Cobb Lake	Windsor Reservoir & Canal Company	20,451	22,300	Mainstem, Poudre Valley Canal & North Poudre Canal	Release to Larimer & Weld Canal

TABLE III-2
CACHE LA POUDRE PROJECT
RESERVOIRS SUTABLE FOR ALTERNATE POINTS OF STORAGE

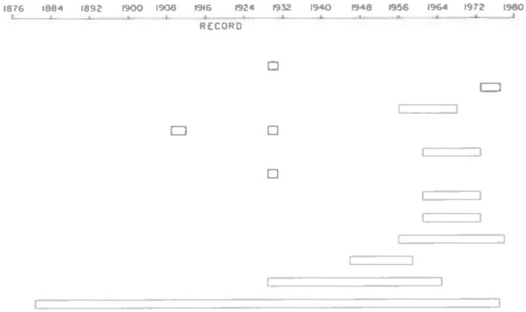
Reservoir Name	Owner	Capacity Decreed (Ac-Ft)	Capacity Surveyed (Ac-Ft)	Source	Use
14. Douglas	Windsor Reservoir & Canal Company	10,560	9,364	Mainstem & Poudre Valley Canal	Release to Larimer County Canal
15. Water Supply & Storage No. 3	Water Supply & Storage Company	4,750	4,826	Mainstem & Larimer County Canal	Release to Larimer & Weld Canal
16. Kluver	"	1,562	1,503	"	"
17. Long Pond #5	"	4,037	4,083	"	"
18. Larimer & Weld (Terry Lake)	Larimer & Weld Reservoir Company	9,757	8,028	Mainstem & Little Cache la Poudre Canal	"
Total:		100,877	97,196		


MATCHLINE
N
STATION LETTER
A
B
C
D
E
F
G
H
I
J
K
L
WYOMING
COLORADO
Eaton Reservoir
S
CATCHMENT BOUNDARY
Panhandle Reservoir
Halligan Reservoir
NORTH
FORK
U
R
Q
CACHE
LA
POUDRE
D
J
RIVER
Milton Seaman Reservoir
W
X
V
L
P
Twin Lakes Reservoir
A
O
Chambers Lake
Barnes Meadow Reservoir
G
H
I
RIVER
F
Comanche Reservoir
Hourglass Reservoir
CATCHMENT BOUNDARY
Joe Wright Reservoir
B
E
SOUTH FORK CACHE LA POUDRE
M
N
ROCKY
MOUNTAIN
Long Draw Reservoir
T
NATIONAL
PARK

PLAN

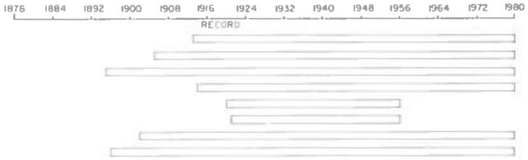
STREAMFLOW GAGING STATIONS UPSTREAM FROM MOUTH OF THE CANYON

STATION NO.	STATION	DRAINAGE AREA, mi^2
	CACHE LA POUDRE BASIN	
674500	CACHE LA POUDRE RIVER ABOVE CHAMBERS LAKE OUTLET	89.2
674610	JOE WRIGHT CREEK NEAR CAMERON PASS	5.05
674750	CACHE LA POUDRE RIVER NEAR RUSTIC	199.
674800	CACHE LA POUDRE RIVER NEAR LOG CABIN	230
674820	FALL CREEK NEAR RUSTIC	3.64
674850	SOUTH FORK CACHE LA POUDRE NEAR EGGERS	69.8
674851	LITTLE BEAVER CREEK NEAR IDYLWILDE	0.89
674853	LITTLE BEAVER CREEK NEAR RUSTIC	12.3
674860	SOUTH FORK CACHE LA POUDRE NEAR RUSTIC	90.3
674900	CACHE LA POUDRE RIVER BELOW ELKHORN CREEK	404
675150	NORTH FORK CACHE LA POUDRE NEAR LIVERMORE	568
675200	CACHE LA POUDRE RIVER NEAR MOUTH OF CANYON	1055



TRANSMOUNTAIN DIVERSIONS INTO CATCHMENT UPSTREAM FROM MOUTH OF THE CANYON

STATION LETTER	STATION NO.	STATION
M	674550	CAMERON PASS DITCH
N	674600	MICHIGAN DITCH [1]
O	674650	SKYLINE DITCH
P	674700	LARAMIE-POUDRE TUNNEL
Q	674720	BOB CREEK DITCH
R	675000	COLUMBINE DITCH
S	675050	WILSON SUPPLY DITCH
T	901000	GRAND RIVER DITCH



[1] PUBLISHED AS RISK AND McNAB DITCH 1904-1912

non

DIVERSIONS FROM CATCHMENT UPSTREAM FROM MOUTH OF THE CANYON

STATION LETTER	STATION
U	NORTH POUDRE CANAL
V	POUDRE VALLEY CANAL
W	FT COLLINS PIPELINE
X	NORTH POUDRE SUPPLY CANAL

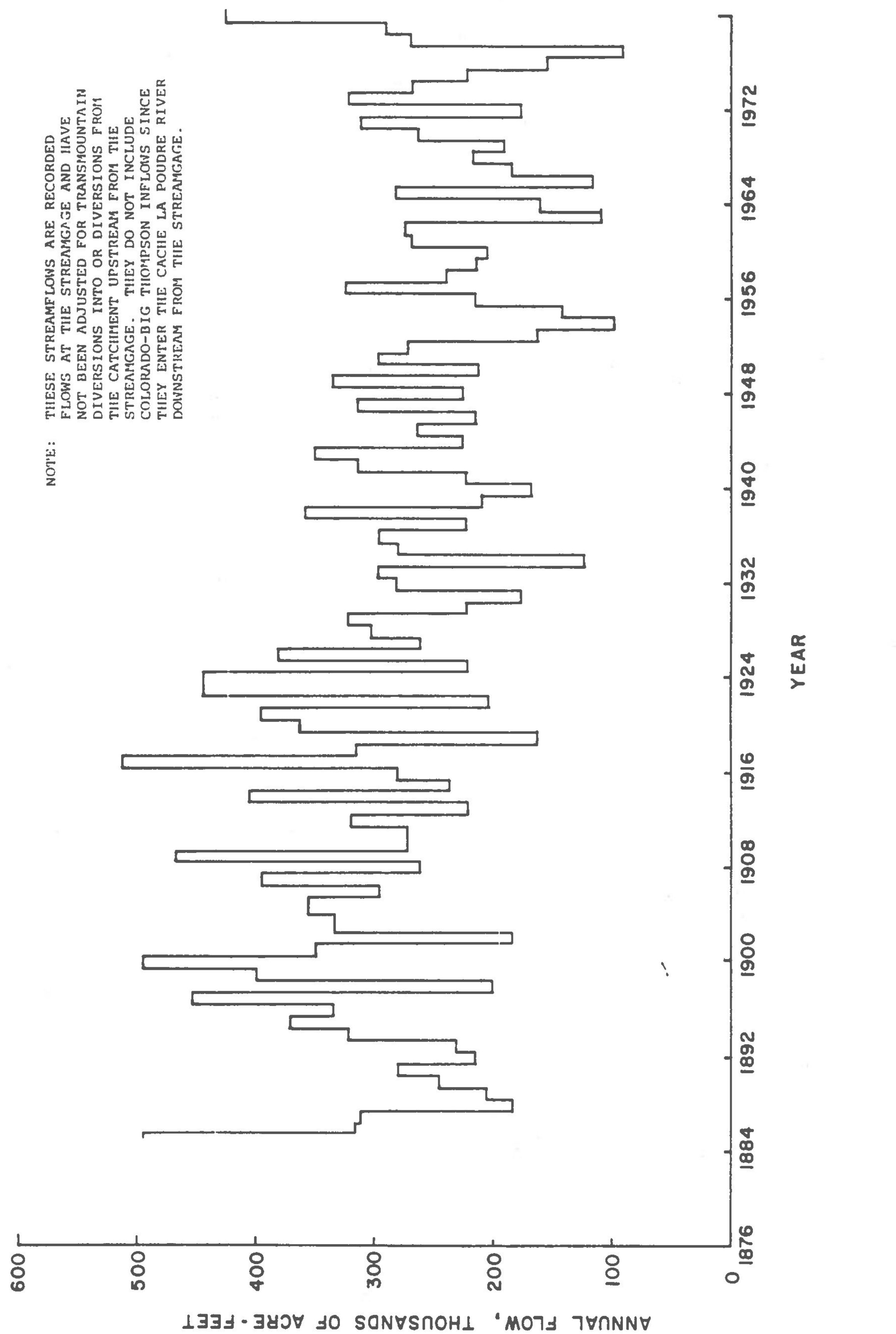
2 1 0 2 4 6
APPROXIMATE SCALE IN MILES

COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

CACHE LA POUDRE RIVER CATCHMENT UPSTREAM FROM MOUTH OF THE CANYON

TUDOR ENGINEERING COMPANY

FIGURE III-1



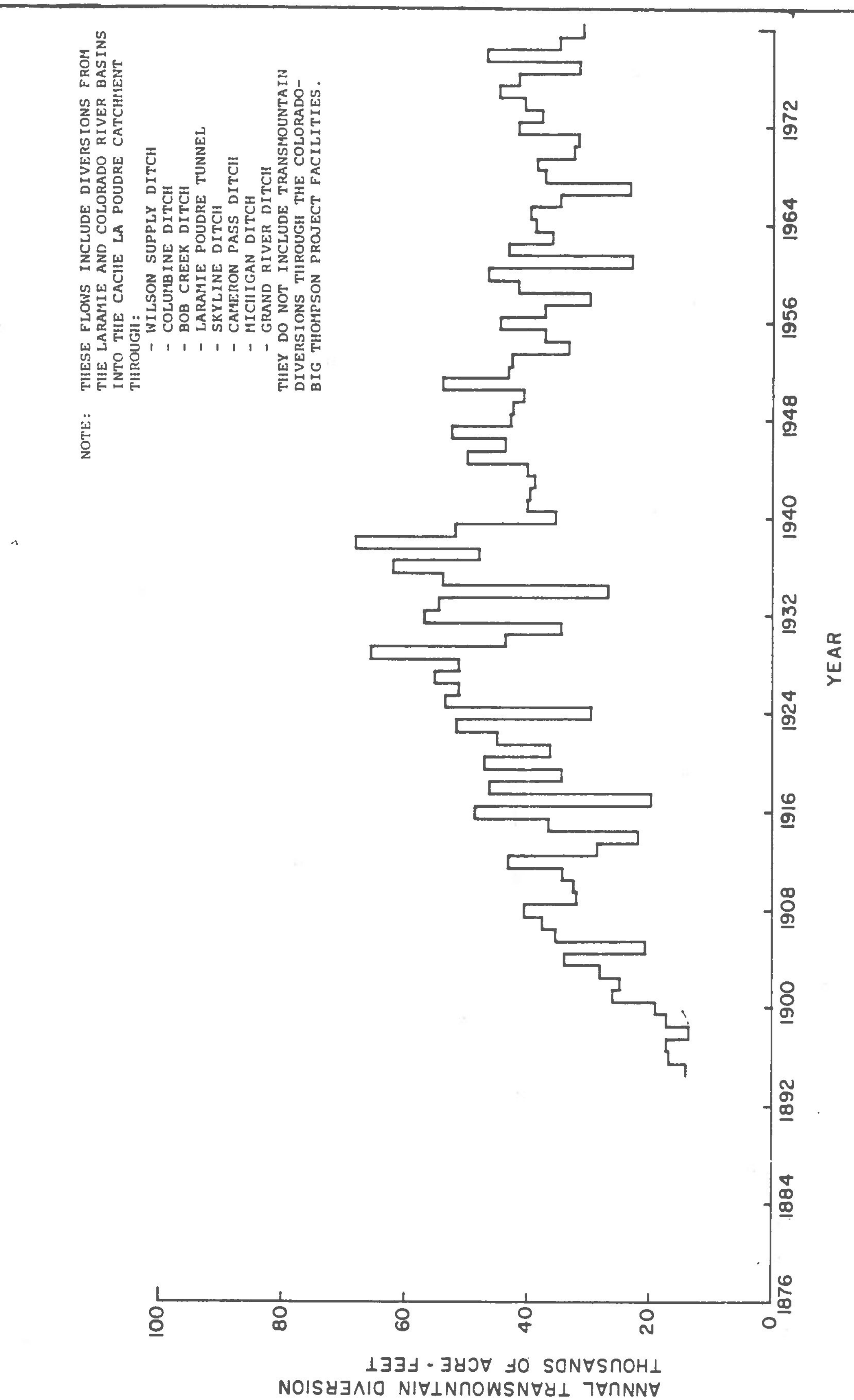
COLORADO WATER CONSERVATION BOARD

CACHE LA POUDRE PROJECT

RECONNAISSANCE STUDY

RECORDED ANNUAL STREAMFLOW AT MOUTH OF THE CANYON

TUDOR ENGINEERING COMPANY FIGURE III-2



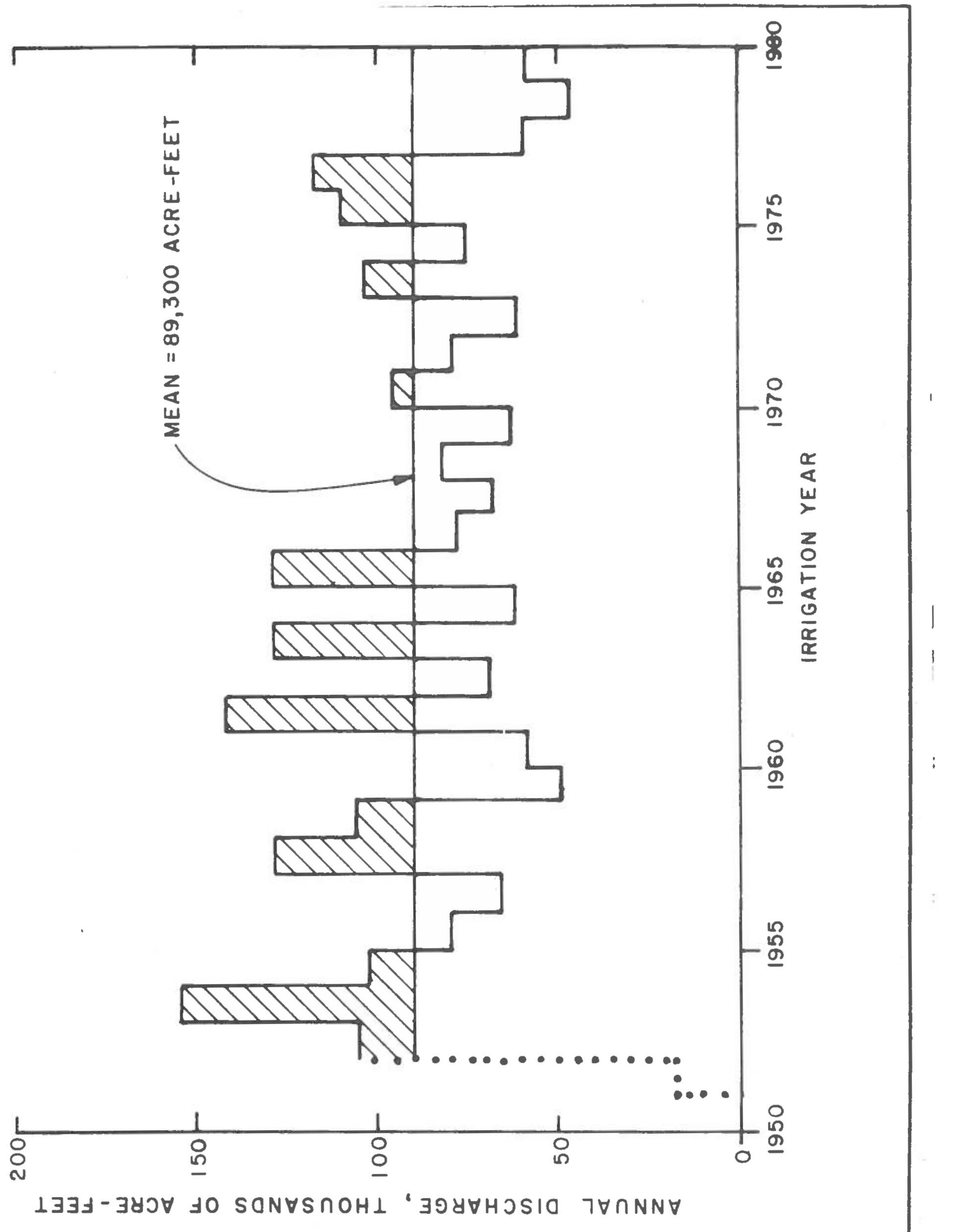
COLORADO WATER CONSERVATION BOARD

CACHE LA POUDRE PROJECT

RECONNAISSANCE STUDY

TRANSMOUNTAIN DIVERSIONS INTO UPSTREAM CATCHMENT FROM MOUTH OF THE CANYON

TUDOR ENGINEERING COMPANY FIGURE: III-3

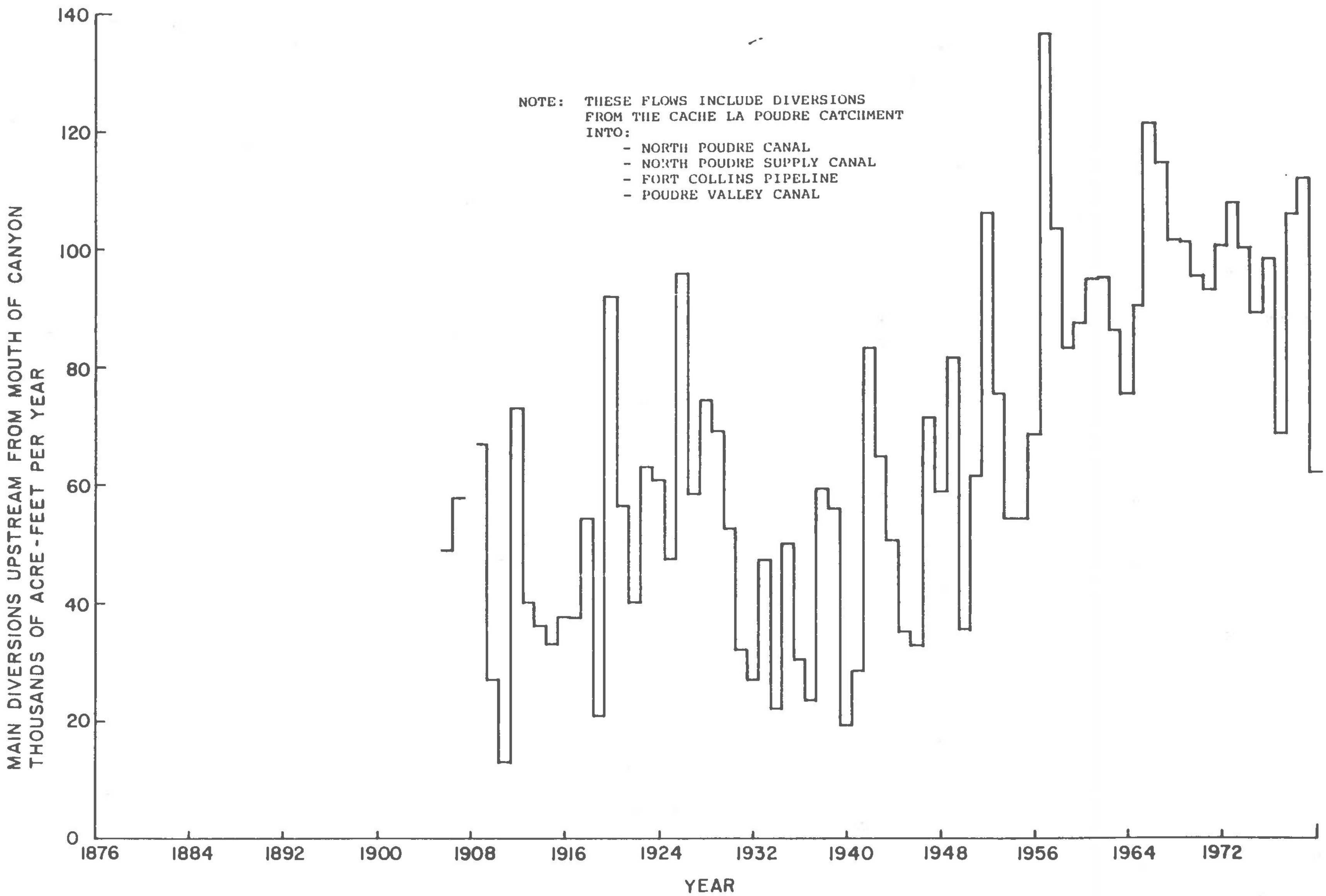


COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

COLORADO-BIG THOMPSON PROJECT ANNUAL DELIVERY TO BASIN

TUDOR ENGINEERING COMPANY

FIGURE: III-4

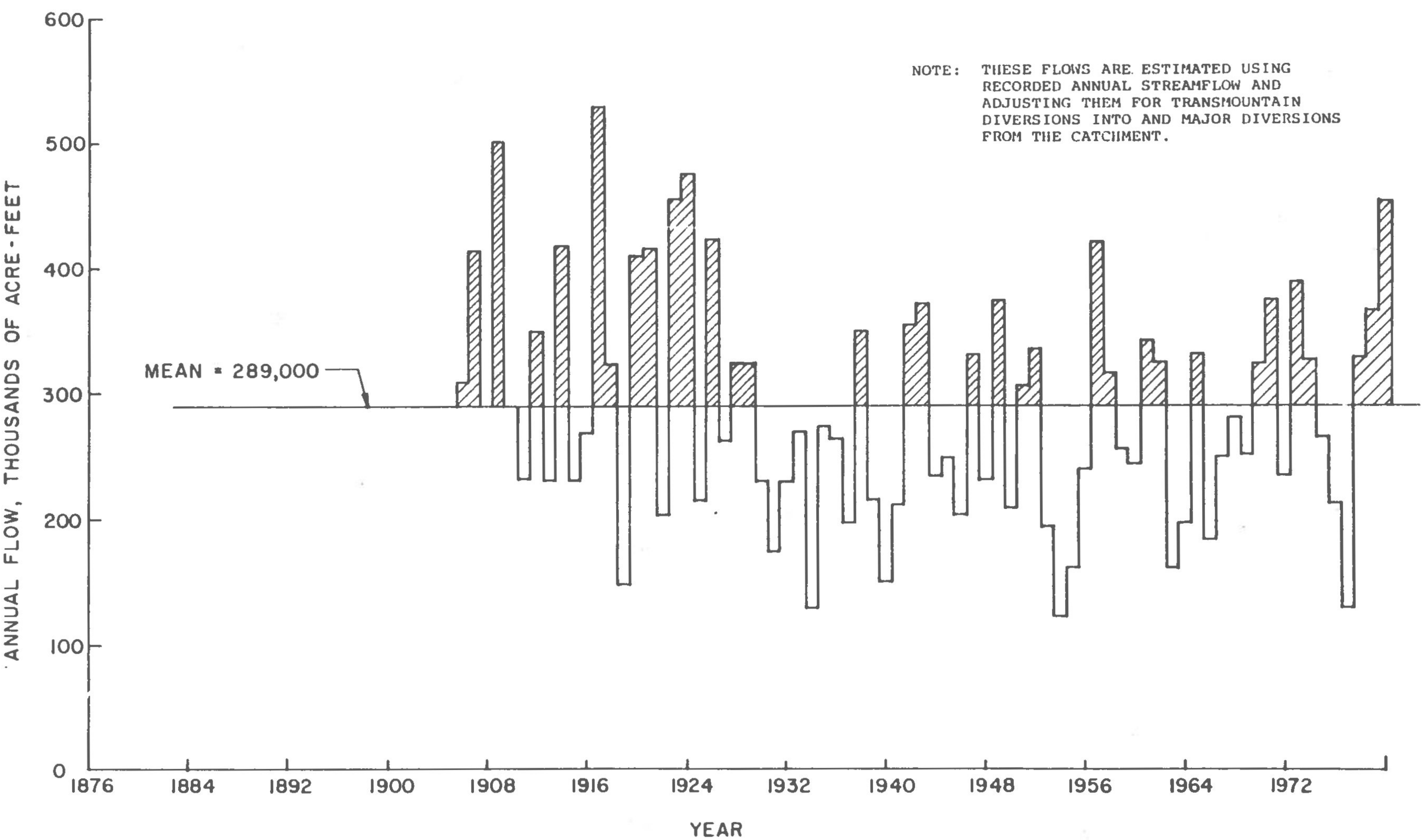


COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

MAJOR DIVERSIONS FROM UPSTREAM CATCHMENT FROM MOUTH OF THE CANYON

TUDOR ENGINEERING COMPANY

FIGURE: III-5

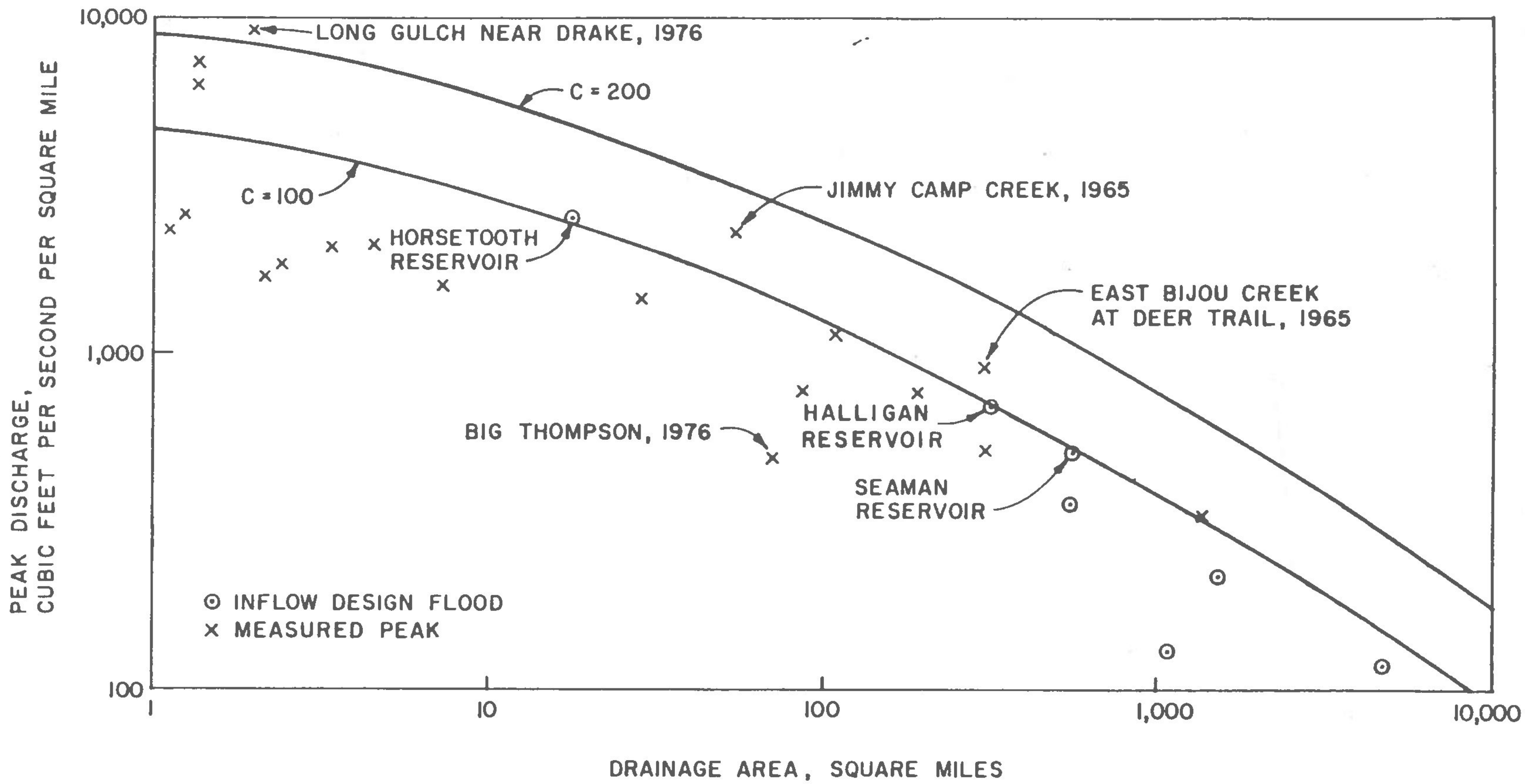


COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

NATIVE FLOWS AT
MOUTH OF THE CANYON

TUDOR ENGINEERING COMPANY

FIGURE: III-6



$$Q = 46CA^{(0.894A^{-0.048})}$$

IN WHICH

Q = PEAK DISCHARGE, CUBIC FEET PER SECOND
C = CREAGER'S C, A COEFFICIENT CHARACTERISTIC OF THE GIVEN DRAINAGE BASIN
A = DRAINAGE AREA, SQUARE MILES

COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

INFLOW DESIGN FLOODS

TUDOR ENGINEERING COMPANY

FIGURE: III-7

CHAPTER IV
FUTURE WATER RESOURCES MANAGEMENT

A. INTRODUCTION

This chapter contains an analysis of future water resource use and management in the Cache la Poudre River Basin. The analysis includes projections of future agricultural, municipal and industrial uses and a discussion of opportunities for improving the management of presently developed water supplies (i.e., water presently diverted or stored at or below the mouth of the canyon). As a part of the analysis, the potential demand for hydroelectric power is explored.

B. POPULATION PROJECTIONS

As a basis for estimating future water use in the Cache la Poudre basin, projections of future population within the service area were developed. Several estimates have been made by others of the future population of Larimer and Weld Counties, the cities of Fort Collins and Greeley, and related municipal water service areas. Most of the available projections extend only to the year 2000. This is to be expected since twenty years covers most immediate planning horizons and the accuracy of any projection diminishes as it lengthens. However, the long-lived nature of water projects - 100 years or more - supports the use of a much longer planning horizon. Projections made in this report cover the fifty year period, 1980-2030. The State of Colorado Division of Planning Projections to 2010 [5] and the U.S. Corps of Engineers estimates to 2020 are therefore of particular interest [6].

Except for the U.S. Corps of Engineers projections, which were completed prior to the rapid growth of the 1970's and consequently seem much too conservative, the growth trends of the available projections appear to cluster. This provides a general framework for development of a range of projections. The analysis and selection of compound growth rates were the most critical factors in deriving the projections.

Given the uncertainties of future growth, it is prudent to examine a range of population projections. Therefore, low, medium, and high population scenarios were developed in this study.

Considering the available data from the cities of Greeley and Fort Collins and the State Demographer's office, the use of a growth rate approximating four percent through year 2000 was a reasonable representation of the high scenario. Beyond that point in time, this relatively high growth rate was dampened by a half percent each decade to two percent in year 2030 to avoid abrupt changes and to "smooth out" the plotted growth curve.

To establish the lower bounds of the population scenarios, the rate of estimated changes from 1980 through 2010 were taken directly from the State Demographer's estimates. General growth trends contained in the State's "low" projections for Larimer and Weld County populations were applied to the 1980 water service area populations. These rates of growth were 3.1 percent for 1980-1990, 2.6 percent for 1990-2000, and 2.0 percent for the final period shown for 2000-2010. The latter rate was assumed in this analysis to hold until 2030.

The medium projection represents the mid-point between the high and low scenarios. This produced average growth rates for Fort Collins and Greeley of 3.5 percent to year 2000, 2.6 percent from 2000-2010, 2.4 percent from 2010-2020, and 2.0 percent from 2020-2030. It should be noted that the projections for the two major cities are intended to cover the related water service areas. This includes a larger area than the city limits as reflected in the official U.S. Census Bureau figures.

There are a number of water districts and rural domestic water systems serving the area, as shown on Figure IV-1 [7]. Windsor, one of the larger communities in these districts, is experiencing rapid growth, and therefore population projections for Windsor were made separately. For the purposes of this analysis, remaining populations to be served by rural and small community water systems are projected at five percent of the combined Fort Collins - Greeley water service area population. It is felt that this is a reasonable approximation of the relative magnitude of the remaining small communities and rural populations, and is adequate for reconnaissance level planning purposes.

The resulting low, medium and high population scenarios are displayed in Table IV-1. In analyzing these projections, it is important to keep in mind the relatively long planning horizon of some 50 years and the extremely rapid past growth in this area.

In applying these population projections to derive projected water use, only the medium population scenario was used. This is to avoid the confusion of many possible combinations of population projections and unit water use projections. This medium projection of population should provide a reasonable basis for water use projections for this level of study.

C. WATER USE PROJECTIONS

1. Municipal and Industrial Water Uses

In order to convert the population projections into projected future municipal and industrial water uses, per capita useage must also be projected. This was done by conferring with water utility planners in Fort Collins, Greeley, and Windsor. Per capita use includes industrial and commercial water uses served by the municipal systems. The per capita day projections are listed in Table IV-2.

Total future municipal and industrial water use was estimated by multiplying the population projections by their respective per capita future water use estimates. The analysis was done in ten-year increments from the year 1980 to the year 2030. Municipal and industrial water use projections for Fort Collins, Greeley, Windsor, and the remaining small town and rural population using the medium range of population growth are shown in Table IV-3

TABLE IV-1
CACHE LA POUDRE PROJECT
POPULATION PROJECTIONS OF WATER SERVICE AREAS
(In Thousands)

Area	Scenario	1970	1980	1990	2000	2010	2020	2030
	Low			99.9	128.6	157.0	191.0	233.0
Fort Collins	Medium	43.3	73.7	105.0	146.8	190.0	238.0	290.0
	High			110.2	165.0	222.0	284.0	346.0
	Low			88.1	113.4	138.0	168.0	205.0
Greeley	Medium	38.9	65.0	91.0	126.7	163.0	210.0	256.0
	High			94.0	140.0	188.0	253.0	308.0
	Low			5.8	7.5	9.1	11.1	13.5
Windsor	Medium	1.6	4.3	6.2	9.8	13.5	17.6	21.2
	High			6.7	12.0	18.0	24.0	29.0
	Low			9.4	12.1	14.7	18.0	21.9
Other Towns	Medium	4.1(est)	6.9(est)	9.8	13.7	17.6	22.4	27.3
and Rural	High			10.2	15.2	20.5	26.8	32.7
Total	Low			203.2	261.6	318.8	388.1	473.4
Cache la Poudre	Medium	87.9	149.9	212.0	297.0	384.1	488.0	594.5
	High			220.9	322.2	448.5	587.8	715.7

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TABLE IV-2

CACHE LA POUDRE PROJECT

GALLON PER CAPITA DAY WATER USE PROJECTIONS

City	1980	1990	2000	2010	2020	2030
Fort Collins	240 1/	230	220	210	200	190
Greeley	250	240	230	220	210	200
Windsor	120 2/	140	160	185	190	200
Small Towns and Rural	180	185	190	195	200	200

1/ Based on 220 gallons, adjusted for use on parks, golf courses, etc.

2/ In the earlier years a significant portion of outside use is provided by existing individual wells, which will decline in importance over the long period.

TABLE IV-3
CACHE LA POUDRE PROJECT
TOTAL MUNICIPAL AND INDUSTRIAL WATER USE PROJECTIONS 1/
(In Thousands of Acre-Feet)

City	1980	1990	2000	2010	2020	2030
Fort Collins	19.8	27.0	36.2	44.7	53.3	61.7
Greeley	18.2	24.5	32.6	40.2	49.4	57.3
Windsor	.6	1.0	1.8	2.7	3.7	4.7
Other Towns and Rural	1.4	2.0	2.9	3.8	5.0	6.1
Total Cache la Poudre	40.0	54.5	73.5	91.4	111.4	130.0
Cooling Water for Rawhide Power Plant 2/	--	4.0	8.1	12.2	16.2	16.2

1/ Average annual usage reflecting supplies needed at city intake works without adjustments often made for future water rights and future reserves.

2/ Platte River Power Authority estimates one generating unit (250 megawatts) will require 4,050 acre-feet per year.

along with the total use estimates. The Rawhide Power Plant requirement, due to the plant's independent water supply, is added separately as shown in the Table.

The projected total municipal and industrial water use can be supplied from several sources as noted in Chapter III. The City of Fort Collins can use water from the Cache la Poudre River as well as the Colorado-Big Thompson Project and first use of the Platte River Power Authority's Windy-Gap Project water. The City of Greeley has access to a number of sources other than the Cache la Poudre River; including Colorado-Big Thompson Project, Windy-Gap Project and waters from the Big Thompson River. Of interest to this study is how much of this total use will be supplied by waters of the Cache la Poudre River. Analysis of existing water rights, projected treatment plant capacities and anticipated increases in transbasin imports, followed by consultation with the respective city officials, was made to determine what sources might be used in the future.

Derivation of the total projected municipal and industrial water use and that portion which would be supplied from the Cache la Poudre River and other sources is shown in Table IV-4. The future use to be supplied from the waters of the Cache la Poudre River, as depicted in Table IV-4, can be supplied in three ways. First, part of this supply will consist of water rights presently held and used by the cities. They will simply continue to use these rights in the future. Second, municipalities can increase their use of the waters of the Cache la Poudre River by developing "surplus" flows. Fort Collins and Greeley, for example, hold conditional storage rights for just this purpose. Finally, municipalities can buy and transfer to their use water rights presently used for agricultural purposes. This has occurred in the past and may be expected to continue in the future.

For purposes of this study, estimates of the projected monthly municipal and industrial water use to be supplied from the Cache la Poudre River were made. Analysis of the historic monthly diversion and use patterns provided a basis for estimating average future monthly use patterns.

Municipal and industrial demand is composed of a base and a seasonal demand. The base demand comes from inside-the-house uses and occurs throughout the year. The seasonal demand is due to lawn irrigation and other outside water uses.

A portion of the total demand, including all of the base and some of the seasonal, of Fort Collins and Greeley has historically been supplied by direct flow and some storage rights on the Cache la Poudre River. The remaining seasonal demand has historically been supplied from other sources, mainly the Colorado-Big Thompson Project. It is anticipated that similar future uses will be supplied from present and additionally acquired senior water rights supplemented by storage in the basin. It is also anticipated that part of the future uses will continue to be supplied from other sources in a similar fashion. Therefore, it is assumed that the

TABLE IV-4
CACHE LA POUDRE PROJECT
DERIVATION OF MUNICIPAL AND INDUSTRIAL USES SUPPLIED FROM THE CACHE LA POUDRE RIVER

Year	Location	Population (In Thousands)	Gallons Per Person Per Day	Annual Total M&I Use (Ac-Ft)	Other Water Supply Sources: CBT 2/ (Ac-Ft)	Other Water Supply Sources: Windy Gap (Ac-Ft)	Other Water Supply Sources: BTR 3/ (Ac-Ft)	Annual Supply from the Cache la Poudre River 1/ (Ac-Ft)
2000	Fort Collins & PRPA	146.8	220	44,280 4/	10,130	12,150	-	22,000
	Greeley	126.7	230	32,640	-	6,640	12,000	14,000
	Windsor	9.8	160	1,760	800	-	960	-
	Rural	13.7	190	2,920	1,120	-	-	1,800
	Total			81,600	12,050	18,790	12,960	37,800
2010	Fort Collins & PRPA	190.0	210	56,850	10,250	16,200	-	30,400
	Greeley	163.0	220	40,170	2,070	8,100	16,000	14,000
	Windsor	13.5	180	2,720	1,620	-	1,100	-
	Rural	17.6	195	3,840	1,600	-	-	2,240
	Total			103,580	15,540	24,300	17,100	46,640
2020	Fort Collins & PRPA	238.0	200	69,500	12,500	16,200	-	40,800
	Greeley	210.0	210	49,400	6,400	8,100	20,500	14,400
	Windsor	17.6	190	3,750	2,650	-	1,100	-
	Rural	22.4	200	5,020	2,020	-	-	3,000
	Total			127,690	23,570	24,300	21,600	58,200
2030	Fort Collins & PRPA	290.0	190	77,920	14,920	16,200	-	46,800
	Greeley	256.0	200	57,360	10,560	8,100	24,300	14,400
	Windsor	21.2	200	4,750	3,550	-	1,200	-
	Rural	27.3	200	6,120	2,540	-	-	3,580
	Total			146,150	31,570	24,300	25,500	64,780

1/ Monthly supply from River will be a percent of annual total.

2/ CBT = Colorado-Big Thompson Project.

3/ BTR = Big Thompson River.

4/ Fort Collins totals represent the addition of Platte River Power Authority (PRPA) use to the total municipal and industrial projected use for Fort Collins as shown in Table IV-3.

future monthly distribution pattern of that portion of the total uses to be supplied from the Cache la Poudre River will conform to the historic distribution of monthly diversions shown in Figure IV-2. Furthermore, because the use to be supplied from the river serves for the larger part the base demand, it is anticipated not to fluctuate appreciably during wet and dry years.

2. Agricultural Water Uses

a. Current Agricultural Water Use

For the purpose of projecting future agricultural water use, the current irrigation water use in the service area was analyzed. The current situation described here is based on published data for the period 1957 through 1981. This period was chosen since it represents the current water supply situation, including Colorado-Big Thompson Project water.

The irrigated acreage, hereafter referred to as the service area, extends outside the basin due to several canals which convey water to lands lying east of the lower basin. Presently, the Cache la Poudre River, supplemented by transbasin imports, supplies irrigation water to approximately 225,000 acres in the service area. The area irrigated is shown in Figure IV-3.

Consumptive use is the water requirement due to evapotranspiration by the crops themselves. Janonis and Gerlek [8] determined the consumptive use for all crops in the Cache la Poudre basin to be 1.95 acre-feet (23.43 inches) per acre per year. This annual value and related monthly consumptive use are assumed to be representative of current and future conditions in the service area.

Effective precipitation is that part of total precipitation which is available for use by the crops in supplying their evapotranspiration needs. An annual total effective precipitation of 9.07 inches and the related monthly values as developed by Janonis and Gerlek [8] were used for the analysis of the current situation.

The crop irrigation requirement is the amount of crop consumptive use minus the effective precipitation. A total annual irrigation requirement of 14.36 inches or 1.20 acre-feet per acre and the monthly requirements, resulting from Janonis and Gerlek's [8] determination of crop requirements and effective precipitation, were used in the analysis of the current situation.

As these irrigation requirements show, in order for crop production to be a maximum, natural rainfall must be supplemented with an annual amount of 1.20 acre-feet per acre of irrigation water. The total water requirement based on crop consumptive use for irrigating 225,000 acres in the service area under current cropping conditions is, therefore, 270,000 acre-feet per year. The amount of water required from any source is higher due to on-farm and conveyance efficiency factors.

The overall utilization of agricultural water in the Cache la Poudre River service area is a very complex situation to analyze. Such an analysis could not be accomplished in the scope of time and budget for the present study. Therefore, a simplified method of determining aggregate agricultural water demand in the service area was used to assess the efficiency of current usage. The method involves determination of a measure of the overall efficiency of agricultural water use or a service area water utilization efficiency.

This efficiency factor is defined as the ratio of the irrigation requirement for the service area divided by the total surface water supplied to the service area, and therefore includes the effects of crop consumptive use, precipitation, on farm efficiency, conveyance efficiency, irrigation water reuse, evaporation from reservoirs, groundwater use, etc.

Current on-farm efficiency is relatively low and has been determined to be on the order of 37 percent. Based on available diversion records, it can be shown that the average farmer receives 3.2 acre-feet of water per acre per year compared to an irrigation requirement of 1.20 acre-feet per acre per year. Likewise, conveyance efficiencies of only 74 percent have been measured in the service area, meaning that an average of 26 percent of diversions are lost from the ditches and canals.

These low efficiencies are not currently considered to be a problem. Most ditches are operated and managed on the premise that they will receive return flows from lands and ditches located above them. Evans [9] notes that --- "many of the canal companies could not operate, would not have enough water to irrigate all their lands, if it were not for this additional water from return flows." It can be shown that agricultural water is reused 2.4 times within the service area. This results in a relatively high overall efficiency of surface water use within the service area. The calculation of the current service area water utilization efficiency is shown on Table IV-5. As can be seen from the Table, the calculated service area water utilization efficiency is 67 percent.

To confirm this derivation of the overall efficiency of water use, an approximate water balance for the service area was calculated. The water balance is shown graphically in Figure IV-4. The values used in the water balance are derived from existing data and are average annual figures for the period 1957 through 1981. The water balance confirms the derivation of the service area water utilization efficiency by closing within a reasonable degree of accuracy.

b. Future Agricultural Water Use

The future total use of irrigation water in the Cache la Poudre River service area depends on future cropping patterns, the amount of lands irrigated in the future and the efficiency of future water use. Factors and assumptions relating to the future use of irrigation water are discussed below.

TABLE IV-5
CACHE LA POUDRE PROJECT
DERIVATION OF SERVICE AREA WATER UTILIZATION EFFICIENCY

Item	Calculation Method	Example Calculations
1. Agricultural water demand due to plant consumptive use	Acreage times annual consumptive use	225,000 acres times 23.43 in. = 439,300 ac-ft
2. Water available from effective precipitation	Acreage times annual effective precipitation or total rainfall less winter evapotranspiration	225,000 acres times 9.07 in. = 170,100 ac-ft or 261,600 ac-ft. - 91,500 ac-ft. = 170,100 ac-ft
3. Irrigation Requirement	Agricultural water demand less effective precipitation	439,300 ac-ft - 170,100 ac-ft = 269,200 ac-ft
4. Surface water supplied by identified sources, including:	Volumes based on:	
• Colorado-Big Thompson Project	• Recorded diversions to agricultural users	85,900 ac-ft
• Return flows	• Recorded waste treatment plant discharges	9,300 ac-ft
• Upper basin flows from native and imported waters for agriculture	• Gaged flows	308,100 ac-ft
Total		403,300 ac-ft
5. Service area water utilization efficiency	Irrigation requirement divided by water supplied by outside sources	269,200 divided by 403,300 = 0.67

No large change is anticipated in the types of irrigated crops being grown in the Cache la Poudre service area. Moreover, most crops require basically the same amount of water on an annual basis, so conversions from one to the other do not appreciably change the overall annual demand for water. For this study, it is assumed that the annual consumptive use will remain at approximately 1.95 acre-feet per acre in the future and will be used according to the monthly pattern required for the current cropping pattern.

Currently, the somewhat depressed market for agricultural produce and livestock and the high interest rates for new capital are not conducive to conversion of dryland to irrigation farming. It is assumed that this market situation will continue; therefore, no development of new irrigated lands is anticipated.

The increase in population discussed earlier in this Chapter was used with an urbanization density factor to derive the acres of rural land converted to urban use during the period of 1980-2030. For the first 10 year increment of growth, a density factor of 10 people per acre was assumed. This factor was assumed to gradually increase to 12 people per acre during the latter part of the 50-year projection. Discussions with city planners and other knowledgable people suggest that 80 to 90 percent of urban development is now occurring on irrigated land. It was assumed that the 80 to 90 percent would gradually reduce to 60 percent by the year 2030 to reflect anticipated shifts of urban growth to dry lands due to relative scarcity of lands.

A summary of the derivation of the number of acres affected by the urban encroachment on irrigated lands is presented in Table IV-6. For the total Cache la Poudre Basin, using the medium range of population growth, there would be from 5,000 to 7,000 acres of irrigated lands converted to urban use in each decade projected, with a total of approximately 28,000 acres by the year 2030.

As explained, the overall service area water utilization efficiency of the service area is already high. If economic conditions were to change, each farmer or each ditch company could increase his efficiency. For example; more labor could be used to distribute water on fields, pumps and sprinklers could replace surface supplies, and ditches could be lined. Currently, there is no incentive to do so. The large return flows are the supply to downstream users. If the price for water should increase rapidly compared to other inputs to the agricultural sector, individual farmers may then begin water conservation practices. However, due to high utilization efficiencies, the gains will be costly and hard to achieve. Therefore, all future agricultural use is estimated using the current service area water utilization efficiency of 67 percent.

Based on the above assumptions, the total annual crop consumptive use was derived by reducing the present total acreage by the amount of acreage effected by urban encroachment and applying the crop consumptive use requirements. This total was then reduced by the average

TABLE IV-6
CACHE LA POUDRE PROJECT
DERIVATION OF URBAN ENCROACHMENT ON IRRIGATED LANDS
(In Thousands of Acres)

Item	1980	1990	2000	2010	2020	2030	Total
Total Population (from Table IV-1)	149.9	212.0	297.0	384.1	488.0	594.5	
Population Increase by Decade		62.1	85.0	87.1	103.9	106.5	444.6
Conversion to Acreage Equivalents: Density (acres per capita)		(.10)	(.10)	(.09)	(.08)	(.08)	
Incremental Acres of Urban Encroachment		6.2	8.5	7.8	8.3	8.5	39.3
Encroachment on Irrigated Lands (%)		(85%)	(80%)	(70%)	(60%)	(60%)	
Incremental Acres of Encroachment on Irrigated Lands		5.3	6.8	5.5	5.0	5.1	27.7
Cumulative Acres of Encrochment on Irrigated Lands		5.3	12.1	17.6	22.6	27.7	

annual amount of effective precipitation for the hydrologic study period and adjusted by the 67 percent service area water utilization efficiency factor to derive the total annual irrigation use. In ten year increments, the total annual average irrigation uses are as follows: for the year 1990, 392,500 acre-feet per year; for the year 2000, 380,300 acre-feet per year; for the year 2010, 370,400 acre-feet per year; for the year 2020, 361,500 acre-feet per year; for the year 2030, 353,000 acre-feet per year.

The projected total irrigation use could be supplied from several sources. Of interest in this study is how much of this total use would be supplied by water from the Cache la Poudre River. Other sources of water to meet irrigation uses are the Colorado-Big Thompson Project and return flows from Fort Collins. Due to location and contractual agreements with irrigation companies outside the Cache la Poudre River Basin, return flows from Greeley are not available for irrigation use within the service area.

For purposes of this study, total irrigation uses on a monthly basis were derived in a manner similar to that described above for the total annual uses using average monthly consumptive uses, historic monthly effective precipitation values for the entire 23-year hydrologic study period and the service area water utilization efficiency of 67 percent. Accounting for effective precipitation on a monthly basis reflected the effects of wet and dry years. The total monthly use was then reduced by the estimated monthly amount available from other sources as was determined in Chapter III to determine the amount to be supplied from the Cache la Poudre River. Calculations to determine that part of the total monthly irrigation uses to be supplied from the Cache la Poudre River were done in ten-year increments. An example of these calculations for one year of the hydrologic study period is shown for the year 2030 conditions in Table IV-7. The results for the entire hydrologic study period with year 2030 conditions are shown in Table IV-8.

D. OPPORTUNITIES FOR IMPROVED WATER MANAGEMENT

To identify potential opportunities for improved management, informal meetings were held with officers and operators of irrigation companies and officials from the affected municipalities. There appears to be a general consensus that a project with a terminal storage reservoir near the mouth of the canyon is the key to opportunities for improved management by providing increased flexibility. Flexibility in the operation of the Cache la Poudre system could be provided through the use of the terminal reservoir to store flows out of priority and as an alternate point of storage for water now stored in numerous off-channel reservoirs in the lower basin. This would permit irrigators to improve the timing of their water deliveries, allowing them to order water on demand rather than to have to take water on a pre-determined schedule. (The concept of use of a terminal reservoir to store flows out of priority and as an alternate point of storage for lower basin reservoirs is discussed in Chapter III.)

Another important aspect of this improved operation would be the ability to exchange water anywhere within the service area. Spring runoff

TABLE IV-7
CACHE LA POUDRE PROJECT
EXAMPLE OF CALCULATION OF
AGRICULTURAL USES SUPPLIED BY THE
CACHE LA POUDRE RIVER

YEAR: 2030, AGRICULTURAL DEMANDS WITH 197,300 ACRES

Month	Plant Consumptive Use (inches)	Effective Precipitation [Yr: 1949] 1/ (inches)	Estimated Agricultural Irrigation Use 2/ (ac-ft)	Adjustments For Other Water Sources in Ac-Ft 3/ CBT	FCRF	NP	Cache la Poudre River (ac-ft)
APR	0.05	0.05	-	-	-	-	-
MAY	4.34	2.62	42,200	2,960	1,720	5,330	32,190
JUN	5.10	4.02	26,500	4,140	2,410	7,070	12,880
JUL	5.60	2.75	69,910	19,220	11,200	5,690	33,800
AUG	4.61	0.70	95,945	21,890	12,750	5,090	56,215
SEP	2.14	0.40	42,680	6,800	3,960	3,500	28,420
OCT	1.59	1.17	10,295	4,140	2,410	320	3,425
TOTAL	23.43	11.73	287,530	59,150	34,450	27,000	166,930

1/ Effective precipitation values are available for each month in the hydrologic study period of 1949 through 1971.

2/ Release requirements are determined with the service area utilization efficiency of 0.67.

3/ Adjustments are determined by:
CBT: (Colorado-Big Thompson Project) Annual average C.B.T. water 115,000 ac-ft - urban demand on C.B.T. = C.B.T. reduction.
FCRF: (Fort Collins' Return Flows) Total annually supplied to Fort Collins times 65% - PRPA needs = FCRF reduction.
NP: (North Poudre Canal Diversion) Historic diversions into North Poudre Canal for 1949 to 1971 period = NP reduction.

TABLE IV-8

CACHE LA POUDRE PROJECT

AGRICULTURAL USES SUPPLIED BY

THE CACHE LA POUDRE RIVER

YEAR 2030 - 197,300 ACRES

(Units are Thousands of Acre-Feet)

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
1949	3.4	0.0	0.0	0.0	0.0	0.0	0.0	32.2	12.9	33.8	56.2	28.4	166.9
1950	25.0	0.0	0.0	0.0	0.0	0.0	0.0	16.2	80.9	67.0	59.4	0.0	248.5
1951	0.0	0.0	0.0	0.0	0.0	0.0	0.0	39.3	63.9	56.7	0.0	15.9	175.8
1952	27.5	0.0	0.0	0.0	0.0	0.0	0.0	19.7	56.8	84.6	50.6	37.2	276.3
1953	29.4	0.0	0.0	0.0	0.0	0.0	0.0	53.8	50.2	72.8	58.2	27.0	291.5
1954	24.0	0.0	0.0	0.0	0.0	0.0	0.0	69.5	90.7	79.2	44.7	15.2	323.4
1955	27.7	0.0	0.0	0.0	0.0	0.0	0.0	54.6	54.4	72.8	40.7	0.0	250.2
1956	30.9	0.0	0.0	0.0	0.0	0.0	0.0	39.6	102.5	52.2	30.0	18.8	274.0
1957	1.7	0.0	0.0	0.0	0.0	0.0	0.0	2.2	72.1	69.9	39.8	26.0	211.6
1958	21.8	0.0	0.0	0.0	0.0	0.0	0.0	20.7	59.0	54.2	48.9	9.5	214.1
1959	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.2	90.4	86.6	60.6	0.0	257.9
1960	.1	0.0	0.0	0.0	0.0	0.0	0.0	41.1	89.2	65.9	69.2	21.8	287.4
1961	18.7	0.0	0.0	0.0	0.0	0.0	0.0	5.2	75.0	32.8	31.5	0.0	163.1
1962	4.9	0.0	0.0	0.0	0.0	0.0	0.0	32.2	46.2	31.8	58.0	30.6	203.7
1963	21.3	0.0	0.0	0.0	0.0	0.0	0.0	79.1	43.8	67.4	11.3	0.0	223.0
1964	28.2	0.0	0.0	0.0	0.0	0.0	0.0	54.3	76.9	89.5	59.2	28.0	336.1
1965	14.0	0.0	0.0	0.0	0.0	0.0	0.0	50.8	37.9	29.9	55.7	0.0	188.3
1966	21.3	0.0	0.0	0.0	0.0	0.0	0.0	85.7	58.8	80.2	41.3	0.0	287.3
1967	20.6	0.0	0.0	0.0	0.0	0.0	0.0	9.9	22.5	44.1	45.9	25.5	168.4
1968	17.6	0.0	0.0	0.0	0.0	0.0	0.0	38.4	90.7	74.0	16.2	33.1	270.0
1969	.1	0.0	0.0	0.0	0.0	0.0	0.0	21.6	54.9	67.9	46.7	15.9	207.1
1970	7.3	0.0	0.0	0.0	0.0	0.0	0.0	67.6	49.0	69.2	52.6	0.0	245.6
1971	17.9	0.0	0.0	0.0	0.0	0.0	0.0	55.3	89.5	85.6	64.4	0.0	312.6
MEAN	15.8	0.0	0.0	0.0	0.0	0.0	0.0	39.5	63.8	63.8	45.3	14.5	242.7

could be stored so junior rights could be filled later in the irrigation season. Storage in a terminal reservoir would permit a more precise determination of annual water supplies and permit a coordinated usage of the many sources of water available to the service area.

A project terminal storage reservoir could effect savings in maintenance costs for existing storage and conveyance facilities. Although current requirements to improve spillways and other works at existing reservoirs would have to be accomplished prior to completion of a Cache la Poudre Project, long-term savings could be realized due to lower reservoir operating levels, reduced cost of cleaning and disposing of sediment from supply canals and reduced cost of future repairs.

Simplification of the operation resulting from a project terminal storage reservoir could allow elimination of some antiquated service area features. With their elimination, operation and maintenance costs and water conveyance losses would be reduced. Indications are that some 30 miles of supply canals with attending operation and maintenance costs and reduced transportation losses can be eliminated. Plus, there is a possibility of elimination of several lower basin reservoirs. Elimination of lower basin reservoirs or their operation at lower water surface levels could also result in some saving in losses of water through evaporation.

Finally, a project terminal storage reservoir would provide required storage for which alternative schemes are now being considered. Some 6,000 acre-feet of storage in the upper basin is being investigated for the purpose of storing increased transbasin diversions. The city of Fort Collins is considering a need for some 10,000 acre-feet of conservation storage to insure the ability to meet future municipal and industrial water needs. Continuation of such piecemeal development will only foster the complexity of system operation while a project terminal reservoir would simplify the system to allow the flexibility for improved management.

E. POWER DEMAND PROJECTIONS

Although a specific power purchaser is not identified at this level of study, an analysis was made of the projected need for the peaking power output from a Cache la Poudre Project and how it could be integrated in the electric utility system. For purposes of this study, the system is represented by the projected loads and resources of the three utilities that most likely would be impacted by the output from a Cache la Poudre Project; Public Service Company of Colorado, Tri-State Generation and Transmission Association, and Platte River Power Authority. These three utilities have been combined into an interconnected system as indicative of potential future peaking demand. To gain a broader perspective and illustrate a broader market for the output, the projected needs of the greater interconnected Rocky Mountain Power Area are also discussed.

The power demand of any electric utility system is continually varying. These variations are caused by such factors as living habits and work schedules of the people served, characteristics of the industries included in the load, and extremes in weather.

A substantial part of the demand is on a continuous basis. Loads are highest during normal working hours and drop off during late-night hours and on weekends. Thus, while about forty percent of the system's capacity must operate almost continuously, or at baseload, the remainder of the capacity, required to serve peak demands, is idle for portions of the time. Whether the peak demands of the system last for a few minutes or a few hours, generating capacity must be available to supply the demand at the moment it develops.

In addition, to ensure that system load demands can be met, sufficient generation capacity must be provided not only to meet the peaks of the load but also to provide adequate reserve capacity. Reserves are needed to replace generating capacity removed from service because of unscheduled forced outages of generation or transmission equipment, to replace capacity removed from service for scheduled maintenance, to serve loads greater than anticipated, and for system control. Reserve capacities of 15 to 20 percent of the total system peak load are generally provided.

Figure IV-5 shows the combined utility system's 1980 hourly loads for a typical week in the sequence in which they occur (load curve). The system loads may also be arranged in order of their frequency of occurrence as a load-duration curve to show the time duration of loads of various magnitudes. Figure IV-6 shows a display of the combined systems of the three utilities' 1980 load-duration curve for the same typical week. The ordinate may be in terms of load demand and the abscissa in terms of total hours, or the ordinate may be in terms of percent peak demand and the abscissa in terms of percent of total hours. The area under the curve represents the energy requirements in megawatt-hours.

The load-duration curve, when expressed in terms of load demand and time, may be used to illustrate how future loads of various magnitudes may be served and to demonstrate the compatibility of proposed capacity additions. For example, a projected peak demand exceeding existing reserves indicates a need for additional capacity. Allocating existing generating facilities, in accordance with energy delivery capability and operating cost data to satisfy capacity and energy requirements of various segments of the curves, provides insight regarding the type of additional capacity required. This type of analysis was done to show how the Cache la Poudre Project might meet future load requirements.

Loads shown for the combined system of the three utilities, shown on Figure IV-6, will be met by resources available within the combined systems. Currently, new efficient steam-electric capacity, mostly coal-fired generation units and some hydroelectric capacity is used to meet the base portion of the electric load. Older, less efficient steam-electric capacity, and hydroelectric capacity are used to serve intermediate portions of the load. Peaking hydroelectric and combustion turbine facilities are used to serve the peak portions. However, it is expected that by

1985, the base portion of the load will be served almost exclusively by coal-fired generating units to the exclusion of hydoelectric units. These very large, highly efficient, baseload steam-electric units are well suited for baseload operation. However, they are not designed for flexible operation required by intermediate or peaking service and, as a result, there will be increasing needs for new generation capacity suited for supplying intermediate and peak loads.

Table IV-9 shows the projected rate of system growth for the three utilities for years 1980 through 2000. The data is taken from materials prepared by the Colorado Public Utilities Commission (PUC) [10], and a recent staff report [11]. In 1980, the peak load demand of the three utilities was approximately 3,161 megawatts. It has been estimated their total peak load demand will be 4,825 megawatts by 1990 and 7,421 megawatts in 2000. The figure of 7,421 megawatts was derived using the projected growth rate of 4.4 percent from 1990 to 2000 projected by the PUC for the Rocky Mountain Power Area.

Figure IV-7 shows the combined three utility system's projected load duration curve for the same typical week for 1990 showing the type of generation required to serve various segments of the load. Figure IV-8 shows the combined utility system's projected load duration curve for the same typical week for the year 2000. The figure includes the conceptual integration of the output from a Cache la Poudre Project, showing the portion of the load it would best serve. The output from a Cache la Poudre Project was inserted into the load-duration curve to make best use of both the installed capacity and available project energy. Using this insertion technique, the Project, when operating at a twenty percent plant factor, would integrate into the intermediate/peaking segment of the load. The height of the shaded area represents the project installed peaking capacity in megawatts, which is 101.5 megawatts for Alternative 2 or 79 megawatts for Alternative 7. The shaded area represents the typical weekly peaking energy that would be generated. It can be seen that the output represents a very small amount of the projected total system capacity and energy demands of the three utilities.

During information discussions, officials of Public Service Company of Colorado, Tri-State Generation and Transmission Association, and Platte River Power Authority indicated general agreement with the findings that there would be a large demand for peaking power after 1990 and that the output of a Cache la Poudre Project could be easily absorbed into the combined utility's power system.

As explained in Chapter III, the larger area for marketing hydroelectric power and energy production from a Cache la Poudre Project would be the Rocky Mountain Power Area of the Western Systems Coordinating Council. Operationally, the output would likely be integrated into the Inland Power Pool. The three utilities mentioned above represent approximately 60 percent of the total load and resources in the Rocky Mountain Power Area.

TABLE IV-9
CACHE LA POUDRE PROJECT

POWER DEMAND PROJECTIONS
1980-2000

Local Utilities	Peak Demand 1980 (MW)	Annual Rate of Growth 1980-1990 (%)	Peak Demand 1990 (MW)	Annual Rate of Growth 1990-2000 (%)	Peak Demand 2000 (MW)
Platte River Power Authority	186	8.0	400	4.4	605
Tri-State Generation and Transmission Association	513	5.8	905	4.4	1,392
Public Service Company of Colorado	2,462	3.6	3,520	4.4	5,414
Total (3 systems)	3,161		4,825		7,421
Weighted Average (3 systems)		4.3		4.4	
State of Colorado	4,255	5.9	7,535	4.4	11,590
Rocky Mountain Power Area	5,137	4.7	8,158	4.4	12,500

The Rocky Mountain Power Area's projected average compound load growth rate for years 1982 through 1991 is 5.2 percent [12]. The average annual compound load growth rates for years 1992 through 2001 is projected to be 4.0 percent. The average annual compound load growth rate for the 20 year period is 4.7 percent. Table IV-9 also shows the projected peak loads for the years 1980, 1990 and 2000 for the Rocky Mountain Power Area. [13]. Figure IV-9 graphically shows the estimated 20 year peak load growth. This shows the peak load requirements to increase from 5,200 megawatts in 1982 to 8,200 megawatts in 1990 and 12,500 megawatts in 2000.

Table IV-10 shows the generation additions projected for the Rocky Mountain Power Area for the years 1982 through 1991 [13]. A total of 3,929 megawatts is currently being planned to meet future load growth. As can be seen, generation additions projected for the 1982-1991 period reflect the heavy reliance that is being placed on coal-fired steam resources. Coal-fired generating units account for 89.7 percent of the generation additions planned through 1991. Only 1.7 percent of the resource additions is projected to be contributed by conventional hydroelectric projects. A reduction of 43 megawatts for oil and gas generation is shown in the table.

A power market survey was undertaken by the Western Area Power Administration to determine the marketability of potential hydroelectric resources being considered for development by the U.S. Bureau of Reclamation's Upper Colorado Region [14]. The survey shows the anticipated electric power requirements between 1980 and 2000, the anticipated necessary operating characteristics of future electric resources, and how those future resources would interface with existing and proposed resources in the survey area, for both public and private utilities. The study area was divided into four sub-areas: (1) The States of Colorado and Wyoming; (2) Utah; (3) New Mexico; and (4) Arizona, Nevada, and Southeastern California. The Colorado/Wyoming sub-area most closely matches the potential marketing area of the Cache la Poudre Project facilities.

The power market survey concludes that "both peaking and baseload resources are needed to serve future loads, in addition to those resources which are existing or presently committed for construction." The load-duration curves showed that approximately 4,595 megawatts of additional capacity would be needed in the Colorado/Wyoming area to operate as a peaking or intermediate resource by the year 2000.

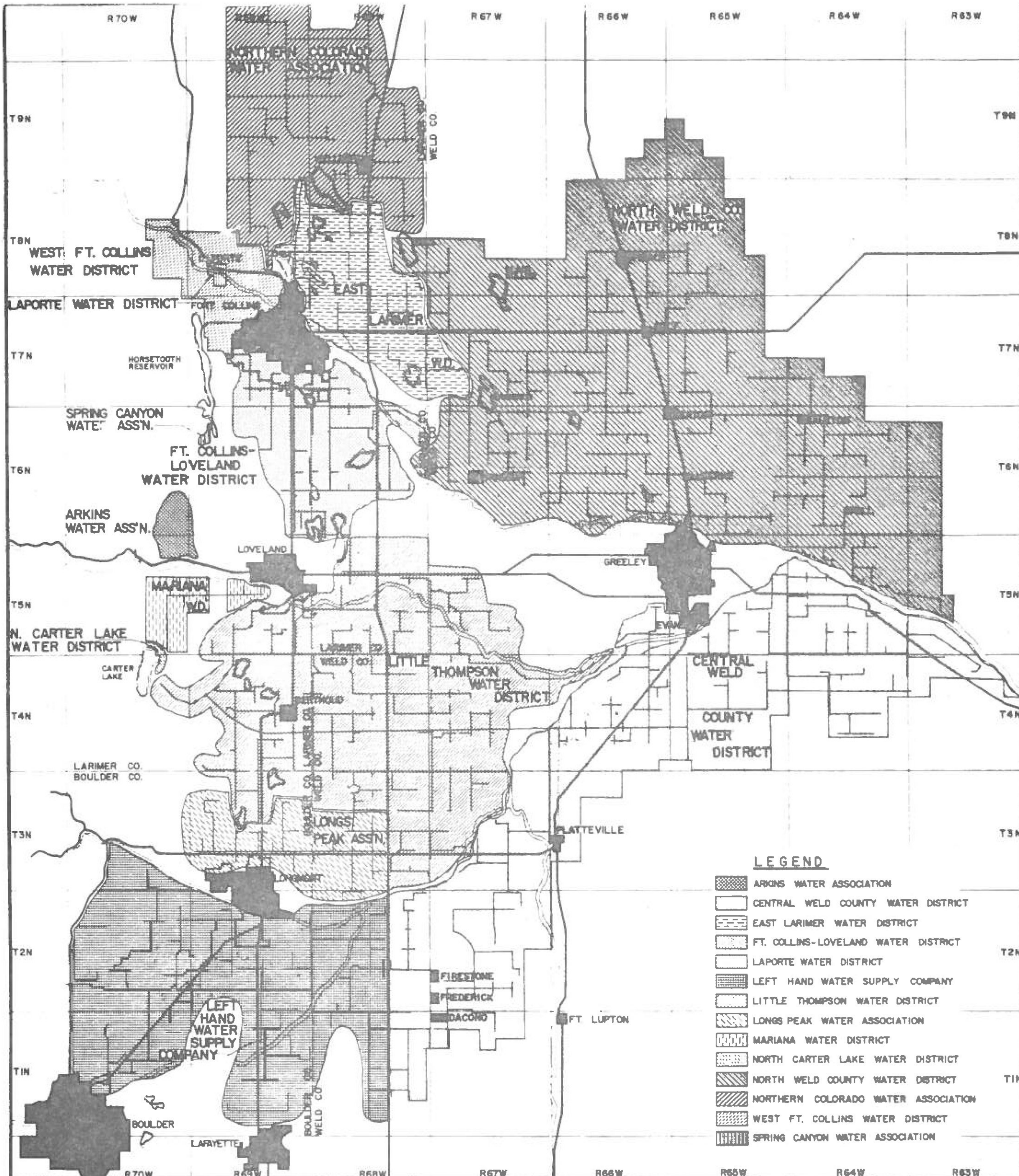
Since the bulk of the generation from a Cache la Poudre Project would be a peaking or intermediate resource and would be small in comparison to these projections, it has been assumed for the purposes of this study that the output could be integrated into the system as shown and would be marketable if competitively priced with alternative intermediate and peaking thermal sources.

GENERATION TYPE	1982	1983
HYDRO - CONVENTIONAL	0	24
HYDRO - PUMPED STORAGE	106	100
STEAM - COAL	1100	400
STEAM - GAS AND OIL	0	-18
NUCLEAR	0	0
COMBUSTION TURBINE	0	0
COMBINED CYCLE	0	0
GEOTHERMAL	0	0
INTERNAL COMBUSTION	0	0
COGENERATION	0	0
OTHER	4	0
TOTAL	1210	506

TABLE IV-10
CACHE LA POUDRE PROJECT
SUMMARY OF GENERATION ADDITIONS AND REDUCTIONS
ROCKY MOUNTAIN POWER AREA
1982 - 1991

(MEGAWATTS)

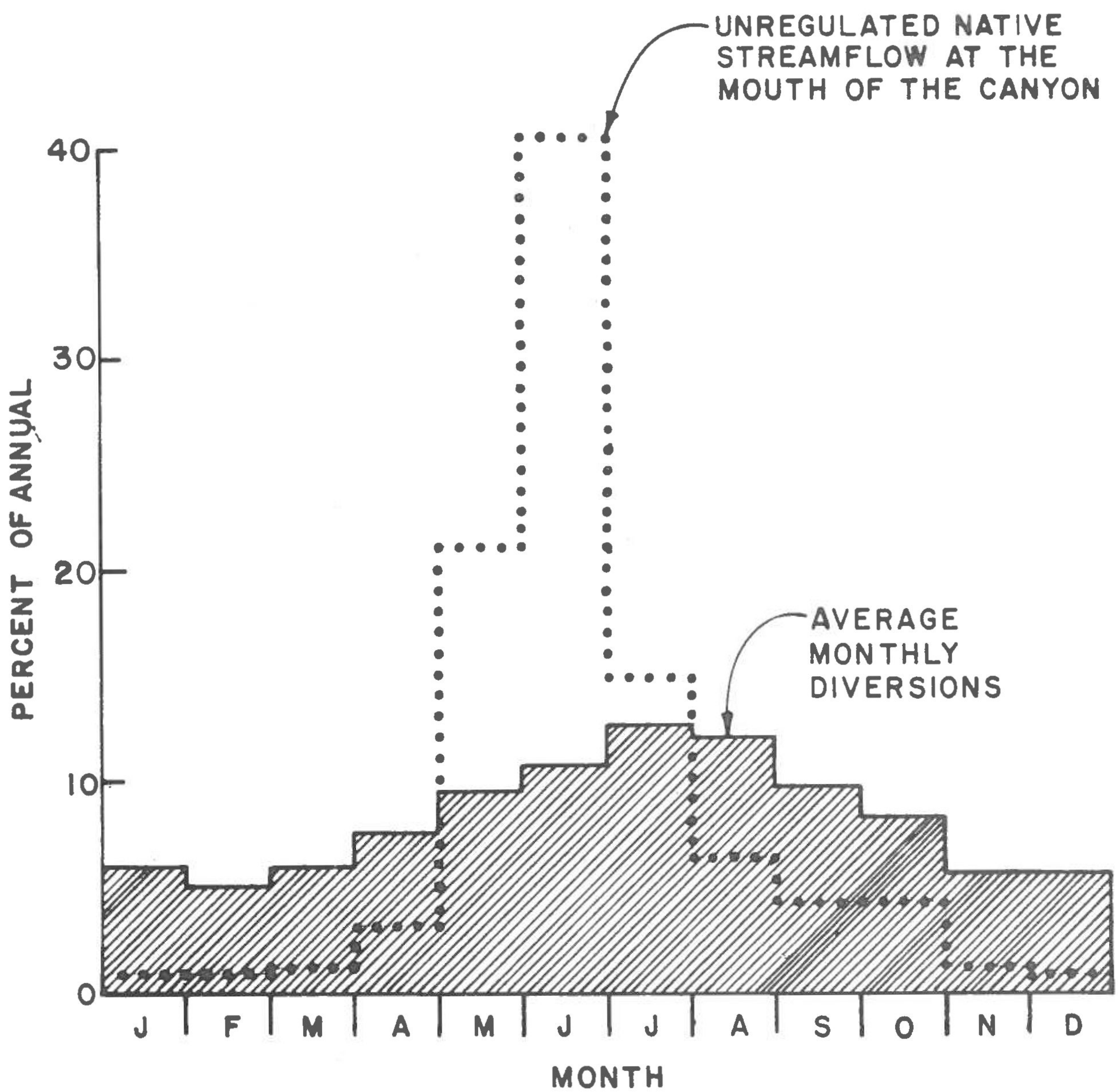
1984	1985	1986	1987	1988	1989	1990	1991	10-YR. PERIOD	PERCENT OF TOTAL
18	3	22	0	0	0	0	0	67	1.7%
0	0	0	0	0	0	0	0	206	5.2%
250	0	0	885	0	885	0	0	3520	89.7%
0	0	0	0	0	0	-8	-17	-43	-1.1%
0	0	75	0	0	0	0	0	75	1.9%
0	0	0	0	0	0	0	0	0	.0%
0	0	0	0	0	0	0	0	0	.0%
0	0	0	0	0	0	0	0	0	.0%
0	0	0	0	0	0	0	0	0	.0%
0	0	0	0	0	0	0	0	0	.0%
0	100	0	0	0	0	0	0	104	2.6%
268	103	97	885	0	885	-8	-17	3929	100.0%



COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

RURAL DOMESTIC WATER SYSTEMS - LARIMER, BOULDER & WELD COUNTIES

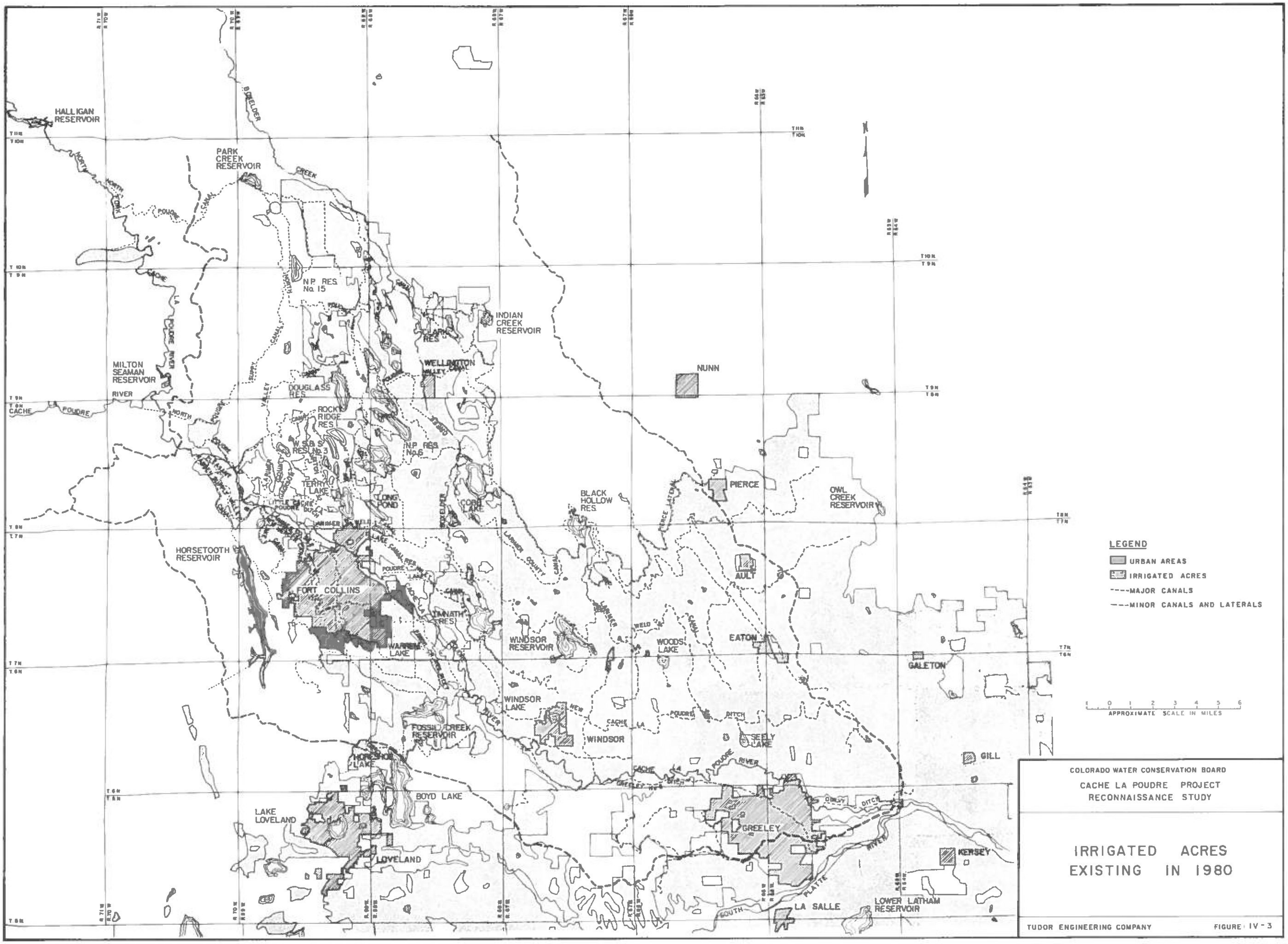
TUDOR ENGINEERING COMPANY — FIGURE: IV - 1



COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

AVERAGE MONTHLY DIVERSIONS - FORT COLLINS AND GREELEY PIPELINES

TUDOR ENGINEERING COMPANY FIGURE: IV-2



COLORADO WATER CONSERVATION BOARD

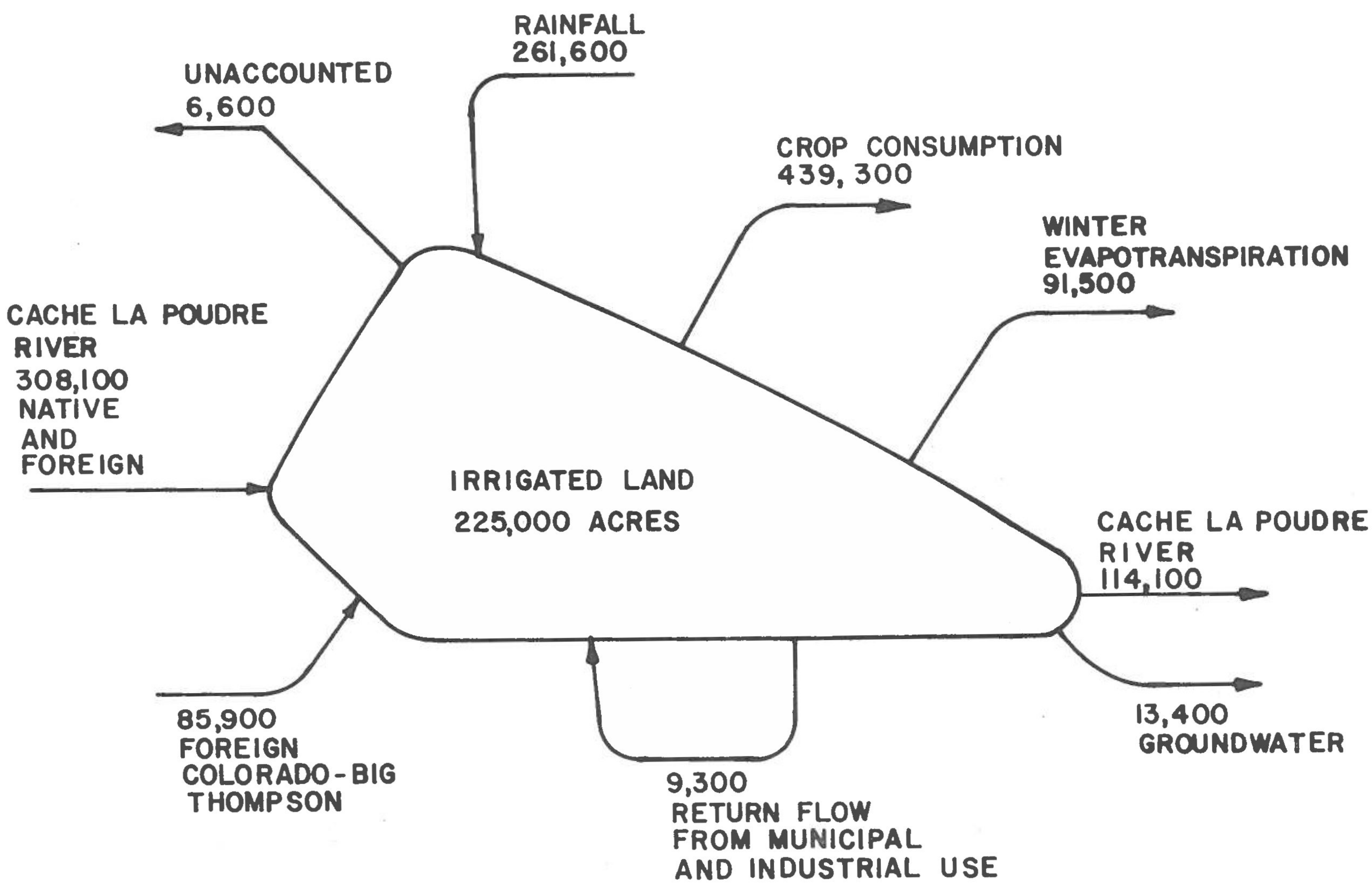
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

IRRIGATED ACRES EXISTING IN 1980

TUDOR ENGINEERING COMPANY

FIGURE: IV-3

NOTE: UNITS ARE
ACRE-FEET PER YEAR

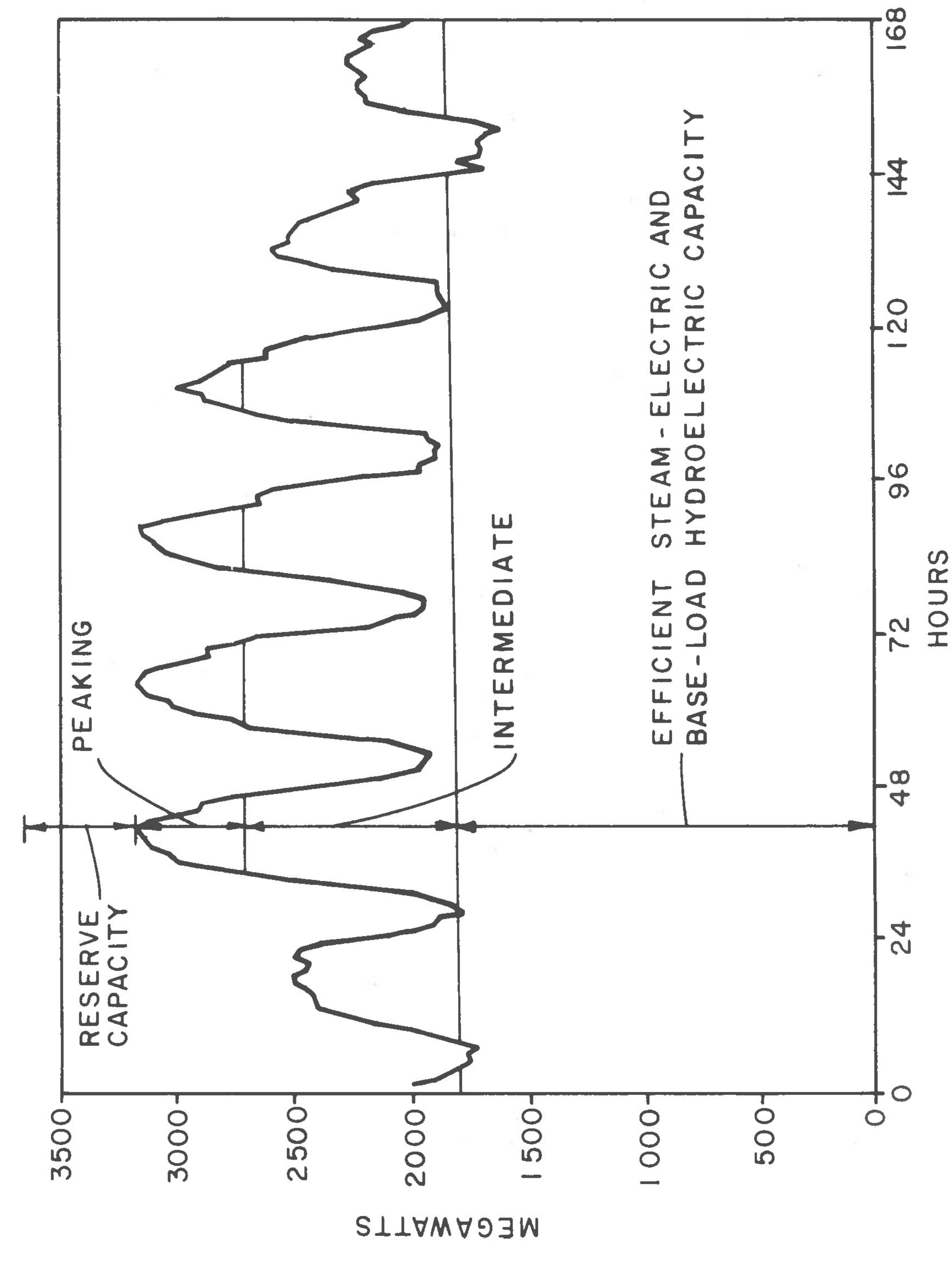


COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

WATER BALANCE FOR
IRRIGATED LAND

TUDOR ENGINEERING COMPANY

FIGURE: IV-4



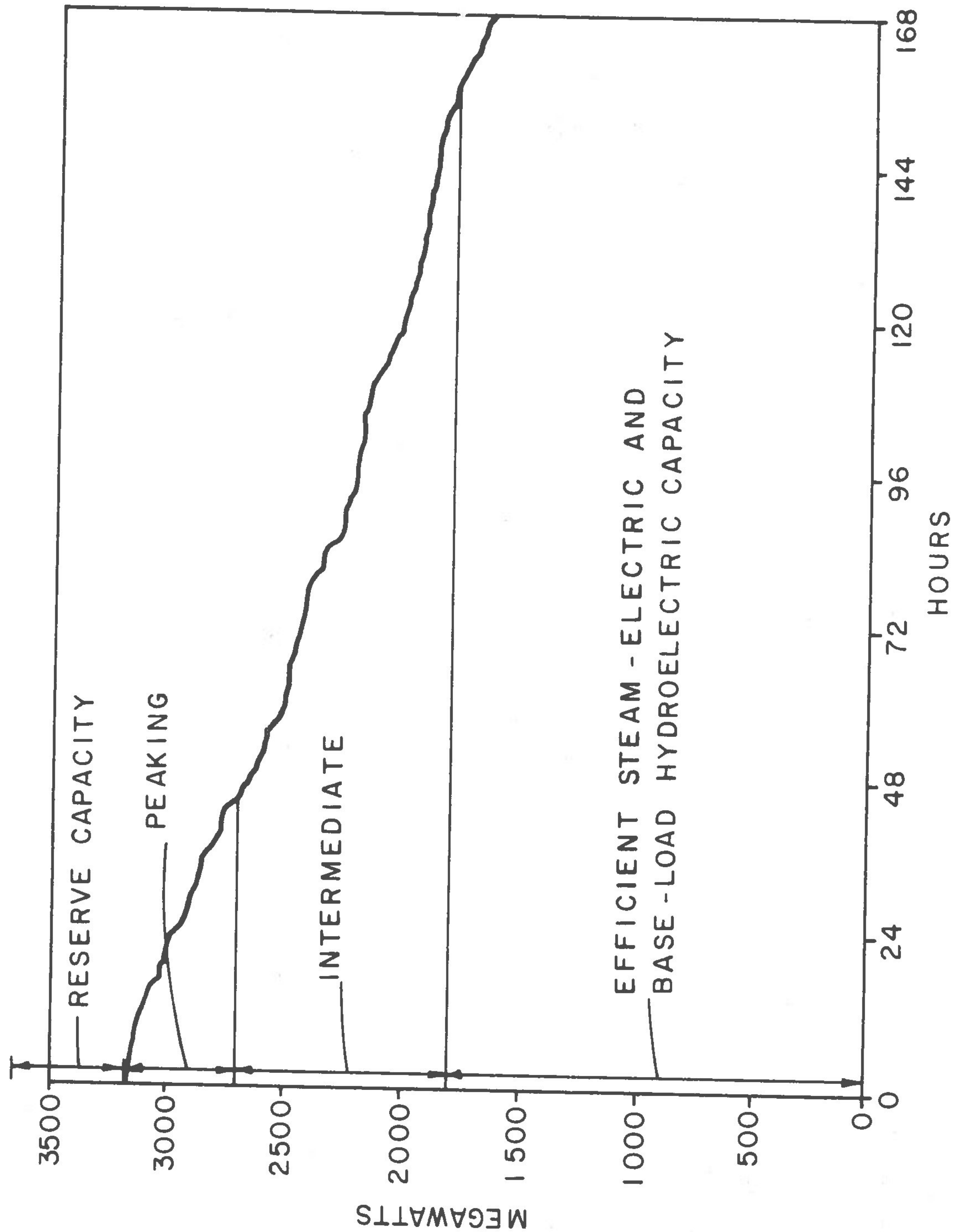
Note: This figure represents the combined loads of three utilities that most likely would be impacted by a Cache la Poudre Project output; Public Service Company of Colorado, Tri-State Generation and Transmission Association and Platte River Power Authority.

COLORADO WATER CONSERVATION BOARD

CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

TYPICAL WEEKLY
LOAD CURVE
1980 SYSTEM LOAD DATA

TUDOR ENGINEERING COMPANY | FIGURE: IV-5



Note: This figure represents the combined loads of three utilities that most likely would be impacted by a Cache la Poudre Project output; Public Service Company of Colorado, Tri-State Generation and Transmission Association and Platte River Power Authority.

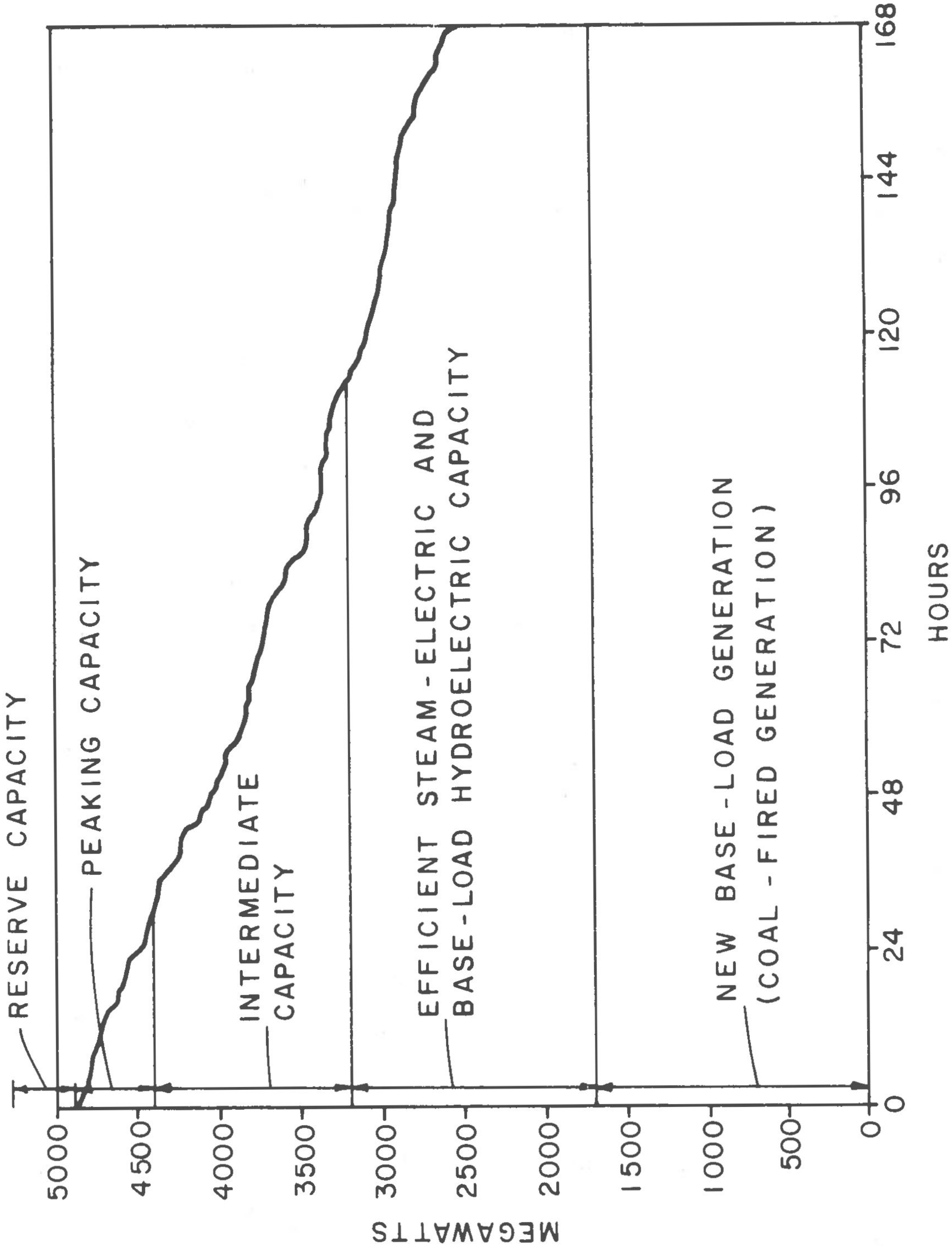
COLORADO WATER CONSERVATION BOARD

CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

TYPICAL WEEKLY LOAD
DURATION CURVE
1980 SYSTEM LOAD DATA

TUDOR ENGINEERING COMPANY

FIGURE: IV-6



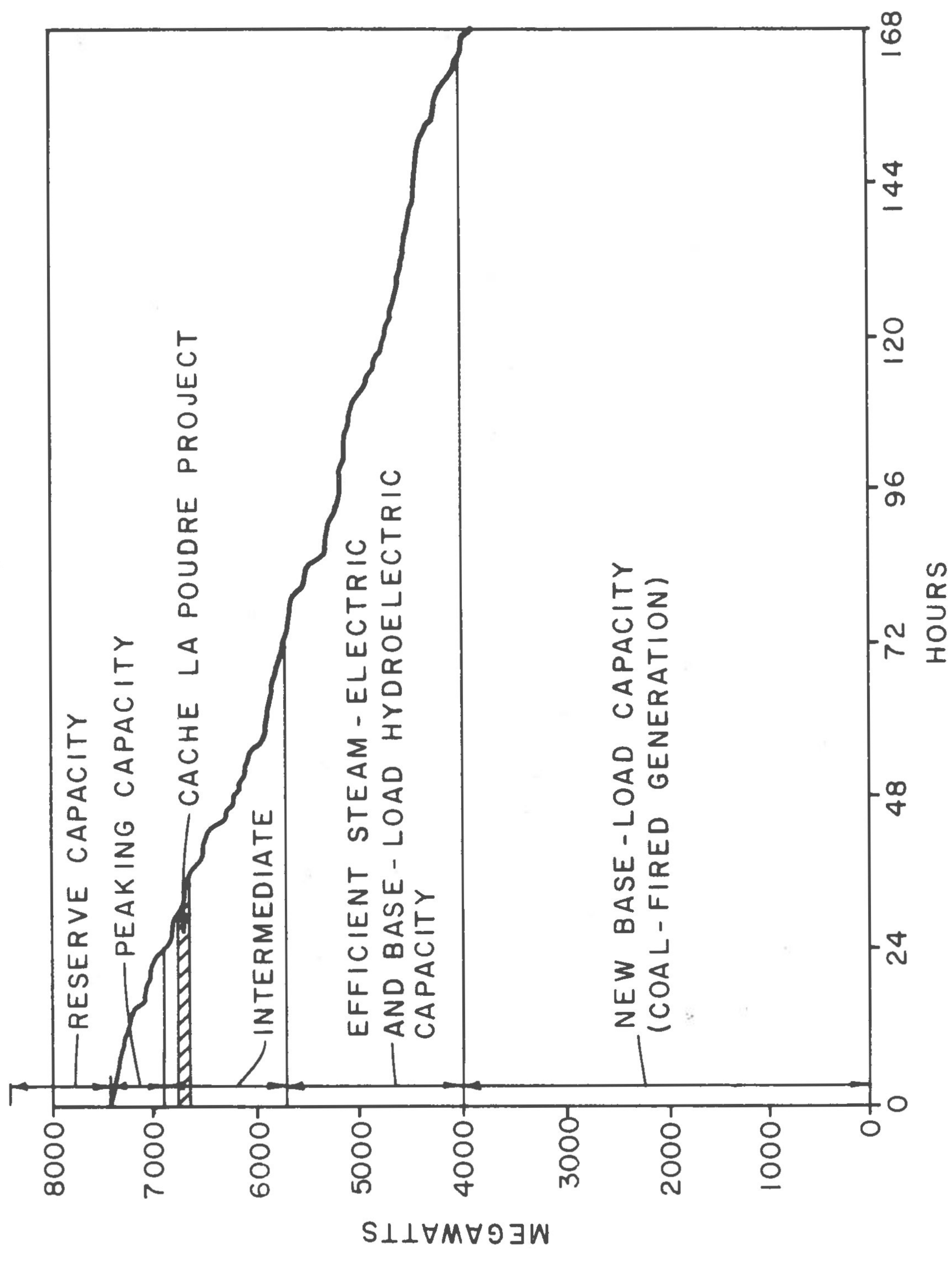
Note: This figure represents the combined loads of three utilities that most likely would be impacted by a Cache la Poudre Project output; Public Service Company of Colorado, Tri-State Generation and Transmission Association and Platte River Power Authority.

COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

TYPICAL WEEKLY LOAD DURATION CURVE
1990 SYSTEM LOAD DATA

TUDOR ENGINEERING COMPANY

FIGURE: IV-7

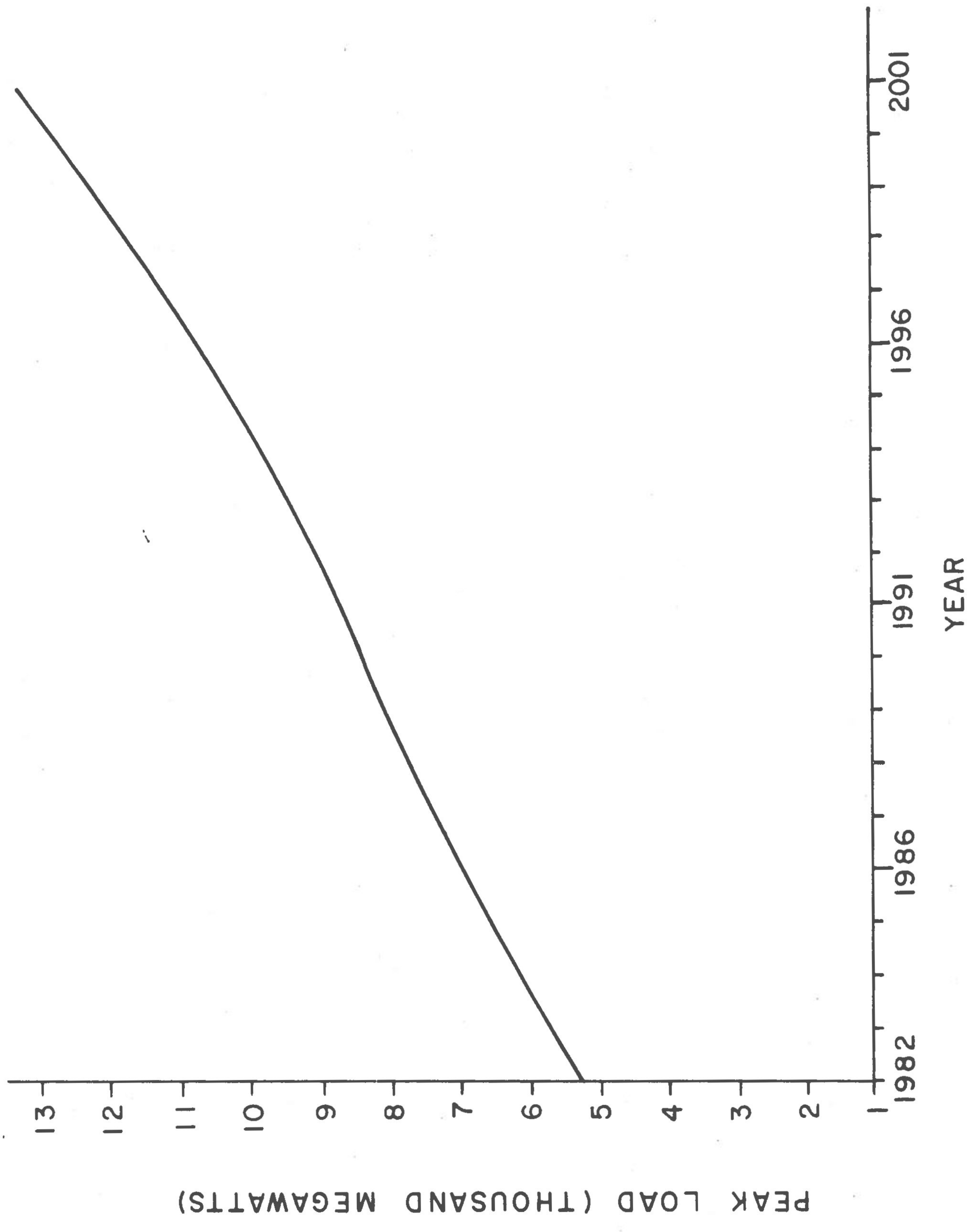


Note: This figure represents the combined loads of three utilities that most likely would be impacted by a Cache la Poudre Project output; Public Service Company of Colorado, Tri-State Generation and Transmission Association and Platte River Power Authority.

COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

TYPICAL WEEKLY LOAD
DURATION CURVE
2000 SYSTEM LOAD DATA

TUDOR ENGINEERING COMPANY   FIGURE: IV-8



COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

ROCKY MOUNTAIN POWER
AREA PROJECTED
PEAK LOAD - 1982 - 2001

TUDOR ENGINEERING COMPANY FIGURE: IV-9

CHAPTER V
FORMULATION AND SELECTION OF PRELIMINARY ALTERNATIVE PROJECTS (PHASE I)

A. INTRODUCTION

This Chapter develops the conceptual basis for identifying potential alternative projects and describes the selection of the eight preliminary alternative projects evaluated in Phase I of the study. It also describes the operation studies used in the formulation of the eight preliminary alternative projects. It concludes with a presentation of the results of the formulation in terms of descriptions of the resulting project configurations, facilities, and physical outputs and of estimates of construction costs.

B. DEVELOPMENT CONCEPTS

1. General

In identifying potential projects for consideration as preliminary alternatives, the following concepts were used:

- All potential reservoir sites considered in the study would be located upstream from the City of Fort Collins as required by S.B. 439.

- The potential reservoir sites considered in the study would be situated to control, to the maximum extent possible, the total flow in the upper basin.

- A number of potential reservoir sites would be considered individually and in various combinations as alternative projects which would exhibit a wide range of possible development.

- All potential projects would include a terminal storage reservoir for conservation storage. This terminal reservoir would be capable of storing and regulating flows to meet future agricultural and municipal and industrial water uses in the service area and to improve the overall management of the water resources of the basin.

- Potential projects could include storage reservoirs in the upper basin for the purpose of regulating flows for hydroelectric peaking power production, as well as for possible additional conservation storage.

2. Reservoirs for Conservation Storage

The ideal reservoir site for storing and regulating flows for conservation storage is at the mouth of the canyon where flows from the entire upper basin can be controlled and stored. Releases from a reservoir at this location could serve all the existing diversion points in the lower basin with the exception of the upper reaches of the North Poudre Canal, which would continue to be served by diversions from the North Fork.

The Grey Mountain Reservoir site is an advantageous site for conservation storage because of its strategic location at the mouth of the canyon. It would be capable of capturing, storing, and regulating all flows from the upper basin for release on demand to meet agricultural, municipal and industrial uses.

As formulation of potential projects proceeded, it became apparent that, with a major hydroelectric development upstream, a New Seaman Reservoir could serve as an afterbay for power development. When used as part of a peaking power project, it would also serve as a conservation storage site although not located on the mainstem. It could not serve as a single reservoir conservation storage project since it could not capture mainstem flows without a diversion structure.

The Elkhorn Reservoir site would be capable of capturing, storing, and regulating the flows from the upper mainstem and the South Fork, the bulk of the flow from the upper basin, for release on demand to meet conservation uses. In addition, it can serve as storage for hydroelectric development when combined with either Grey Mountain or New Seaman as a conservation storage reservoir.

Therefore, the three sites considered as potential conservation storage reservoirs were Grey Mountain, New Seaman, and Elkhorn.

3. Reservoirs for Hydroelectric Development

Study of the hydrology of the upper basin shows that the bulk of the upper basin flows originate in the high mountain areas of the upper reaches of the mainstem and the South Fork. Flows from the North Fork contribute only a minor portion of the total runoff from the upper basin. The North Fork, then, was not considered suitable for large scale hydroelectric development.

In addition to streamflow, hydroelectric development requires elevation differential, or head, through which the water drops to drive turbines for power and energy production. Inspection of the topography of the upper basin reveals that a major elevation differential exists along the mainstem as the river drops from the high mountains to the mouth of the canyon. Another major elevation differential exists along the South Fork as it falls from the high mountains to its confluence with the mainstem.

Therefore, efforts to identify reservoir sites to store and regulate flows for hydroelectric development concentrated on the mainstem and South Fork. Sites were investigated which would allow storage and regulation of flows from the upper reaches of these streams and would be situated so that these regulated flows could be diverted through power conduits to lower elevations thus developing the head necessary for large-scale hydroelectric development.

Considering the terminal storage reservoir as afterbay storage for hydroelectric development, reservoir sites were sought in the middle reaches of the mainstem. Some such reservoir could also serve as an afterbay for hydroelectric developments utilizing stored flows on the South Fork. Storage reservoirs identified for hydroelectric development in the middle reaches of the mainstem were Elkhorn Reservoir, Indian Meadows Reservoir, and Idylwilde Reservoir.

A reservoir on the South Fork would provide the means of storing flows from the high mountain reaches of the South Fork and serve as an afterbay for upstream mainstem power developments. This reservoir could release stored South Fork flows through a power development utilizing a reservoir in the middle reaches of the mainstem as an afterbay. The only suitable site identified on the South Fork was the Rockwell Reservoir.

Similarly, a reservoir in the upper reaches of the mainstem would provide means of storing flows from the high mountain watershed of the mainstem. Such a reservoir could release stored mainstem flows through a power development utilizing a reservoir in the middle reaches of the mainstem or on the South Fork as an afterbay. Although there are many potential sites on the upper mainstem, only one, the Upper Poudre Reservoir, was considered.

In summary, the five major reservoir sites identified for use in hydroelectric development are:

Elkhorn Reservoir, middle reaches of the mainstem.

Indian Meadows Reservoir, middle reaches of the mainstem.

Idylwilde Reservoir, middle reaches of the mainstem.

Rockwell Reservoir, on the South Fork.

Upper Poudre Reservoir, upper reaches of the mainstem.

C. SELECTION OF THE PRELIMINARY ALTERNATIVE PROJECTS

The seven potential major reservoir sites selected represent possible storage locations at various elevations that could be linked together to form potential projects to serve the functions of conservation storage and hydroelectric power generation. Fourteen potential alternative projects were initially assessed, each using combinations of any of the seven potential storage reservoirs mentioned above plus connecting power tunnels and conduits, diversion dams, power plants and power plant forebay and afterbay reservoirs. Included as one of the potential alternatives was a single reservoir project, the Grey Mountain Reservoir, which would provide conservation storage but would not include any major power development. Basic information on these 14 potential preliminary projects is shown on Table V-1.

Preliminary layouts were made for each of the potential alternatives and very preliminary cost estimates were made for all the facilities making up the

ITEM	GREY MTN. ONLY	I
MAJOR STRUCTURES		
ELKHORN RESERVOIR		
GREY MOUNTAIN RESERVOIR	X	X
IDYLWILDE RESERVOIR		X
INDIAN MEADOWS RESERVOIR		
ROCKWELL RESERVOIR		
NEW SEAMAN RESERVOIR		
UPPER POUDRE RESERVOIR		
MINOR STRUCTURES		
CACHE LA POUDRE FOREBAY		X
HAGUE DIVERSION DAM		
JOE WRIGHT DIVERSION DAM		
INDIAN MEADOWS FOREBAY		
KINIKINIK AFTERBAY		X
LITTLE BEAVER FOREBAY		
MISHAWAKA AFTERBAY		
POUDRE DIVERSION DAM		
RUSTIC DIVERSION DAM		X
RUSTIC FOREBAY		
SEAMAN FOREBAY		
SOUTH FORK DIVERSION DAM		
QUANTITY OF STRUCTURES		
NUMBER OF MAJOR STRUCTURES	1	2
NUMBER OF MINOR STRUCTURES	0	3
NUMBER OF POWER PLANTS		2
TOTAL LENGTH OF CONDUITS (MILES)	0	13.2
PRELIMINARY ESTIMATE OF DEPENDABLE CAPACITY (MW) AT A 20 PERCENT PLANT FACTOR	0	78
ESTIMATED COSTS		
TOTAL COSTS ($/MILLION)	78.5	248.2
COST/KW ($/MILLION)	N.A.	3,182
RELATIVE COST/KW	N.A.	1.30

TABLE V-1
CACHE LA POUDRE PROJECT
BASIC INFORMATION ON
POTENTIAL PRELIMINARY ALTERNATIVE PROJECTS
PHASE I

POTENTIAL ALTERNATIVE											
II	III	IV	V	VI	VIII	I-A	II-A	V-A	VI-A	VII-A	IX-A
					X						
X	X	X	X	X	X						
	X					X					
X			X	X			X	X	X	X	X
X	X	X	X	X			X	X	X	X	
						X	X	X	X	X	X
		X	X	X				X	X		
X			X	X							
X							X				
		X	X	X				X	X		
			X					X			
						X					
		X		X					X		
	X	X									
		X	X	X				X	X		
						X					
			X					X			
						X	X	X	X	X	X
	X										
3	3	3	4	4	2	2	3	4	4	3	2
2	2	4	5	4	0	3	2	5	4	1	1
2	3	2	3	3	1	2	2	3	3	2	1
22.6	20.2	25.4	33.9	32.1	8.3	14.5	24.0	35.2	33.4	16.9	14.5
122	135	175	193	190	100	58	95	158	165	75	55
364.3	365.6	443.8	472.3	503.8	253.1	227.1	339.2	444.7	479.2	299.9	224.3
2,986	2,708	2,536	2,447	2,652	2,531	3,916	3,571	2,815	2,904	3,999	4,078
1.22	1.11	1.04	1.00	1.08	1.03	1.60	1.46	1.15	1.19	1.63	1.67

project configurations. Very preliminary operation studies were performed to determine the dependable power plant capacity, energy produced and conservation water supplied.

All of the work in this first stage of the analysis was conceptual in nature and was designed to develop only enough information to provide a basis for selecting four to six preliminary alternative projects for further analysis. Since a comparison of the potential alternatives in economic terms was most readily made through a comparison of hydroelectric power development, cost effectiveness tests were made by comparing unit costs per kilowatt of dependable capacity.

The alternatives were formulated to identify four to six project configurations which would represent a range of the degree of development of the power potential in the basin and would, on the other hand, represent a range of change in the present use of the streams in the upper basin. Comparison of the cost-effectiveness of the several potential alternatives revealed that, considering the preliminary nature of the cost estimates and power potential, no one plan stood out as being particularly cost-effective or ineffective. Therefore, five potential upstream power intensive alternatives with a reasonable relative cost effectiveness were selected as representing the full range of possible power development and the full range of possible change in the present use of the streams in the basin. A sixth alternative was added to represent a plan providing only conservation storage. The six alternative projects selected for a preliminary evaluation were:

- Preliminary Alternative 1 - Grey Mountain Reservoir
- Preliminary Alternative 2 - Grey Mountain Reservoir, Idylwilde Reservoir
- Preliminary Alternative 3 - Grey Mountain Reservoir, Elkhorn Reservoir
- Preliminary Alternative 4 - New Seaman Reservoir, Indian Meadows Reservoir, Rockwell Reservoir
- Preliminary Alternative 5 - New Seaman Reservoir, Indian Meadows Reservoir, Rockwell Reservoir
- Preliminary Alternative 6 - Grey Mountain Reservoir, Indian Meadows Reservoir, Rockwell Reservoir, Upper Poudre Reservoir

Comments received from the study Advisory Committee and from the public, at public meetings held to explain the study, resulted in the addition of two alternatives which would have a lesser degree of impact on existing development in the canyon. These two alternatives were:

- Preliminary Alternative 7 - New Seaman Reservoir, Elkhorn Reservoir

- Preliminary Alternative 8 - Elkhorn Reservoir

The general project layout for these eight preliminary alternatives is shown in a single display for comparison on Figures V-1a and V-1b.

D. FORMULATION OF PRELIMINARY ALTERNATIVE PROJECTS

1. General

This section describes the operation studies and the resulting formulation of the eight preliminary alternative projects. Preliminary estimated costs for each preliminary alternative project are also presented. Since water resource development projects are long-lived, on the order of a 100-year economic life, all operation studies were carried out using future conditions projected in ten-year increments of time to the year 2030.

Formulation of the eight selected preliminary alternative projects was carried out to the extent necessary to refine the projects to a pre-reconnaissance level of detail. This involved an iterative process which utilized reservoir operation studies. These studies were performed with a computer simulation model, HEC-3, developed by the U.S. Army Corps of Engineers. The HEC-3 model performs a multipurpose routing of a reservoir system. The model can accept any configuration of reservoirs, diversions, power plants and releases to meet conservation demands and other project purposes. The model simulates the operation of a river basin and accounts for and balances all flows into and out of control points, such as reservoirs, diversions, and power plants.

In this study, the routing of flows for each preliminary alternative project was performed using monthly values for water supply as developed in Chapter III and projected water uses on a monthly basis as developed in Chapter IV. The purpose of the operation studies was to provide information concerning the sizing and configuration of the major features of each alternative project.

2. Operation Studies

In the operation studies, the monthly native streamflows and monthly transbasin imports for the entire 23-year hydrologic study period, as developed in Chapter III, and monthly values for projected agricultural and municipal and industrial water use at the year 2030, as developed in Chapter IV, were initially simulated for the hydrologic study period as if no project were constructed in the future. Facilities for each alternative project were then imposed on the system and operation of the system was simulated.

Operation studies were carried out in a manner to insure that all municipal and industrial demands were met and any shortages of water would be borne by the agricultural sector. Project outputs were measured in megawatts of dependable installed hydroelectric capacity, kilowatt-hours of hydroelectric energy produced, and acre-feet of water yield as measured as a reduction in shortages in meeting the projected agricultural water uses.

a. Assumptions

In performing the operation studies, several assumptions were necessary to simulate future conditions.

- Project facilities would be sized to control, to the maximum practical extent, the uncontrolled upper basin flows.

- Terminal storage releases would meet, to the extent possible, all conservation uses. All future municipal and industrial demands, both in the with and without project situations, would be satisfied. Any shortages would be borne by the agricultural demands. Differences in shortages to meet agricultural demands between the future with a project and the future without a project are a measure of the new water yield developed by the alternative project configuration.

- Upper basin storage reservoir releases would be controlled by power plant operation designed to produce dependable peaking capacity at a required annual plant factor of approximately 20 percent.

- Bypass flows would be released from upstream storage facilities and would be available for run-of-the-river power generation. These bypass flows would then not be available for diversion into peaking power facilities. Table V-2 shows the assumed bypass flow requirements by reaches of stream.

- Bypass flows far exceed the uses of water for conservation purposes in the upper basin and would thus adequately provide for them.

- All major upper basin reservoirs would continue to be operational, with the exception of Peterson Lake Reservoir. The City of Greeley has indicated that this reservoir would probably be abandoned in the future. Further, it was assumed that under the future with a project condition, the operation of the upper basin reservoirs could be changed to manage bypass releases and/or maximize power production.

- The lower basin reservoirs would be maintained and available to meet future agricultural demands using releases from a project terminal reservoir.

- All new project reservoirs would be full at the beginning of the 23-year hydrologic study period and must refill after the critical dry period of 1953-1956. Existing reservoirs would be drawn down to dead storage levels at the beginning of the hydrologic study period since the hydrologic study period begins October 1, when most of the reservoirs are traditionally drawn down following the irrigation season.

- The terminal storage reservoir would be used to store, within its physical limits, the entire flow entering the reservoir until some use requires it to be released. The storage of water, when possible, would be

TABLE V-2
CACHE LA POUDRE PROJECT
ASSUMED BYPASS FLOWS
(Units are Cubic Feet Per Second)

Reach		Season	
From	To	Oct-Apr	May-Sept
MAINSTEM CACHE LA POUDRE RIVER:			
1. Rocky Mountain National Park	Joe Wright Confluence	10	16
2. Joe Wright Confluence	South Fork Confluence	50	98
3. South Fork Confluence	North Fork Confluence	60	120
4. North Fork Confluence	Greeley Pipeline	65	137
SOUTH FORK CACHE LA POUDRE RIVER:			
1. Rocky Mountain National Park	Little Beaver Creek Confluence	10	10
2. Little Beaver Creek Confluence	Mainstem Confluence	10	15

done on the reservoir's own storage decree. Additional water would be stored through the use of the out-of-priority storage option.

- Decrees for alternate points of storage would be obtainable, which would further increase the amount stored in the terminal reservoir.

- Water rights in the Cache la Poudre service area that have been fulfilled historically would continue to be fulfilled through releases from the terminal storage reservoir.

- Storage rights for any Cache la Poudre Project storage reservoir would be junior to storage rights for a Lower South Platte River project, such as the Narrows Reservoir.

- Flows up to 2,600 cubic-feet per second measured at the mouth of the canyon would not be called out by a Lower South Platte River project and could be stored out-of-priority by potential Cache la Poudre Project facilities. Discussion with the Assistant Division Engineer indicated that water users on the Cache la Poudre River can utilize up to 2,600 cubic feet per second, as measured at the mouth of the canyon, under rights that are senior to those on the South Platte River. Therefore, a Lower South Platte River Project storage reservoir could not place a call on a Cache la Poudre Project terminal storage reservoir until inflows into the terminal storage reservoir exceed that amount. Furthermore, if the Lower South Platte River Project storage reservoir is spilling flows, calls cannot be made on the Cache la Poudre River even if these flows exceed 2,600 cubic feet per second. Also, if the Cache la Poudre Project terminal storage reservoir is spilling, these spills would fulfill South Platte River calls and calls would not be made on the terminal storage reservoir even if these flows exceed 2,600 cubic feet per second.

- Groundwater rights would have no material affect on the future availability of unappropriated water at potential Cache la Poudre Project facilities.

b. Model Configurations

To simulate future conditions in the basin, a schematic configuration of all existing and potential reservoirs and diversion facilities was developed as input into the model for each preliminary alternative project and for the future without a project.

For simplification of input data, the major existing upper basin reservoirs in the future with each preliminary alternative project were consolidated by reaches of stream while minor existing upper basin reservoirs were not considered in the model configuration. For the same reason, the lower basin reservoirs were consolidated into one simulated aggregate reservoir. For purposes of simplifying the simulation of release requirements for the project terminal storage reservoir while yet simulating the effects of plains reservoir storage, the selected model configuration simulated all agricultural uses as being supplied from this aggregate plains reservoir. In actuality, some small portion would be supplied by direct diversion of releases from the terminal reservoir without passing through the plains reservoirs. It was judged that this refinement in the model configuration would not have appreciably changed the release requirement from the terminal reservoir.

In the future with each preliminary alternative project, municipal and industrial demands were modelled to be met directly from the terminal storage reservoir. For the future without the project model configuration, a 12,000 acre-foot capacity Rockwell Reservoir with 10,000 acre-feet of active conservation storage was included to help satisfy the municipal and industrial uses. These uses would continue to be supplied by diversion from the river. Since specific demands must be met from individual upper basin reservoirs, consolidation of the upper basin reservoirs was not as extensive in this configuration.

Existing North Fork storage facilities were not included in the model configuration for the future with and without as they were assumed to continue their historic operations and would not substantially influence the operations of the preliminary alternative projects.

Figure V-2 shows the schematic model configuration for Alternative 1. Figure V-3 shows a typical configuration with upstream hydropower development using Alternative 6. Figure V-4 shows the configuration in the future without a project situation.

c. Results

Successive computer runs were made simulating the flows and uses for each preliminary alternative project to maximize dependable peaking power output and minimize agricultural water shortages and spills from project reservoirs. Sufficient iterations to optimize reservoir sizes, power plant capacities and agricultural water shortages were not attempted in this preliminary phase of study.

Several iterations were done with differing levels of bypass flow releases from project storage facilities. Table V-3 shows the comparison of dependable power generation and energy production with no bypass flows and with the assumed bypass flows.

When daily flows exceed 2,600 cubic feet per second at the mouth of the canyon, as noted in the discussion of water rights considerations, that excess of water could be demanded by water users outside the Cache la Poudre service area.

Correlation of the historic flow records, operation studies done by the U.S. Bureau of Reclamation for the Lower South Platte River (Narrows) Project and operation studies done during this study showed that daily flows exceeded 2,600 cubic feet per second on only 75 days during the 23 years of the hydrologic study period. The flows exceeding this amount averaged less than 2,000 acre-feet per year.

TABLE V-3
CACHE LA POUDRE PROJECT
EFFECTS OF BYPASS FLOWS
ON POWER GENERATION

	ALT. 1	ALT. 2	ALT. 3	ALT. 4	ALT. 5	ALT. 6
Dependable Capacity W. No Bypass (MW)	0	137.5	128	140.0	157.0	254.0
Dependable Capacity W. Assumed Bypass (MW)	0	103.5	91.0	100.0	116.0	166.0
Change in Dependable Capacity (MW)	0	34.0	37.0	40.0	41.0	88.0
Percent Change	-	33	41	40	35	53
Dependable Energy W. No Bypass (GWh)	0	216.4	201.4	220.4	247.0	399.7
Dependable Energy Assumed Bypass (GWh)	0	162.9	143.2	157.4	182.5	261.2
Change in Dependable Energy (GWh)	0	53.5	58.2	63.0	64.5	138.5
Percent Change	-	33	41	40	35	53

Further analysis of both operation studies showed that either the Lower South Platte Project storage reservoir or the Cache la Poudre Project terminal storage reservoir would be spilling during some of these occurrences, reducing them to 28 days and an average of 1,056 acre-feet per year. Further analysis showed that in 27 of these 28 days no shortages were indicated in the Lower South Platte Project operation studies, reducing the number of days that calls on the Cache la Poudre River from the Lower South Platte River could be made to one occurrence in the 23 year period averaging only 8 acre-feet per year. Therefore, in light of the accuracy of this study, the results indicate that a Cache la Poudre Project terminal storage reservoir would not be materially affected by calls from a Lower South Platte River Project storage reservoir.

A summary of the results of the operation studies in terms of project outputs for the eight preliminary alternative projects are shown in Tables V-4 through V-11 and for the future without a project on Table V-12. The tables summarize the outputs as average annual figures with the year 2030 water use conditions. It is felt that the year 2030 project outputs are representative of the long-term operation of a potential Cache la Poudre Project. Monthly values for the entire 23-year hydrologic study period were used in the iterative operation studies runs. The following is an explanation of the tables:

- Total storage is the total reservoir capacity used in operation studies.

- Active storage is that reservoir capacity available for project purposes, including downstream conservation uses and hydroelectric production.

- Non-active storage is that reservoir capacity not available for project purposes because of physical constraints. It includes inactive storage, dead storage and space for sediment storage.

- Inflows are average annual inflows into the project facility over the hydrologic study period, including native flows and transbasin imports.

- Bypass releases are assumed requirements for streamflows downstream from facilities for fishing, stream enhancement, or other environmental purposes.

- Peaking power releases are reservoir releases to satisfy peaking power demands and generate firm peaking energy.

- Other power releases are flows in excess of peaking power load factor requirements and bypass releases and are available to generate non-firm energy.

- Municipal and industrial releases are those made to meet all urban uses.

TOTAL STORAGE (AF)
ACTIVE STORAGE (AF)
NON-ACTIVE STORAGE (AF)
INFLOWS: (AF/YR)
OUTFLOWS: (AF/YR)
    BYPASS RELEASES
    PEAKING POWER RELEASES
    OTHER POWER RELEASES
    M & I RELEASES
    AGRICULTURAL RELEASES
    SPILLS
    EVAPORATION

SHORTAGES (AF)

YIELD OF NEW WATER (AF)

CAPACITY: (MEGAWATTS)
    DEPENDABLE PEAKING
    DEPENDABLE BASE LOAD
    INTERMITTENT

ENERGY: (GIGAWATT-HOURS/YR)
    FIRM ENERGY
    OTHER

TABLE V-4
CACHE LA POUDRE PROJECT
RESULTS OF OPERATION STUDIES
PRELIMINARY ALTERNATIVE 1
(YEAR 2030)

FACILITY	
GREY MOUNTAIN	PLAINS RESERVOIRS
200,000	175,000
190,000	155,000
10,000	20,000
281,400	222,300
--	--
--	--
207,000	--
64,800	--
--	218,600
15,300	3,700
1,700	--
--	24,100
--	16,300
--	--
--	--
12.0	--
--	--
42.5	--

	IDYLWILDE RESERVOIR
TOTAL STORAGE (AF)	200,000
ACTIVE STORAGE (AF)	183,000
NON-ACTIVE STORAGE (AF)	17,000
INFLOWS: (AF/YR)	182,100
OUTFLOWS: (AF/YR)	
BYPASS RELEASES	--
PEAKING POWER RELEASES	140,000
OTHER POWER RELEASES	40,200
M & I RELEASES	--
AGRICULTURAL RELEASES	--
SPILLS	--
EVAPORATION	2,600
SHORTAGES (AF)	--
YIELD OF NEW WATER (AF)	--
CAPACITY: (MEGAWATTS)	
DEPENDABLE PEAKING	22.0
DEPENDABLE BASE LOAD	--
INTERMITTENT	2.0
ENERGY: (GIGAWATT-HOURS/YR)	
FIRM PEAKING	34.6
OTHER	10.8

TABLE V-5
CACHE LA POUDRE PROJECT
RESULTS OF OPERATION STUDIES
PRELIMINARY ALTERNATIVE 2
(YEAR 2030)

FACILITY				
KINIKINIK AFTERBAY	RUSTIC DIVERSION	CACHE LA POUDRE FOREBAY	GREY MOUNTAIN	PLAINS RESERVOIRS
1,000	30	5,400	200,000	175,000
800	0	3,400	190,000	155,000
200	30	2,000	10,000	20,000
180,200	188,000	134,500	278,900	220,200
50,700	52,900	--	--	--
--	125,900	125,900	--	--
129,500	8,600	8,400	207,000	--
--	--	--	64,800	--
--	--	--	--	216,600
--	580	--	13,200	3,600
50	20	200	1,620	--
--	--	--	--	26,100
--	--	--	--	14,300
--	--	81.5	--	--
0.5	--	--	--	--
--	--	--	12.0	--
--	--	128.3	--	--
4.4	--	8.4	42.5	--

TOTAL STORAGE (AF)
ACTIVE STORAGE (AF)
NON-ACTIVE STORAGE (AF)

INFLOWS: (AF/YR)

OUTFLOWS: (AF/YR)
- BYPASS RELEASES
- PEAKING POWER RELEASES
- OTHER POWER RELEASES
- M & I RELEASES
- AGRICULTURAL RELEASES
- SPILLS
- EVAPORATION

SHORTAGES (AF)

YIELD OF NEW WATER (AF)

CAPACITY: (MEGAWATTS)
- DEPENDABLE PEAKING
- DEPENDABLE BASE LOAD
- INTERMITTENT

ENERGY: (GIGAWATT-HOURS/YR)
- FIRM PEAKING
- OTHER

TABLE V-6
CACHE LA POUDRE PROJECT
RESULTS OF OPERATION STUDIES
PRELIMINARY ALTERNATIVE 3
(YEAR 2030)

FACILITY

ELKHORN RESERVOIR	GREY MOUNTAIN POWER PLANT	GREY MOUNTAIN RESERVOIR	PLAINS RESERVOIRS
196,000	--	200,000	175,000
186,000	--	190,000	155,000
10,000	--	10,000	20,000
254,500	--	278,700	220,200
61,600	--	--	--
151,800	--	--	--
39,020	--	207,000	--
--	--	64,800	--
--	--	--	216,300
--	--	13,200	3,900
2,160	--	1,590	--
--	--	--	26,400
--	--	--	14,000
--	91.0	--	--
1.3	--	--	--
--	--	12.0	--
--	143.5	--	--
11.4	36.9	42.5	--

	ROCKWELL RESERVOIR
TOTAL STORAGE (AF)	40,000
ACTIVE STORAGE (AF)	35,000
NON-ACTIVE STORAGE (AF)	5,000
INFLOWS: (AF/YR)	43,000
OUTFLOWS: (AF/YR)	
BYPASS RELEASES	8,760
PEAKING POWER RELEASES	26,300
OTHER POWER RELEASES	6,900
M & I RELEASES	--
AGRICULTURAL RELEASES	--
SPILLS	--
EVAPORATION	780
SHORTAGES (AF)	--
YIELD OF NEW WATER (AF)	--
CAPACITY: (MEGAWATTS)	
DEPENDABLE PEAKING	11.3
DEPENDABLE BASE LOAD	--
INTERMITTENT	--
ENERGY: (GIGAWATT-HOURS/YR)	
FIRM PEAKING	17.8
OTHER	4.7

TABLE V-7
CACHE LA POUDRE PROJECT
RESULTS OF OPERATION STUDIES
PRELIMINARY ALTERNATIVE 4
(YEAR 2030)

	FACILITY		
INDIAN MEADOWS RESERVOIR	CACHE LA POUDRE FOREBAY	NEW SEAMAN RESERVOIR	PLAINS RESERVOIR
190,000	5,400	200,000	175,000
180,000	3,000	190,000	155,000
10,000	2,400	10,000	20,000
223,400	168,600	205,500	218,300
52,900	--	--	--
151,100	151,100	--	--
17,500	17,500	125,700	--
--	--	64,800	--
--	--	--	215,100
--	--	20,100	2,900
1,890	170	1,400	--
--	--	--	27,600
--	--	--	12,800
--	88.7	--	--
1.0	--	--	--
--	--	8.0	--
--	139.6	--	--
8.8	16.0	29.0	--

TABLE V-8
CACHE LA POUDRE PROJECT
RESULTS OF OPERATION STUDIES
PRELIMINARY ALTERNATIVE 5
(YEAR 2030)

	FACILITY					
	HAGUE DIVERSION	ROCKWELL RESERVOIR	INDIAN MEADOWS RESERVOIR	CACHE LA POUDRE FOREBAY	NEW SEAMAN RESERVOIR	PLAINS RESERVOIRS
TOTAL STORAGE (AF)	10	86,000	58,000	5,400	200,000	175,000
ACTIVE STORAGE (AF)	0	81,000	48,000	3,000	190,000	155,000
NON-ACTIVE STORAGE (AF)	10	5,000	10,000	2,400	10,000	20,000
INFLOWS: (AF/YR)	89,500	121,400	222,700	158,800	195,500	217,200
OUTFLOWS: (AF/YR)						
Bypass Releases	10,700	8,800	52,900	--	--	--
Peaking Power Releases	52,100	84,300	121,000	121,000	--	--
Other Power Releases	26,700	26,700	37,800	37,600	116,600	--
M & I Releases	--	--	--	--	64,800	--
Agricultural Releases	--	--	--	--	--	213,600
Spills	--	--	10,060	--	17,900	3,060
Evaporation	--	1,430	990	200	1,510	--
SHORTAGES (AF)	--	--	--	--	--	29,100
YIELD OF NEW WATER (AF)	--	--	--	--	--	11,300
CAPACITY: (MEGAWATTS)						
Dependable Peaking	--	45.0	--	71.0	--	--
Dependable Base Load	--	--	0.7	--	--	--
Intermittent	--	--	--	--	8.0	--
ENERGY: (GIGAWATT-HOURS/YR)						
Firm Peaking	--	70.8	--	111.7	--	--
Other	--	22.4	5.8	34.7	29.0	--

	UPPER POUDRE RESERVOIR	JOE WRIGHT DIVERSION
TOTAL STORAGE (AF)	97,000	30
ACTIVE STORAGE (AF)	87,000	0
NON-ACTIVE STORAGE (AF)	10,000	30
INFLOWS: (AF/YR)	104,000	33,600
OUTFLOWS: (AF/YR)		
Bypass Releases	50,770	--
Peaking Power Releases	51,980	13,900
Other Power Releases	--	19,700
M & I Releases	--	--
Agricultural Releases	--	--
Spills	--	--
Evaporation	1,070	--
SHORTAGES (AF)	--	--
YIELD OF NEW WATER (AF)	--	--
CAPACITY: (MEGAWATTS)		
Dependable Peaking	--	--
Dependable Base Load	--	--
Intermittent	--	--
ENERGY: (GIGAWATT-HOURS/YR)		
Firm Peaking	--	--
Other	--	--

TABLE V-9
CACHE LA POUDRE PROJECT
RESULTS OF OPERATION STUDIES
PRELIMINARY ALTERNATIVE 6
(YEAR 2030)

		FACILITY				
POUDRE DIVERSION	LITTLE BEAVER FOREBAY	ROCKWELL RESERVOIR	INDIAN MEADOWS RESERVOIR	CACHE LA POUDRE FOREBAY	GREY MOUNTAIN RESERVOIR	PLAINS RESERVOIRS
20	800	50,000	58,000	5,400	200,000	175,000
0	600	45,000	48,000	3,000	190,000	155,000
20	200	5,000	10,000	2,400	10,000	20,000
141,300	94,500	133,300	221,900	165,600	277,700	219,000
50,770	--	8,800	52,900	--	--	--
70,830	74,800	99,300	138,500	138,500	--	--
19,700	19,650	24,100	28,100	26,900	207,000	--
--	--	--	--	--	64,800	--
--	--	--	--	--	--	215,300
--	--	--	1,420	--	12,000	3,690
--	--	920	960	200	1,560	--
--	--	--	--	--	--	27,400
--	--	--	--	--	--	13,000
--	26.2	50.7	--	89.1	--	--
--	--	--	0.7	--	--	--
--	--	--	--	--	12.0	--
--	41.2	79.8	--	140.2	--	--
--	10.9	19.4	5.8	27.2	42.5	--

TOTAL STORAGE (AF)
ACTIVE STORAGE (AF)
NON-ACTIVE STORAGE (AF)

INFLOWS: (AF/YR)
OUTFLOWS: (AF/YR)
- BYPASS RELEASES
- PEAKING POWER RELEASES
- OTHER POWER RELEASES
- M & I RELEASES
- AGRICULTURAL RELEASES
- SPILLS
- EVAPORATION

SHORTAGES (AF)

YIELD OF NEW WATER (AF)

CAPACITY: (MEGAWATTS)
- DEPENDABLE PEAKING
- DEPENDABLE BASE LOAD
- INTERMITTENT

ENERGY: (GIGAWATT-HOURS/YR)
- FIRM PEAKING
- OTHER

TABLE V-10
CACHE LA POUDRE PROJECT
RESULTS OF OPERATION STUDIES
PRELIMINARY ALTERNATIVE 7
(YEAR 2030)

FACILITY			
ELKHORN RESERVOIR	NEW SEAMAN POWER PLANT	NEW SEAMAN RESERVOIR	PLAINS RESERVOIRS
196,000	--	200,000	175,000
186,000	--	190,000	155,000
10,000	--	10,000	20,000
254,500	--	216,400	217,600
61,600	--	--	--
144,200	--	--	--
46,500	--	130,800	--
--	--	64,800	--
--	--	--	215,400
--	--	19,300	2,200
2,160	--	1,540	--
--	--	--	27,200
--	--	--	13,100
--	79.0	--	--
1.3	--	--	--
--	--	8.0	--
--	124.3	--	--
11.4	40.1	29.3	--

TOTAL STORAGE (AF)
ACTIVE STORAGE (AF)
NON-ACTIVE STORAGE (AF)

INFLOWS: (AF/YR)

OUTFLOWS: (AF/YR)
- BYPASS RELEASES
- PEAKING POWER RELEASES
- OTHER POWER RELEASES
- M & I RELEASES
- AGRICULTURAL RELEASES
- SPILLS
- EVAPORATION

SHORTAGES (AF)

YIELD OF NEW WATER (AF)

CAPACITY: (MEGAWATTS)
- DEPENDABLE PEAKING
- DEPENDABLE BASE LOAD
- INTERMITTENT

ENERGY: (GIGAWATT-HOURS/YR)
- FIRM ENERGY
- OTHER

TABLE V-11
CACHE LA POUDRE PROJECT
RESULTS OF OPERATION STUDIES
PRELIMINARY ALTERNATIVE 8
(YEAR 2030)

FACILITY	
ELKHORN	PLAINS RESERVOIRS
196,000	175,000
186,000	155,000
10,000	20,000
254,400	219,700
--	--
--	--
173,500	--
64,800	--
--	216,700
20,100	2,600
1,400	--
--	26,000
--	14,400
--	--
--	--
14.0	--
--	--
47.3	--

TABLE V-12
CACHE LA POUDRE PROJECT
RESULTS OF OPERATION STUDIES
FUTURE WITHOUT A PROJECT
(YEAR 2030)

	ROCKWELL RESERVOIR	URBAN DIVERSION FROM RIVER	PLAINS RESERVOIRS
TOTAL STORAGE (AF)	12,000	--	175,000
ACTIVE STORAGE (AF)	10,000	--	150,000
NON-ACTIVE STORAGE (AF)	2,000	--	20,000
INFLOWS: (AF/YR)	42,700	280,200	216,100
OUTFLOWS: (AF/YR)			
Bypass Releases	--	--	--
Peaking Power Releases	--	--	--
Other Power Releases	--	--	--
M & I Releases	29,610	64,100	--
Agricultural Releases	--	--	203,300
Spills	12,800	216,100	12,480
Evaporation	290	--	--
SHORTAGES (AF) --	700	40,400 1/	
CAPACITY: (MEGAWATTS)			
Dependable Peaking	--	--	--
Dependable Base Load	--	--	--
Intermittent	--	--	--
ENERGY: (GIGAWATT-HOURS/YR			
Firm Peaking	--	--	--
Other	--	--	--

1/ Year 2000 shortages are estimated to be 37,500 acre-feet per year. The relatively small change between 2000 and 2030 is due to offsetting factors of reduction in acreage and reduction in water supply as urban development encroaches on irrigated lands.

- Agricultural releases are those available to meet lower basin irrigation uses. (As explained earlier, because of the simplified model configuration used, these are shown to be met entirely by releases from the plains reservoirs.)

- Spills are flows in excess of other release requirements when project reservoirs are full.

- Evaporation is the amount of water lost through evaporation from the surfaces of potential reservoirs.

- Shortages are the deficiencies of project releases to meet the total agricultural water use in the lower basin.

- Yield of new water is by definition the difference in shortages between the future without a project and the future with the alternative project.

- Dependable peaking capacity is the hydroelectric capacity available 100 percent of the time for the peaking power plants to operate at an average annual load factor of approximately 20 percent. For purposes of simplification, an availability of 100 percent was used in this preliminary stage of study. In actuality, a criteria of 90 percent availability is accepted by the power industry.

- Dependable base load capacity is the hydroelectric capacity available from downstream bypass flow requirements and has a high degree of availability.

- Intermittent capacity is the hydroelectric capacity available from flows in excess of peaking power requirements and bypass releases including releases of flows for conservation uses.

- Firm peaking energy is the energy produced by the dependable capacity of the peaking power plants.

- Other energy is the energy produced by dependable base load and intermittent capacity of the power plants.

Table V-13 summarizes the project outputs for the eight preliminary alternative projects. Yield of new water is equal to the difference in agricultural shortages between the future with the preliminary alternative project and the future without a project. The future without a project scenario has a new 12,000 acre-foot Rockwell Reservoir to help satisfy future municipal and industrial demands. In addition to providing future regulation for acquired water rights, this reservoir would yield an additional 300 acre-feet of new water. The yield shown in Table V-13 includes this 300 acre-feet of yield.

TABLE V-13
CACHE LA POUDRE PROJECT
SUMMARY OF PROJECT OUTPUTS

Preliminary Alternative	Hydroelectric Peaking Capacity (MW)	Hydroelectric Non-Peaking Capacity (MW)	Hydroelectric Energy (GWh)	M&I Water Releases (Ac-Ft)	Agricultural[1/] Water Releases (Ac-Ft)	Yield Of New Water (Ac-Ft)
1	0	12	42.5	64,800	218,600	16,300
2	103.5	14.5	229.0	64,800	216,600	14,300
3	91.0	13.3	234.0	64,800	216,300	14,000
4	100.0	9.0	215.9	64,800	215,100	12,800
5	116.0	8.7	274.4	64,800	213,600	11,300
6	166.0	12.7	367.0	64,800	215,300	13,000
7	79.0	9.3	205.1	64,800	215,400	13,100
8	0	14	47.3	64,800	216,700	14,400

1/ The North Poudre Canal diverts an additional average of approximately 27,000 acre-feet per year from the North Fork.

3. Description of Potential Major Reservoir Sites

a. Grey Mountain Dam

The Grey Mountain Damsite would be located on the mainstem of the Cache la Poudre River about 2 miles downstream from the Fort Collins Water Treatment plant. This dam and reservoir is included in Preliminary Alternatives 1, 2, 3 and 6. The dam would be a 395 foot high roller compacted concrete gravity structure with a spillway design discharge capacity of 570,000 cubic feet per second. The reservoir would have a total storage capacity of 200,000 acre-feet of which 190,000 acre-feet would be active conservation storage. The reservoir would extend to just downstream of the Town of Poudre Park on the mainstem and about three miles upstream from Milton Seaman Dam on the North Fork.

b. New Seaman Dam

The New Seaman Damsite, located on the North Fork of the Cache la Poudre River immediately upstream from the Fort Collins Treatment Plant, is included in Preliminary Alternatives 4, 5, and 7. The dam would be a 390 foot high roller compacted concrete gravity structure with a spillway design discharge capacity of 410,000 cubic feet per second. The reservoir would have a total storage capacity of 200,000 acre-feet of which 190,000 acre-feet would be active conservation storage. The reservoir would extend about six miles up the North Fork to the old town site of Livermore.

c. Elkhorn Dam

The Elkhorn Damsite is included in Preliminary Alternatives 3, 7, and 8. It is located on the Cache la Poudre River at the upper end of the Big Narrows, about two miles downstream from its confluence with the South Fork. The dam would be a 455 foot high roller compacted concrete gravity structure with a spillway design discharge capacity of 360,000 cubic feet per second. The reservoir would have a total storage capacity of 196,000 acre-feet of which 186,000 acre-feet would be active conservation storage. The reservoir would extend upstream about seven miles to the town of Eggers.

d. Indian Meadows Dam

The Indian Meadows Damsite, located on the Cache la Poudre River about 4 miles downstream from the town of Rustic, is included in alternatives 4, 5, and 6. The dam for Preliminary Alternative 4 would be a 415 foot high roller compacted concrete gravity structure. The reservoir would have a total storage capacity of 190,000 acre-feet of which 180,000 acre-feet would be active conservation storage. The reservoir would extend about two miles upstream of the town of Rustic. The dam for Preliminary Alternatives 5 and 6 would be a 275 foot high roller compacted concrete gravity structure. The reservoir would have a total storage capacity of 58,000 acre-feet of which 48,000 acre-feet would be active conservation storage. The reservoir would extend upstream about 3 miles to a point just downstream of the town of Rustic. Both the alternative dams would have a spillway design discharge capacity of 278,000 cubic feet per second.

e. Rockwell Dam

The Rockwell Damsite, located on the South Fork of the Cache la Poudre River about 6 air miles from it's confluence with the mainstem of the Cache la Poudre River is included in Preliminary Alternatives 4, 5, and 6. The dam in each alternative would be a roller compacted concrete gravity structure with a spillway design discharge capacity of 165,000 cubic feet per second. The dam for Preliminary Alternatives 4, 5, and 6 would have dam heights of 260, 325 and 280 feet, respectively. The reservoir for Preliminary Alternative 4 would have a total storage capacity of 40,000 acre-feet and an active conservation storage of 35,000 acre-feet and would extend approximately 3.5 miles upstream on the South Fork. The reservoir for Preliminary Alternative 5 would have a total storage capacity of 86,000 acre-feet and an active conservation storage capacity of 81,000 acre-feet and extend about 5 miles upstream on the South Fork. The reservoir for Preliminary Alternative 6 would have a total storage capacity of 50,000 acre-feet and an active conservation storage capacity of 45,000 acre-feet and would extend about 4 miles upstream on the South Fork.

f. Idylwilde Dam

The Idylwilde Damsite, located on the mainstem of the Cache la Poudre River about 5 miles upstream of the town of Rustic, is included only in Preliminary Alternative 2. The dam would be a 310-foot high roller compacted concrete gravity structure with a spillway design discharge capacity of 260,000 cubic feet per second. The reservoir would have a total storage capacity of 200,000 acre-feet of which 183,000 acre-feet would be active conservation storage. The reservoir would extend about 8 miles upstream from the dam to a point just upstream of the Sleeping Elephant Campground.

g. Upper Poudre Dam

The Upper Poudre Damsite is located on the mainstem of the Cache la Poudre River about four miles upstream of its confluence with Joe Wright Creek. It is included only in Preliminary Alternative 6. The dam would be a 420-foot high roller compacted concrete gravity structure with a spillway discharge design capacity of 150,000 cubic feet per second. The reservoir would have a total capacity of 97,000 acre-feet of which 87,000 acre-feet would be active conservation storage. The reservoir would extend about four miles upstream of the dam.

4. Description of Preliminary Alternative Projects

a. Preliminary Alternative 1

Preliminary Alternative 1 would have only one major feature, a 200,000 acre-foot Grey Mountain Reservoir. This reservoir would store flows from the total upper basin for eventual release to the river to serve conservation uses in the lower basin. A 12.0 megawatt Grey Mountain Dam power plant would generate power using these flows. These flows would occur mainly during the irrigation season and would produce some intermittent dependable capacity. A total of 42,500,000 kilowatt-hours of energy would be produced by this alternative. Grey Mountain Reservoir would supply 64,800 acre-feet of water per year for municipal and industrial uses and 218,600 acre-feet of water per year for agricultural uses. It would produce a yield of 16,300 acre-feet of water per year of new water.

b. Preliminary Alternative 2

Preliminary Alternative 2 is basically the scheme studied by the U.S. Bureau of Reclamation in the early 1960's. It would include two large mainstem storage reservoirs, Grey Mountain and Idylwilde, each with 200,000 acre-feet of total storage. It would also include Kinikinik Afterbay Dam, Rustic Diversion Dam and Cache la Poudre Forebay Dam. Mainstem flow would be stored at Idylwilde Reservoir for release through a 24.0 megawatt Idylwilde Dam Power Plant which would provide 22.0 megawatts of dependable peaking capacity. These power releases would be stored at Kinikinik Afterbay Dam for continual release to the river. This flow, with the exception of downstream bypass releases, would be diverted into a tunnel and conduit at Rustic Diversion Dam. The conduit would carry the flow to Cache la Poudre Forebay Reservoir where it would be stored temporarily for release to the Grey Mountain Power Plant, an 81.5 megawatt peaking power plant. Grey Mountain Reservoir would serve as an afterbay for this power plant and would store the flows for eventual release to serve conservation uses in the lower basin. A 0.5 megawatt Kinikinik Dam Power Plant would produce dependable base load capacity using the downstream bypass releases and a 12.0 megawatt Grey Mountain Dam Power Plant would provide intermittent dependable capacity using the releases to serve conservation needs. This alternative would provide a total of 103.5 megawatts of dependable peaking capacity and 14.5 megawatts of non-peaking capacity. The total energy production would average 229,000,000 kilowatt-hours per year. Grey Mountain Reservoir would supply 64,800 acre-feet of water per year for municipal and industrial uses and 216,600 acre-feet of water per year for agricultural uses. It would produce a yield of 14,300 acre-feet per year of new water.

c. Preliminary Alternative 3

Preliminary Alternative 3 would include two large mainstem storage reservoirs, Grey Mountain with 200,000 acre-feet of total storage and Elkhorn with 196,000 acre-feet of total storage. Mainstem and South Fork flows would be stored at Elkhorn Reservoir and released directly through a power tunnel to Grey Mountain Power Plant, a 91.0 megawatt peaking power plant. Downstream bypass flows would be released to the river from Elkhorn Dam Power Plant to provide 1.3 megawatts of dependable base load capacity. Grey Mountain Reservoir would serve as an afterbay for the peaking power plant and would store the flows for eventual release to serve conservation uses in the lower basin. These flows would pass through a 12.0 megawatt Grey Mountain Dam Power Plant to provide intermittent dependable capacity. This alternative would provide a total of 91.0 megawatts of dependable peaking capacity and 13.3 megawatts of non-peaking capacity. The total energy production would average 234,000,000 kilowatt-hours per year. Grey Mountain Reservoir would supply 64,900 acre-feet of water per year for municipal and industrial uses and 216,300 acre-feet of water per year for agricultural uses. It would produce a yield of 14,000 acre-feet per year of new water.

d. Preliminary Alternative 4

Preliminary Alternative 4 would include three large storage reservoirs; New Seaman on the North Fork with 200,000 acre-feet of active storage, Indian Meadows on the mainstem with 190,000 acre-feet of total storage and Rockwell on the South Fork with 40,000 acre-feet of total storage. Upper South Fork flows would be stored at Rockwell Reservoir and released through a power tunnel to Indian Meadows Power Plant, an 11.3 megawatt peaking power plant. These flows, combined with the upper mainstem flows, would be stored at Indian Meadows Reservoir for release through a tunnel and conduit to Cache la Poudre Forebay Reservoir. Here, flows would be stored temporarily for release to New Seaman Power Plant, an 88.7 megawatt peaking power plant.

New Seaman Reservoir would serve as an afterbay for the power plant and would store the flows for eventual release to serve conservation needs in the lower basin. Downstream bypass flows would be released from Rockwell Reservoir directly to the South Fork. Downstream bypass flows from Indian Meadows Reservoir would pass through Indian Meadows Dam Power Plant which would provide 1.0 megawatt of dependable base load capacity. Conservation releases from New Seaman Reservoir would provide 8.0 megawatts of intermittent dependable capacity at New Seaman Dam Power Plant. This alternative would provide a total 100 megawatts of dependable peaking capacity and 9.0 megawatts of non-peaking capacity. It could produce an average of 215,900,000 kilowatt-hours of energy per year. New Seaman Reservoir would supply 64,800 acre-feet of water per year for municipal and industrial uses and 215,100 acre-feet of water per year for agricultural uses. It would produce a yield of 12,800 acre-feet of new water per year.

e. Preliminary Alternative 5

Preliminary Alternative 5 would include three large storage reservoirs; New Seaman on the North Fork with 200,000 acre-feet of total storage, Indian Meadows on the mainstem with 58,000 acre-feet of total storage, and Rockwell on the South Fork with 86,000 acre-feet of total storage. It would also include Hague Diversion Dam and Cache la Poudre Forebay Dam. Flows from the upper mainstem would be diverted at Hague Diversion Dam into a tunnel to existing Comanche Reservoir in the South Fork drainage. These flows would pass through Comanche Reservoir and, combined with flows from the upper South Fork, would be stored at Rockwell Reservoir and released through a power tunnel to Indian Meadows Power Plant, a 45.0 megawatt peaking power plant. The flows from this power plant, combined with the remaining flows from the upper mainstem, would be stored at Indian Meadows Reservoir for release through a tunnel and conduit to Cache la Poudre Forebay Reservoir. Here the flows would be temporarily stored for release to New Seaman Power Plant, a 71.0 megawatt peaking power plant.

New Seaman Reservoir would serve as an afterbay for this power plant and would store flows for eventual releases to serve conservation needs in the lower basin. Downstream bypass flows from Rockwell Reservoir would be released directly to the South Fork. Downstream bypass flows from Indian Meadows Reservoir would pass through Indian Meadows Dam Power Plant which would provide 0.7 megawatts of dependable base load capacity. Conservation releases from New Seaman Reservoir would pass through New Seaman Dam Power Plant which would provide 8.0 megawatts of intermittent dependable capacity. This alternative would provide a total of 116.0 megawatts of dependable peaking capacity and 8.7 megawatts of non-peaking capacity. It would produce an average of 274,400,000 kilowatt-hours of energy per year. New Seaman Reservoir would supply 64,800 acre-feet of water per year for municipal and industrial uses and 213,600 acre-feet of water per year for agricultural uses. It would produce a yield of 11,300 acre-feet of new water per year.

f. Preliminary Alternative 6

Preliminary Alternative 6 would include four large storage reservoirs; Grey Mountain on the lower mainstem with 200,000 acre-feet of total storage, Indian Meadows on the middle mainstem with 58,000 acre-feet of total storage, Upper Poudre on the upper mainstem with 97,000 acre-feet of total storage and Rockwell on the South Fork with 50,000 acre-feet of total storage. It would also include Joe Wright Diversion Dam, Poudre Diversion Dam, Little Beaver Forebay Dam, and Cache la Poudre Forebay Dam.

Flows from upper Joe Wright Creek would be diverted at Joe Wright Diversion Dam through a tunnel to the upper mainstem. Flows from the upper mainstem would be stored at Upper Poudre Reservoir and released to be combined with the flows diverted from Joe Wright Creek to be diverted to the South Fork drainage through a tunnel at Poudre Diversion Dam. Outflow from this tunnel would be stored at Little Beaver Forebay Dam for release through a power conduit to Rockwell Power Plant, a 26.2 megawatt peaking power plant. Flows from the upper South Fork would be combined with releases from this power plant and stored at Rockwell Reservoir. Rockwell Reservoir storage would be released through a power tunnel to Indian Meadows Power Plant, a 50.7 megawatt peaking power plant. The flows from this power plant combined with the remaining flows from the upper mainstem, would be stored at Indian Meadows Reservoir for release through a tunnel and conduit to Cache la Poudre Forebay Dam. Here, flows would be temporarily stored for release to Grey Mountain Power Plant; an 89.1 megawatt peaking power plant.

Grey Mountain Reservoir would serve as an afterbay for this power plant and would store the flows for eventual release to serve conservation needs in the lower basin. Downstream bypass flows from Upper Poudre Reservoir and Rockwell Reservoir would be released directly to the streams, while those from Indian Meadows Reservoir would pass through Indain Meadows Dam Power Plant which would provide 0.7 megawatts of dependable base load capacity. Conservation releases from Grey Mountain Reservoir would provide 12.0 megawatts of intermittent dependable capacity at Grey Mountain Dam Power Plant.

This alternative would provide a total of 166.0 megawatts of dependable peaking capacity and 12.7 megawatts of non-peaking capacity. It would produce 367,000,000 kilowatt-hours of energy per year. Grey Mountain Reservoir would supply 64,800 acre-feet of water per year for municipal and industrial uses and 215,300 acre-feet of water per year for agricultural uses. It would produce a yield of 13,000 acre-feet of new water per year.

g. Preliminary Alternative 7

Preliminary Alternative 7 would include two large storage reservoirs, New Seaman with 200,000 acre-feet of total storage and Elkhorn with 196,000 acre-feet of total storage. Mainstem and South Fork flows would be stored at Elkhorn Reservoir and released directly through a power tunnel to New Seaman Power Plant, a 79.0 megwatt peaking power plant. Downstream bypass flows would be released to the river from Elkhorn Dam Power Plant and would provide 1.3 megawatts of dependable base load capacity. New Seaman Reservoir would serve as an afterbay for the peaking power plant and would store the flows for eventual release to serve conservation uses in the lower basin. These flows would pass through a 8.0 megawatt New Seaman Dam Power Plant to provide intermittent dependable capacity. This alternative would provide a total of 79.0 megawatts of dependable peaking capacity and 9.3 megawatts of non-peaking capacity. The total energy production would average 205,100,000 kilowatt-hours per year. New Seaman Reservoir would supply 64,800 acre-feet of water per year for municipal and industrial uses and 215,400 acre-feet of water per year for agricultural uses. It would produce a yield of 13,100 acre-feet per year of new water.

h. Preliminary Alternative 8

Preliminary Alternative 8 would have only one major feature, a 196,000 acre-foot capacity Elkhorn Reservoir. This reservoir would store flows from the South Fork and upper mainstem for eventual release to the river to serve conservation uses in the lower basin. A 14.0 megawatt Elkhorn Dam Power Plant would generate power using these flows. These flows would occur mainly during the irrigation season and would produce some intermittent dependable capacity. An average of 47,300,000 kilowatt-hours of energy would be produced annually by this alternative. Elkhorn Reservoir would supply 64,800 acre-feet of water per year for municipal and industrial uses and 216,700 acre-feet of water per year for agricultural uses. It would produce a yield of 14,400 acre-feet of water per year of new water.

5. Costs of Preliminary Alternative Projects

a. General

All estimated project costs used in the comparative evaluation of the eight preliminary alternative projects are, by nature of the level of study in Phase I, very preliminary cost estimates. Care should be exercised, therefore, in not attaching too much significance to them in terms of absolute costs. They are meaningful primarily for use in the comparative evaluation of the eight alternatives and are only indicative of a magnitude of absolute costs. All cost estimates reflect January 1982 price levels.

b. Engineering Geology

The preliminary study of engineering geology for this first phase of the study consisted of a review of existing geologic data and previous geological studies, interpretation of available aerial photographs and a visit to the sites of potential facilities by Tudor geologists.

Numerous previous studies have been performed in the upper basin. Of particular note are geologic maps of the study area done by the U.S. Geological Survey and others [15, 16, 17, 18, 19, 20]. Several studies of water resources development in the upper basin have been undertaken [21, 22, 23, 24, 25, 26, 27, 28, 29].

In addition, aerial photographs flown in 1980 by R & D Aerographics, Inc. of Loveland, Colorado for the Northern Colorado Water Conservancy District were acquired. The photos are 1:6,000 scale steroscopic pairs covering the area of all potential storage dams, diversion dams, afterbay dams and forebay dams considered in the potential alternative projects.

All of the potential facilities are located on Precambrian crystalline rocks of the Front Range geomorphic province. These igneous and metamorphic rocks are generally hard and massive. Locally the rocks are jointed and faulted, however, they are basically very strong rocks that are well suited for tunnels and damsites. Although these crystalline rocks are relatively similar throughout the drainage basin, site specific considerations associated with each potential facility could affect, to some degree, the estimated cost of constructing a particular potential facility.

As a result of these preliminary engineering geology studies, it was concluded that there are no identified significant geological or geotechnical problems that would preclude construction of the dams, diversion dams, powerhouses, tunnels and conduits investigated as potential facilities in the preliminary alternative projects investigated. Geological structures and forms were considered in so far as they would affect the estimated costs for construction of the facilities.

c. Design Considerations

In order to maintain consistency throughout the various potential and preliminary alternatives analyzed in Phase I, certain criteria were established as they applied to each of the potential project facilities. A discussion of these criteria is included in the following paragraphs.

Two types of dam structures were evaluated; rockfill dams and roller compacted concrete gravity dams. Recent advances in the construction methods of concrete dams have made the costs of the roller compacted concrete dams very attractive and, in fact, resulted in significantly lower costs than rockfill structures. Earthfill dams were not considered due to the general lack of sufficient quantities of earthfill materials. Additionally, the more complex types of concrete dams were not considered in this preliminary phase. Because of foundation conditions, it appears that it would be technically feasible to consider concrete gravity dams at all sites. Concrete gravity dams are well suited to be designed to pass extremely large floods over the dam without failure.

The conceptual design of the rockfill dams assumed a 20-foot crest width, and a narrow impervious core having 1/2:1 side slopes to provide a barrier to prevent seepage. The entire structure was founded on sound rock to avoid the possibility of piping of foundation materials into the voids in the rockfill. Outlet works, and overflow emergency spillways were included in the conceptual designs for rockfill dams.

The conceptual design of the roller compacted concrete gravity dams assumed a 15-foot crest width, a vertical upstream face and a 0.7:1 downstream face. The entire structure was founded on sound rock. The outlet works were considered to be an integral part of the dam as was the overflow spillway which would be formed as a part of the dam. All dams were designed to have a maximum of 30 feet of flow over the crest of the spillway and 5 feet of freeboard.

Preliminary spillway sizes were established so that the spillway would pass the inflow design flood, either over concrete dams or over emergency spillways associated with rockfill dams, rather than provide costly flood/storage space in the reservoir.

Diversion dams were considered in some potential project configurations to divert natural streamflows or releases from storage reservoirs into power conduits. These diversion dams were designed to be low concrete overflow dams and were considered in the operation studies to hold no carry-over storage.

Where it was advantageous from the standpoint of power conduit sizing in relation to power plant size and operation, forebay dams were included to reregulate flows into power plants on a daily basis. These forebays were sized to provide from two to three days storage for power plant operation and were designed as low concrete gravity overflow dams.

Where project configurations resulted in releases of flows from daily peaking power operation directly into the river, afterbay dams were provided to store flows on a daily basis to smooth out releases to the river. These afterbay dams were designed as low concrete gravity overflow dams.

Concrete lined circular tunnels were sized to maintain flows below a maximum velocity of 10-feet per second. The minimum tunnel size, based on construction constraints, was assumed to be 12 feet in diameter.

Prestressed concrete penstocks were designed to carry velocities of 15-feet per second with no constraint on minimum size.

Power plants and switchyards were designed as above ground facilities although underground plants may be preferable and should be investigated in future studies. For this stage of the study, power plants were evaluated based on their dependable capacity. Dependable capacity, for this study, is defined as that power that can be produced 100 percent of the time at an average annual plant factor of approximately 20 percent during the study period, including the most adverse series of months within the hydrologic study period.

d. Construction Costs

Construction cost estimates for the eight preliminary alternatives are shown in Table V-14. Construction costs for major dams are based on estimated quantities and recent bid prices and estimates for roller compacted concrete dams by the U.S. Army Corps of Engineers, U.S. Bureau of Reclamation and Tudor Engineering Company.

Construction costs for major relocations includes a preliminary estimate of right-of-way acquisition, major road relocations and relocation of major facilities such as the Fort Collins Treatment plant and the State fish hatchery near Idylwilde.

Construction costs for diversion, forebay and afterbay dams are based on estimated quantities and recent cost experience for construction of similar facilities.

Construction costs of tunnels was based on recent bid documents for similiar tunnels constructed in similar geological conditions. Cost of conduits were based on recent bidding information for similar concrete and steel pipelines.

Construction costs for power facilities, such as power plants, switchyards and transmission lines were based on cost estimating curves of the U.S. Army Corps of Engineers and U.S. Bureau of Reclamation.

Construction costs shown include an allowance for unlisted items and contingencies that may arise during construction because of unforeseen site conditions.

e. Interest During Construction

Interest during construction, shown on Table V-14, is the cost of financing construction of various project facilities over the construction period.

Table V-14 also shows the assumed development schedule for each of the alternatives. The schedule includes estimated time periods for feasibility study, a period to comply with the required Federal and State permitting processes, final design and the estimated construction period. The

TABLE V-14
CACHE LA POUDRE PROJECT
SUMMARY OF CONSTRUCTION COSTS, CONSTRUCTION SCHEDULE
INTEREST DURING CONSTRUCTION, AND O M AND R COSTS
(COSTS ARE IN THOUSANDS OF DOLLARS)

	ALTERNATIVE								FUTURE WITHOUT PROJECT
	1	2	3	4	5	6	7	8	
CONSTRUCTION COSTS									
MAJOR DAM & RESERVOIRS	87,000	153,000	153,000	181,000	162,000	222,000	134,000	66,000	25,000
MAJOR RELOCATIONS	28,000	46,000	44,000	13,000	15,000	42,000	16,000	16,000	--
DIVERSION, FOREBAY, AND AFTERBAY DAM	--	12,000	--	10,000	11,000	15,000	--	--	--
TUNNELS AND CONDUITS	--	81,000	108,000	116,000	165,000	222,000	133,000	--	--
POWER FACILITIES	8,000	56,000	46,000	50,000	57,000	89,000	40,000	9,000	--
TOTAL CONSTRUCTION COSTS	123,000	348,000	351,000	370,000	410,000	590,000	323,000	91,000	25,000
DEVELOPMENT SCHEDULE (BEGIN IN 1983)									
FEASIBILITY STUDY PERIOD	2	3	3	4	4	4	3	2	1
PERMITTING AND LICENSING PERIOD	2	3	3	3	3	3	3	2	1
FINAL DESIGN PERIOD	2	3	3	3	3	3	3	2	2
CONSTRUCTION PERIOD	5	6	6	7	7	7	6	5	4
ON-LINE DATE	1993	1997	1997	1999	1999	1999	1997	1993	1990
INTEREST DURING CONSTRUCTION (AT 7.5 PERCENT INTEREST)	23,060	78,300	78,980	97,120	107,620	154,880	72,680	17,060	3,750
ANNUAL OPERATION, MAINTENANCE AND REPLACEMENT COSTS	370	1,800	1,460	1,620	1,820	2,670	1,300	400	40

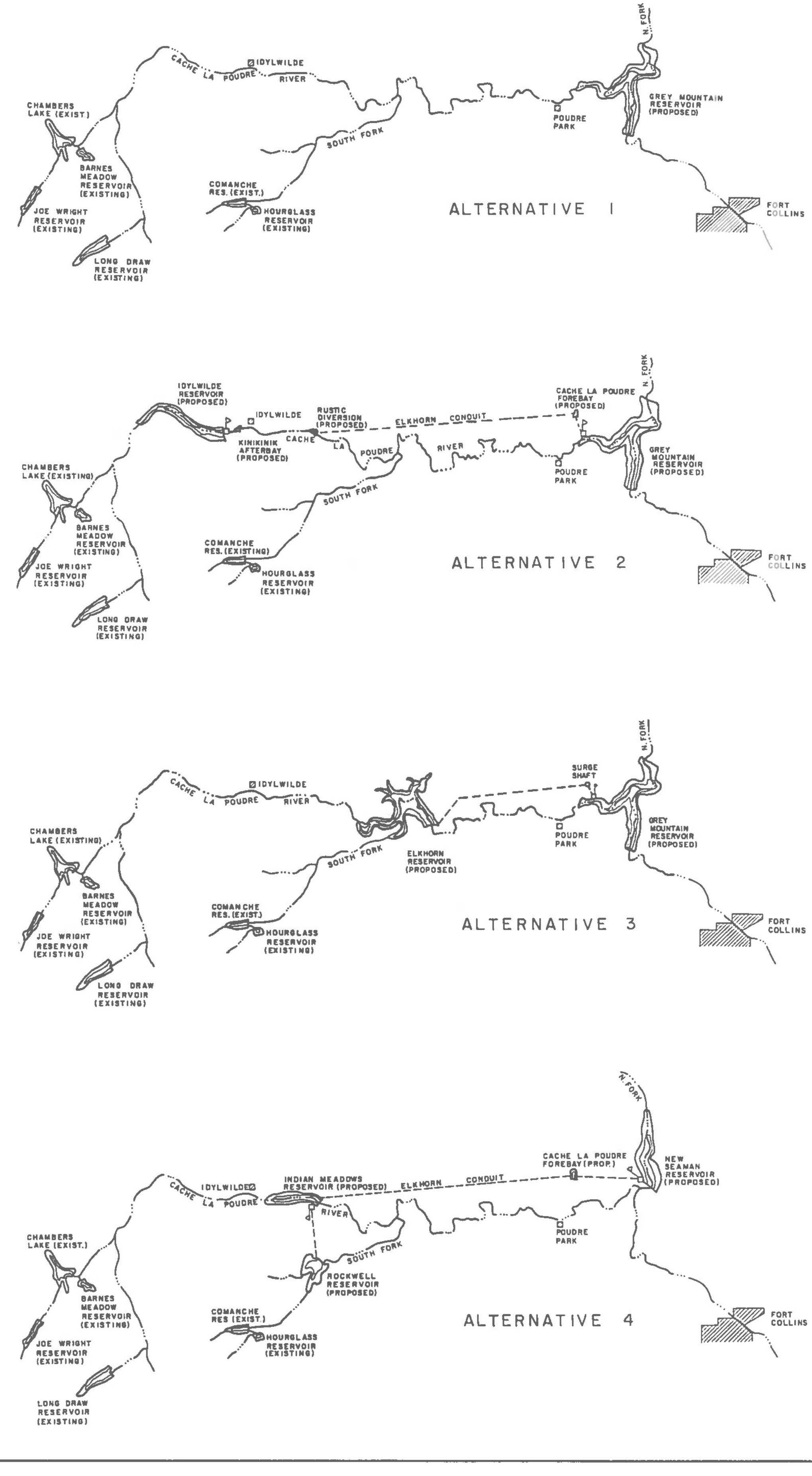
estimated time periods in the development schedule are based on recent experience with similar major projects. Interest during construction was estimated based on a short-cut method using the following equation:

$$IDC = \frac{\text{Interest Rate x Total Construction Cost x Years in Construction Period}}{2}$$

This method makes a simplifying assumption that the outlay of funds during construction will be uniformly distributed over the entire construction period.

f. Operation, Maintenance and Replacement Costs

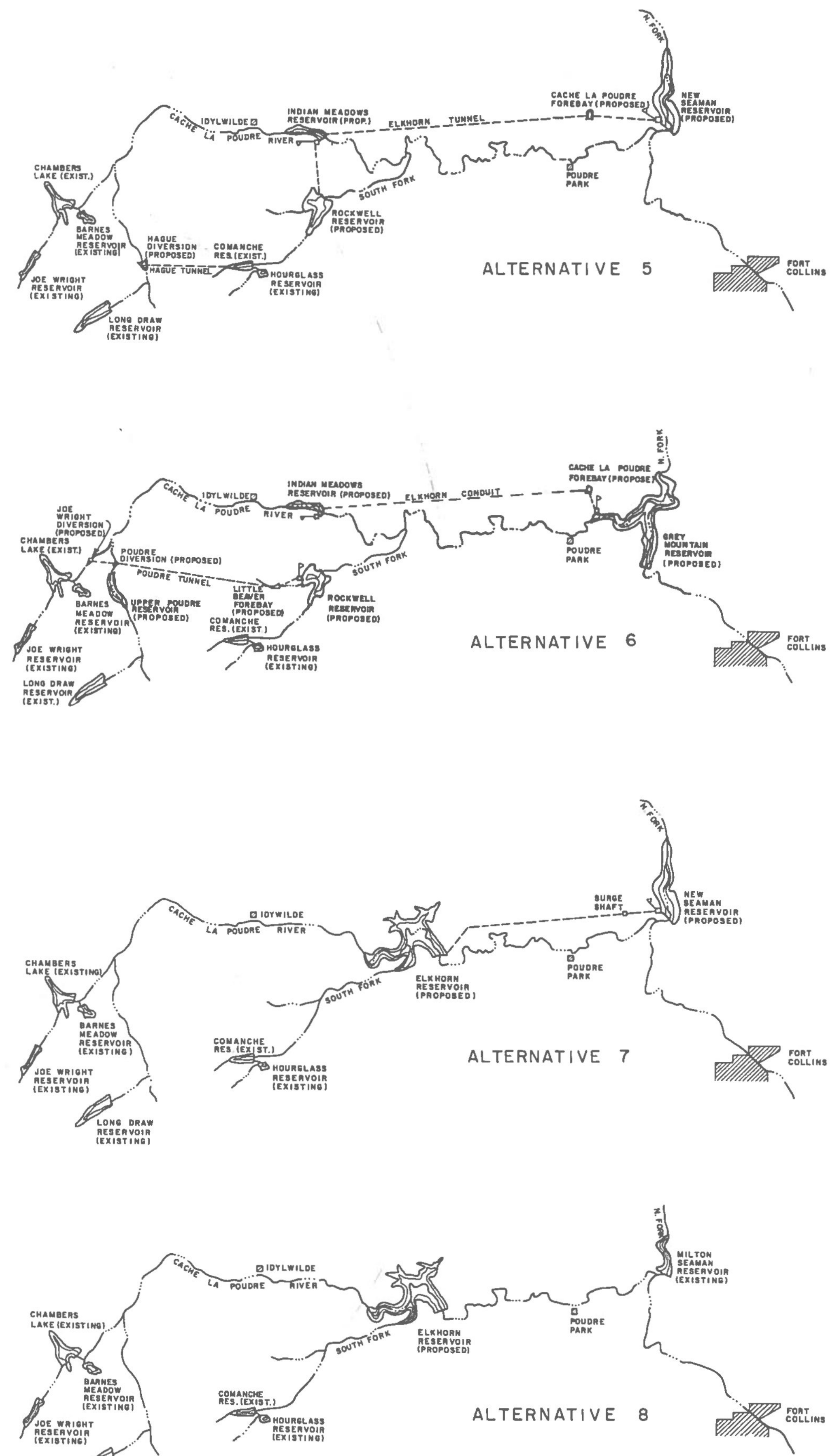
Estimates for operation, maintenance and replacement costs, shown on Table V-14, are based on information developed by the U.S. Bureau of Reclamation and Tudor Engineering Company. Operation and maintenance costs are based on curves developed for a range of power plants and reservoir sizes. Replacement cost are based on a percentage of construction cost of the various facilities.



COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

PRELIMINARY ALTERNATIVE
PROJECT CONFIGURATIONS

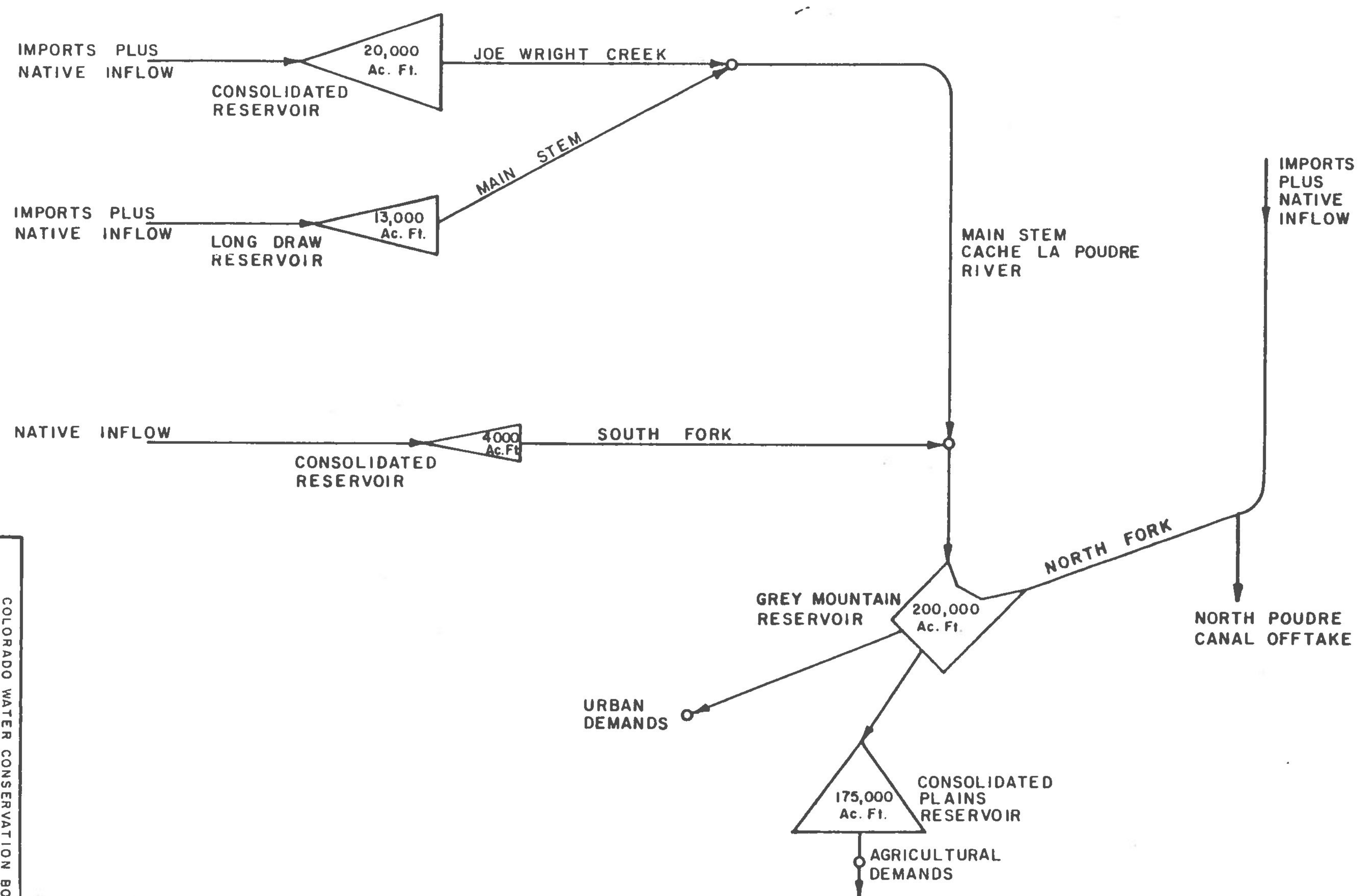
TUDOR ENGINEERING COMPANY FIGURE V-1a



COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

PRELIMINARY ALTERNATIVE
PROJECT CONFIGURATIONS

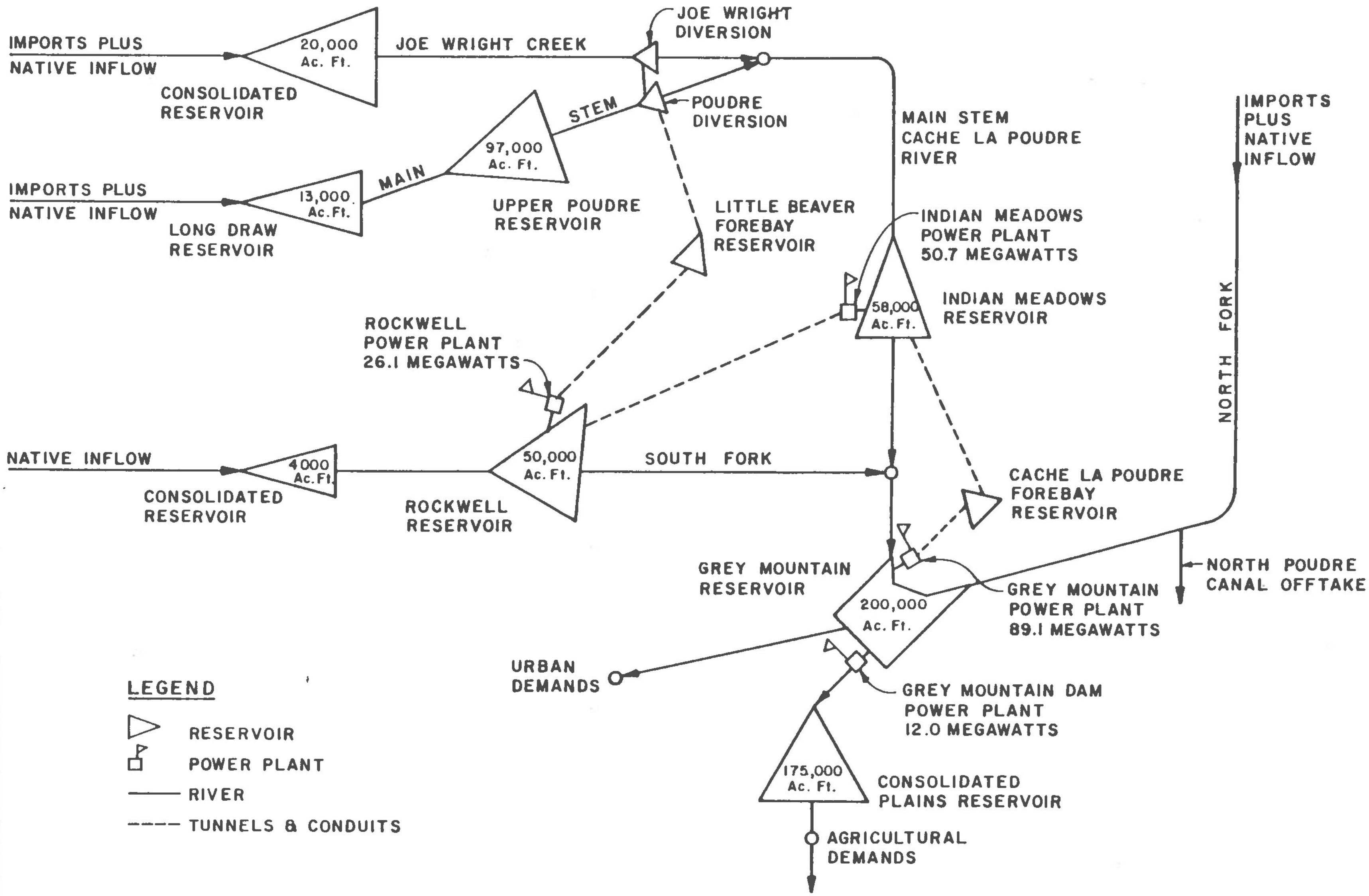
TUDOR ENGINEERING COMPANY FIGURE: V-1b



COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

MODEL CONFIGURATION
ALTERNATIVE I

TUDOR ENGINEERING COMPANY — FIGURE: V-2

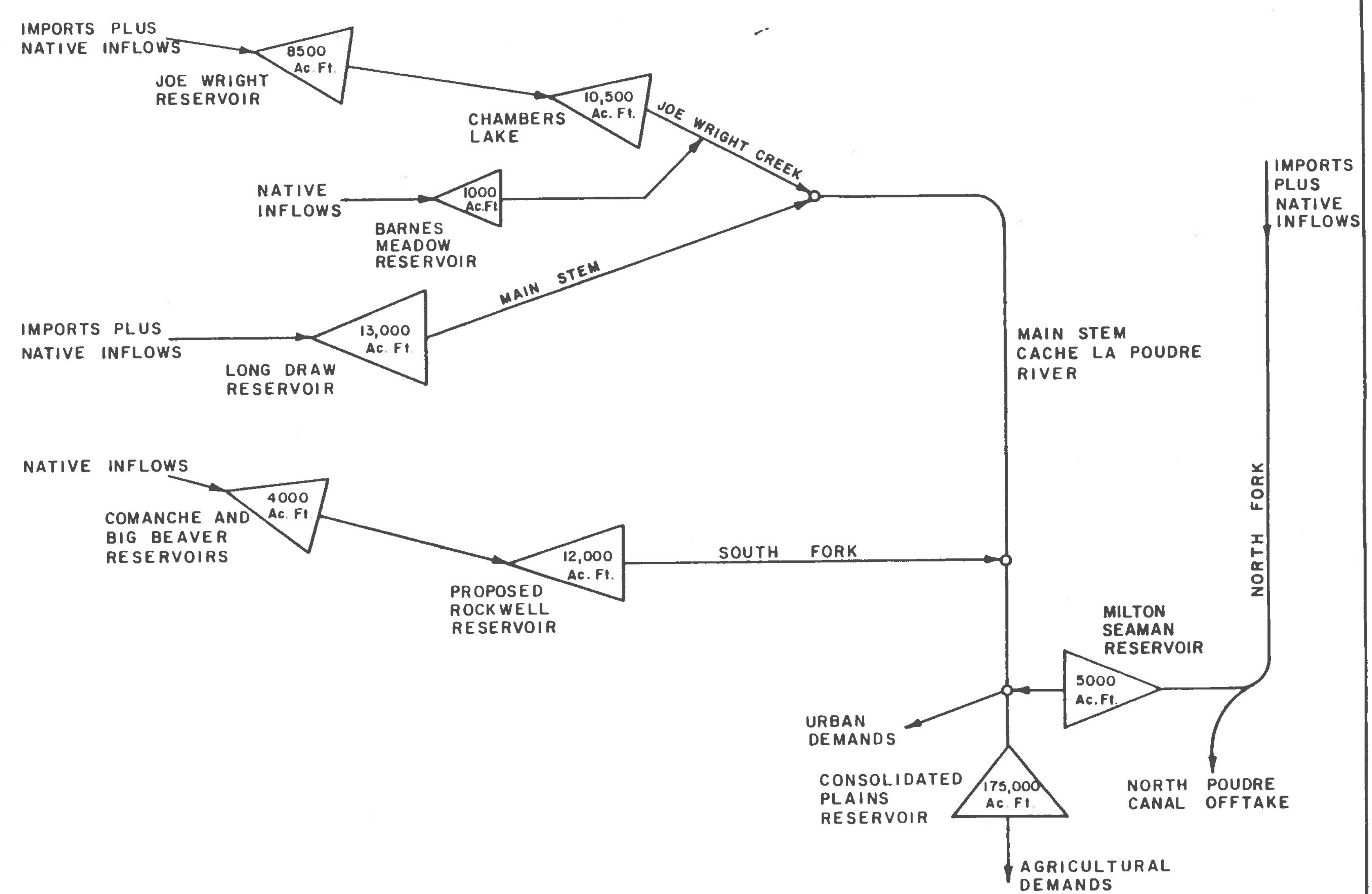


MODEL CONFIGURATION
ALTERNATIVE 6

COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

TUDOR ENGINEERING COMPANY

FIGURE: V-3



COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

MODEL CONFIGURATION
FUTURE WITHOUT PROJECT

TUDOR ENGINEERING COMPANY

FIGURE: V-4

CHAPTER VI
EVALUATION OF PRELIMINARY ALTERNATIVE PROJECTS
(PHASE I)

A. INTRODUCTION

This Chapter presents the criteria used in a comparative evaluation of the eight selected preliminary alternative projects. It also shows the results of the comparative evaluation. This comparative evaluation was used to assist in the process of selecting alternatives for further investigation in Phase II of this study.

Each of the eight preliminary alternative projects under consideration would produce, if constructed, a unique set of changes in the natural and man-made environment relative to the conditions which might be expected to occur if no project is built. These prospective changes are the effects, or impacts, of a project.

The effects, or impacts, which a water resources development project would have, both during construction and after a project becomes operational, are numerous and varied. Furthermore, it is not possible to measure all project effects in the same terms. Therefore, one must explicitly specify the evaluation criteria to be used for describing project impacts.

The criteria used for the evaluation of the eight preliminary alternative projects were specified by the staff of the Colorado Water Conservation Board. Consistent with the objective of the study, the criteria selected address the economic and engineering feasibility of a potential Cache la Poudre project.

The criteria used in evaluating the eight preliminary alternative projects may be grouped into two categories: monetary and non-monetary. The monetary criteria include: (1) project costs, (2) benefit-cost ratio, (3) net direct economic benefits, and (4) cost effectiveness, expressed in terms of project costs per kilowatt of installed electric capacity and per acre-foot of storage capacity. The non-monetary criteria relate to physical and engineering factors and include: (1) geologic conditions, and (2) impacts from inundation.

It is important to point out that at this preliminary level of study all estimates, whether expressed in monetary or non-monetary terms and whether quantified or merely descriptive, are not precise in absolute magnitude. Rather it is their consistent application to the array of alternatives for the purpose of making relative comparisons that will provide meaningful assistance in the selection process. Also, no effort was made to weigh one evaluation criterion against another to establish relative importance.

B. MONETARY EVALUATION CRITERIA

Many project effects consist of changes in quantities of goods and services which are bought and sold. The market prices reflected by these transactions provide convenient measures of such effects and make it possible to compare and aggregate effects. Examples of such effects are the use of materials and labor for project construction, production and sales of agricultural commodities, and generation and sale of hydroelectric power.

Other project effects, both "costs" and "benefits," are in the form of goods and services which are not bought and sold and are, therefore, unpriced. Examples include changes in fish and wildlife populations, in the recreational use of rivers, and in the esthetic character of a locale. Although some analytical techniques have been developed for imputing monetary values to a variety of unpriced goods and activities, such techniques are not being employed in this study due to time and budgetary constraints.

The analysis has assumed constant, January 1982, price levels. A period of analysis of 100 years and an interest rate of 7.5 percent were used to convert costs and benefits to a common point in time.

1. **Project Costs**

Total project costs consisted of estimated construction costs and interest during construction -- which together make up the initial investment required -- and annual operation, maintenance, and replacement costs. These costs and the assumed construction period are summarized in Table VI-1. These costs have been annualized, as shown on the Table, to derive total average streams of costs over the period of analysis at the specified interest rate in order to facilitate comparison of the preliminary alternative projects.

2. **Project Benefits**

Only those prospective project effects which are marketed, and are thus market priced, are included in the analysis of monetary benefits. At this preliminary stage of investigation, those effects were limited to hydroelectric power, municipal and industrial water supply, supplemental irrigation water supply, and improved management of existing water systems. Potential benefits from the control of floods have been considered to be incidental and are not considered at this level of study. Furthermore, monetary measurements of indirect or secondary effects on employment and income were not assessed.

a. Hydropower Benefits

Other than in Preliminary Alternatives 1 and 8, which provide only terminal conservation storage, production of hydroelectric peaking power provided the major source of benefits. In fact, formulation of Preliminary Alternatives 2 through 7 focused on that primary purpose. In addition to peaking power, which is designed to meet peak loads in the 20 percent plant factor range, run-of-the-river hydroelectric generation has been incorporated.

The derivation of unit monetary values for these two distinctive types of power was based on the approach of measuring the costs of the most likely thermal alternative plants that would be displaced in the regional power market area by the hydropower facility. This approach is valid

TABLE VI-1

CACHE LA POUDRE PROJECT

SUMMARY OF TOTAL PROJECT COSTS

(in thousand $ - January 1982 prices)

Item	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8
Estimated Construction Cost	123,000	348,000	351,000	370,000	410,000	590,000	323,000	91,000
Interest During Construction	23,000	78,000	79,000	97,000	108,000	155,000	73,000	17,000
(construction period - yrs.)	(5)	(6)	(6)	(7)	(7)	(7)	(6)	(5)
Project Investment Cost	146,000	426,000	430,000	467,000	518,000	745,000	396,000	108,000
Annual Equivalent of Invest. Cost (Amortized 100 yrs. 7 1/2% 0.07505)	11,000	32,000	32,300	35,000	38,900	55,900	29,700	8,100
Average Annual Operation, Maintenance and Replacement Costs	370	1,800	1,460	1,620	1,820	2,670	1,300	400
Total Average Annual Costs	11,370	33,800	33,760	36,620	40,720	58,570	31,000	8,500

only if demand for the output of the displaced thermal plants would in fact exist. The power demand projections in Chapter IV, which are based upon presently available data provided by utilities, suggest that this would be the case. However, this is a critical area of analysis which could not be independently examined within the time and budget constraints of this study.

1) Value of Hydro-Peaking Capacity

The power system into which the output from a Cache la Poudre project would logically be integrated is predominantly a thermal system, with major reliance for energy placed on coal-fired plants. If current demand patterns continue, the demand for additional peaking capacity will increase, especially in the intermediate plant factor range where existing and currently planned coal-fired base load plants operate very inefficiently. To meet this difficult intermediate load demand area, the electric power industry appears to be shifting from the use of oil-fired combined cycle plants to coal cycling plants. This was corroborated in discussions with large regional power suppliers and staff of the Federal Energy Regulatory Commission.

Because coal cycling plants normally operate in the 30 to 40 percent average plant factor range, as opposed to hydroelectric plants which will optimize better in lower ranges, an energy adjustment is necessary when analyzing the effects from a total system standpoint. This adjustment is necessary to keep the total energy of the system in balance under conditions with and without a proposed hydroelectric increment. Hydroelectric plants are unique in that they can operate efficiently in the 15 to 25 percent plant factor range, which is a "no-mans" land for thermal alternatives because combustion turbines, combined cycle plants, and coal cycling plants do not operate at maximum economic efficiency in that range.

For the purposes of this preliminary analysis, capacity values reflecting avoided fixed costs and energy values reflecting avoided system variable costs were developed using a coal-fired cycling plant as the likely thermal alternative. Based on informal discussions with two of the major utilities in the market area, Tri-State Generation and Transmission Association and Public Service Company of Colorado, a 20 percent average annual plant factor was assumed for the hydro peaking plant.

The following general cost assumptions were used:

Plant Type	Coal Cycling
Size	400 to 500 MW
Capital Cost	$1500 per kW (includes transmission)
Fuel Cost	Coal @ $1.20 per MBTU

As a simplified reflection of market conditions, a fixed charge reflecting both public and private financing was assumed at 15 percent. The cost per installed kilowatt was considered comparable to the current Rawhide base load plant increased by $100 per kilowatt to allow for special cycling equipment. A summary of preliminary computations of capacity and energy values is presented in Table VI-2.

TABLE VI-2
CACHE LA POUDRE PROJECT
HYDROPOWER VALUES FOR PEAKING PLANTS
(Based on Avoided Costs of Coal-Fired Cycling Plant)

CAPACITY VALUE

Capacity Costs (assumed to include

transmission component)	$ 1,500/kW
Fixed Charge at 15% Factor	225/kW yr
Fixed O&M Costs	15/kW yr
Subtotal	$ 240/kW yr

Adjusted for Hydro Differential
Mechanical Availability

$$\frac{\text{Hydro}}{\text{Thermal}} \quad \frac{.98}{.80} = 1.225$$

Flexibility 0.05
Adj. Factor 1.275

Adjusted Capacity Value for Hydro Differential — $ 306/kW yr

VARIABLE ENERGY VALUE

Fuel Costs @ $1.20/MBTU; Heat Rate
10,500 BTU — 12.6 mills/kWh
Variable O&M — 2.5 mills/kWh
Rounded Variable Energy Value — 15 mills/kWh

CAPACITY VALUE ADJUSTED FOR CHANGE IN SYSTEM PRODUCTION COSTS

Formula: P.F. Thermal Minus P.F. Hydro times Incmtl. Energy Costs times 8.76 [c]

(.375 - .20) x (15 - 25 [a]) x 8.76 (unescalated) - $15/kW-Yr.
(.375 - .20) x (28 - 48 [a]) x 8.76 (escalated) - $31/kW-Yr.

PEAKING POWER BENEFITS (UNESCALATED)

Capacity (rounded)	$ 290/kW yr
Energy	15 mills/kWh

PEAKING POWER BENEFITS - ADJUSTED FOR REAL FUEL ESCL. [b]

Capacity	$ 275/kW yr
Energy	28 mills/kWh
Composite Capacity and Energy Value in $/kW/yr	$324/kW yr
Composite Capacity and Energy Value in mills/kWh	185 mills/kWh

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[a] Marginal costs of fuel displacement; See derivation of non-firm energy value in next section.

[b] Energy components, both positive and negative credits were adjusted by a levelization factor of 2 to reflect future price shifts.

[c] Factor presents hours in a year divided by 1000.

It should be noted that in developing capacity values, adjustments have traditionally been made to reflect the advantage of hydroelectric power plants for their increased reliability and operating flexibility previously mentioned. The approach used is to add a component of cost to the thermal plant capacity under conditions without the proposed hydroelectric project to enable the thermal system to contribute to the same peak load-carrying capability as with the hydroelectric project. The procedure used in this analysis follows procedures currently being developed for evaluations of hydroelectric power plants [30].

In adjusting power values to reflect differences in system operating costs when a hydroelectric power plant is substituted for a thermal plant to meet the requirements of load growth, it is best to use system production cost models. A number of these models are being used but no published results were available which reflect the integrated power system. Instead of detailed studies, the short-cut formula developed by the Federal Energy Regulatory Commission is used to approximate the system energy adjustment [31]. By converting the difference in average production costs to an annual dollar basis, this resulted in a reduction in the fixed capacity value from $306 to $290 per kilowatt year leaving the variable energy benefit component unchanged at 15 mills per kilowatt-hour. The energy adjustment computation is also shown on Table VI-2.

It is common practice in the electric utility industry in evaluating electric power alternatives to recognize future real changes in variable costs, especially fuel [32, 30]. Real escalation reflects only that which occurs in excess of general price escalation. For example, general price escalation may equal seven percent with fuel having a higher rate of ten percent. The difference of three percent represents real fuel escalation.

Levelization factors are normally applied to current fuel costs to reflect increases in real fuel costs over time. For this preliminary study a levelization factor of two was applied to the energy components only. This factor was selected after reviewing available data referenced previously. This is admittedly judgemental as the multiplier could vary significantly depending on assumed escalation rates, total period of analysis over which escalation occurs, and the plant on-line date. Nevertheless, it is believed that the resulting factor of 2.0 produces reasonable results that recognizes the increasing relative value of substituting renewable resources for non-renewable fossil fuel supplies. As shown on Table VI-2, the effect of recognizing real fuel escalation decreased the capacity benefit to $275 per kilowatt year and increased the energy benefit to 28 mills per kilowatt-hour.

The peaking power benefit, including the effects of real fuel escalation, is also shown in Table VI-2 in terms of a single composite value which includes both the capacity and energy components. This composite value can be expressed in terms of dollars per kilowatt-year or mills per kilowatt-hour. The composite value is $324, per kilowatt-year or 185 mills per kilowatt-hour.

2) Value of Run-of-the-River Plants

It is anticipated that relatively small hydroelectric power plants, under 20,000 kilowatts, would be located at project storage facilities to utilize releases to the streams for power generation. These would be primarily energy producers, with average annual plant factors at or above 40 percent. The plants would utilize bypass flows and releases for conservation purposes. A portion of these flows would occur during the summer power system peak season.

Avoided or marginal costs of existing producers and prospective users were used as a measure of benefits. These values must be forward-looking as they are projected over the long life of a hydroelectric facility.

The approach used in estimating the economic value of small-scale hydroelectric power plants is the establishment of a range of non-firm and firm values for plants producing intermittently available but highly dependable energy [33].

Based on this approach, two sets of values were developed in the analysis reflecting conditions with and without escalation of real fuel prices. Ranges of preliminary values for the regional power market area based on current, January 1982 prices are shown in Table VI-3. The value of the non-firm energy assumed that the daily operations of the hydroelectric plant would displace coal at the margin about 90 percent of the time and oil the remainder. The basis for the firm energy value is detailed in Table VI-4.

TABLE VI-3
CACHE LA POUDRE PROJECT
SUMMARY OF HYDROPOWER VALUES
FOR RUN-OF-THE-RIVER PLANTS

	Current Unescalated	Reflecting Real Fuel Escalation
Non-Firm (50% or less availability)	25 mills/kWh	48 mills/kWh
Firm (90% or more availability)	70 mills/kWh	81 mills/kWh

3) Application of Values

The unit values derived for peaking power were applied to the estimated outputs from Preliminary Alternatives 2 through 7. Run-of-the-

TABLE VI-4
CACHE LA POUDRE PROJECT
BASIS FOR UNESCALATED, FIRM ENERGY VALUE FOR RUN-OF-THE-RIVER PLANTS
(Based on Coal-Fired Base Load Plant)

CAPACITY VALUES		
Capacity Costs (assumed to include transmission component)		$1,400/kW
Fixed Charge at 15% Factor		$ 210/kW yr
Fixed O&M Costs		15/kW yr
Subtotal		$ 225/kW yr
Adjusted for Hydro Differential Mechanical Availability		
Hydro / Thermal	.98 / .84 = 1.167	
Flexibility	1.050	
Adj. Factor	1.217	
Adjusted Capacity Value for Hydro Differential		$ 274/kW yr
VARIABLE ENERGY VALUE		
Fuel Costs @ $1.20 MBTU; Heat Rate 9,000 BTU	10.8 mills/kWh	
Variable O&M Costs	2.5 mills/kWh	
Rounded Variable Energy Value		13 mills/kWh
CAPACITY VALUE CONVERTED TO ENERGY EQUIVALENT		
Average Plant Factor Over 30 years, 55% ($274 divided by 4,818 kW/hrs)		57 mills/kWh
AVERAGE VALUE OF FIRM ENERGY (UNESCALATED)		70 mills/kWh
AVERAGE VALUE OF FIRM ENERGY-ADJUSTED FOR REAL FUEL ESCAL. [a/]		81 mills/kWh

a/ Energy component adjusted by a levelization factor of 2 to reflect future price shifts.

river or energy oriented production facilities of all of the preliminary alternative projects were separately identified and appropriate unit values applied. For the preliminary comparative analyses, the run-of-the-river values were set at the midpoint between firm and non-firm energy values. It should be noted that initial formulating criteria for the peaking plants used an extremely conservative assumption that capacity had to be available 100 percent of the time. Accepted practices recognize 90 percent availability as a more appropriate determination of dependable capacity. In later studies, the 100 percent availability assumption should be revised to 90 percent. This will result in proportionately higher installed peaking capacities for each plan. However, this should not significantly change the relative comparison of the various preliminary alternative projects.

A summary of the application of power values to derive power benefits for the eight preliminary alternative projects is presented in Table VI-5. Power benefits reflecting no increases due to indexing for real fuel escalation are also shown parenthetically to demonstrate the effect of this assumption.

b. Municipal and Industrial Water Supply Benefits

Benefit values for municipal and industrial water supply may be estimated from; (1) the prices that similar users are paying or are willing to pay for comparable water service as reflected by current market conditions, (2) a simulation of that price through estimating the cost of comparable service from the most likely alternative to the project under consideration, or (3) the marginal value of new water supplies.

The cities of Fort Collins and Greeley are the logical major municipal beneficiaries of a potential Cache la Poudre project. To provide insight into what municipalities are willing to pay for water in the basin, recent purchases or acquisitions of large quantities of water were reviewed. Cash payments required by Fort Collins and Greeley in lieu of providing water rights for proposed residential and commercial development were set in January 1982 at $1,700 for a share of Colorado-Big Thompson Project water, which has a variable yield of .6 to 1.0 acre-foot per share. The City of Fort Collins reports an average allotment between 1957 and 1979 of .76 acre-foot. In terms of an effective full acre-foot yield and a 10 percent interest rate, this would produce a value of $220 per acre-foot delivered ($165 per acre-foot at a 7.5 percent interest rate). A 10 percent rate was used to represent the long-term average interest cost to the city. By contrast, the marginal value of new water supplies (i.e., the value of water in its least productive use, which is agriculture) is about $30 per acre-foot.

Current contracts for Windy Gap Project water suggest an average price of approximately $300 per acre-foot delivered. Windy-Gap Project water will be delivered through the Colorado-Big Thompson Project facilities to the Eastern Slope. This has many of the service characteristics of Colorado-Big Thompson Project water with the exception that there may be some seasonal carry over rights and customers have full rights of reuse.

TABLE VI-5

CACHE LA POUDRE PROJECT

HYDROPOWER BENEFITS

Item	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8
Installed Capacity (MW)								
Dependable Cap. Peaking (100%)		103.5	91.0	100.0	116.0	166.0	79.0	
Dependable Cap. Base Load (100%)		.5	1.3	1.0	.7	.7	1.3	
Intermittent Cap. (less than 100%)	12	14.0	12.0	8.0	8.0	12.0	8.0	14
Total Installed Capacity	12	118.0	104.3	109.0	124.7	178.7	88.3	14
Energy Output (GWh/year)								
Peaking Energy		162.9	143.2	157.4	182.5	261.2	124.3	
Firm and Non-Firm Energy	42.5	66.1	90.8	58.5	91.9	105.8	80.8	47.3
Total Energy	42.5	229.0	234.0	215.9	274.4	367.0	205.1	47.3
Peaking Power Benefits ($1,000/year)								
Capacity @ $275/kW Yr.	0	28,460	25,020	27,500	31,900	45,650	21,720	0
Energy @ 28 Mills/kWh	0	4,560	4,010	4,400	5,110	7,310	3,480	0
Subtotal Peaking	0	33,020	29,030	31,900	37,010	52,960	25,200	0
Firm and Non-Firm Energy Values ($1,000/year)								
Mid-point value at 65 mills/kWh	2,760	4,300	5,900	3,800	5,970	6,880	5,250	3,070
Total Power Benefits W/Real Fuel Escal.	2,760	37,320	34,930	35,700	42,980	59,840	30,450	3,070
Total Power Benefits W/O Real Fuel Esc.)	(2,120)	(35,760)	(33,080)	(34,280)	(40,980)	(57,340)	(28,810)	(2,360)

The cost of providing water from internal system improvements must also be considered. Fort Collins has options of building Rockwell or Sheep Creek Reservoirs to make better use of its water rights, improving the yield of the Michigan Ditch, or building a pumping plant and pipeline facility to utilize its water rights in southside canal companies.

An effective increase in supply can also be captured by the use of metering and conservation programs. While these types of programs are not now being implemented, conservation efforts seem probable within the life of a potential Cache la Poudre project. Using estimates of the benefits and costs of metering and conservation from the City of Fort Collins documents, it is estimated that this kind of program would cost from $220 to $300 per acre-foot of water saved.

At the initiation of the study, it was assumed that any new water yield from a potential Cache la Poudre project would be used as a municipal and industrial water supply since it would command the highest price. Estimates of total annual monetary benefits could then be simply derived from the prices developed above times the new yield. However, in the course of the study it was concluded that the net effect of the new project yield would be a reduction in agricultural rather than urban shortages. This is because, under future conditions without a project, urban users are expected to acquire from agriculture, through city expansion or through purchase, sufficient water rights to meet projected water requirements.

Discussions with the municipalities confirmed the adequacy of water rights. However, water planners for the City of Fort Collins indicated that without project terminal storage, the City would likely construct a reservoir containing approximately 10,000 acre-feet of conservation space in the upper basin. The logical site would be the Rockwell Dam location, inasmuch as the city has conditional storage decrees at that site and physical conditions are favorable. Greeley planners feel that due to their location lower in the basin, sufficient storage capacity will be available in their upper basin and Thompson River basin reservoirs to permit efficient use of currently held water rights and water rights acquired in the future.

As a consequence of these considerations, the cost of a single-purpose reservoir at the Rockwell site was used as the likely alternative in the absence of a Cache la Poudre project. In this particular situation, it is felt that the annualized cost, assuming amortization over a 50-year period at long term municipal interest rate of 10 percent, was indicative of the City's willingness to pay. Since the likely alternative storage would be needed at about the same time that project conservation storage could be provided, the completion dates were assumed to coincide.

The construction cost of the likely alternative reservoir was estimated at $25,000,000, and interest during a 4 year construction period increased the investment to $30,000,000. Operating expenses were estimated to be $40,000 per year. The addition of amortization results in an average annual benefit equal to avoided costs of $3,060,000. This amount is applicable to all alternatives since the equivalent of 10,000 acre-feet of desired conservation space that would otherwise be built by the city is provided in each of the eight preliminary alternative projects.

c. Supplemental Irrigation Water Supply Benefits

The amount that a farmer would be willing to pay for an acre-foot of irrigation water is used as the measure of irrigation benefits. This is the increase in net income that results from the use of that water. Net income from water can be calculated by the residual method, where the costs of all inputs in production except water are subtracted from gross income. A further adjustment is made by reducing net income from irrigation by the alternative income that would have been produced under dry land conditions. This estimated value of irrigating new land has been used in the past as a simple approximation of the average value of supplemental water on presently irrigated land to avoid the complexities of developing an incremental analysis for small amounts of water spread over a large irrigation base.

To estimate preliminary values of irrigation water, crop budgets for irrigated corn and dryland wheat were used. These budgets came from two principal sources: the crop budgets developed at Colorado State University for the Colorado Ogallala-High Plains Project and cost and data compiled for the Lower South Platte River Valley in 1975.

The resulting change in net income when comparing dryland and irrigation farm operations is $61 per acre. With 26 acre-inches applied, the returns to water or willingness to pay is $28 per acre-foot. Because of the preliminary nature of the basic data this value was rounded to $30 per acre-foot. The budget analysis yielding this value is detailed on Table VI-6.

The operation studies described in Chapter V indicated that conservation storage in a project terminal reservoir could reduce irrigation shortages by a maximum of 16,000 acre-feet when comparing with and without project conditions beginning the first year of the analysis. Application of the $30 per acre-foot unit value would produce $180,000 in benefits each year for those alternatives reducing shortage by 16,000 acre-foot. This amount is reduced proportionately for those alternatives eliminating less shortage.

d. Benefits From Improved System Management

Benefits from potential improvements in management and operations of the lower basin water use systems through a change in points of storage have long been considered important attributes of any plans for a Cache la Poudre project. Although this is a difficult and complex subject ultimately requiring detailed study beyond the scope of this level of investigation, an effort was made to develop preliminary monetary values for such benefits.

Discussions with key individuals and rough operational analyses were a part of the effort. Informal meetings were held with officers and operators of irrigation companies in an attempt to place dollar values on the benefits associated with improved management that could result from a project terminal storage reservoir. Possible benefits identified were as follows:

TABLE VI-6

CACHE LA POUDRE PROJECT

IRRIGATION BENEFITS

IRRIGATED CORN (Surface irrigation)

Gross Income - 120 Bu/Acre x $2.50/Bu		300.00	
Grazing value		10.00	$310.00
Less -			
Total Variable Costs			-134.29
Total Fixed Costs			- 64.71
Machinery Fixed Cost	$37.16		
Overhead Costs	27.55		
Management Cost (6% of Gross Income)			- 18.60
Net Income -			92.40
Less - Returns to Land Assuming Dryland Winter Wheat (see table below)			- 31.21
Net returns to water for 26 acre-inches			$ 61.19
Returns to Water Per Acre-Foot -			$ 28.24
Irrigation benefits per acre-foot, rounded			$ 30.00

DRYLAND WINTER WHEAT

Gross Income - 30 Bu/Acre x $3.50/Bu per 2 years		$105.00
Less -		
Total Variable Costs		-17.21
Total Fixed Costs		-19.08
Machinery Fixed Cost	$15.08	
Overhead Cost	4.00	
Management Cost (6% of Gross Income)		-6.30
Net Income Per 2 Years Wheat-Fallow Rotation		62.41
Net Annual Income (returns to land in above budget)		$31.21

- Provide substitute storage for 6,000 acre-feet now being investigated which would permit increased transmountain diversions. This could be considered either as an additional water supply which would reduce shortages without project storage, or as the savings in several millions of dollars in future investment.

- Effect savings in maintenance costs for reservoir rehabilitation and repairs due to lower operating levels. This would be over and above current requirements to improve spillways and other works which would have to be accomplished prior to completion of a Cache la Poudre Project.

- Effect savings in cleaning and disposing of sediment in supply canals.

- Possible elimination of roughly 30 miles of supply canals with reductions in attendant operation and maintenance costs and reduced transportation losses.

- Provide opportunity for possible elimination of several reservoirs.

- Permit more irrigators to order water on demand rather than to have to take water on a predetermined schedule.

- Possible reductions in evaporation losses through the elimination of reservoirs and by allowing other reservoirs to be maintained at levels with less surface area.

In trying to attach monetary values to a portion or all of these items, there was considerable concern expressed by the discussants on how much the irrigators might be actually assessed. Current conditions of high interest rates, inflated farm production costs, and relatively low crop prices made this a particularly sensitive subject. Nevertheless, there was a consensus that potential storage transfer would be beneficial.

One approach to the monetary evaluation problem is to place a "rental" value on the 50,000 acre-foot of space that could be made available by providing alternate points of storage for the Upper Plains reservoirs as discussed in Chapter V. Although no definitive recommendations were made and no concensus reached in the field interviews, Tudor investigators selected a figure of $5.00 per acre-foot per year or a total of $250,000 annually, as a conservative first approximation of the farmers' willingness to pay for storage space. If this value were averaged over the number of acres irrigated in the Poudre Basin it would amount to about $1 per acre.

3. Benefit-Cost Ratios

The ratios of total average annual direct benefits measured for the various identified project outputs to the total average annual equivalent costs for construction, interest during construction and operation previously presented in Table VI-1 are summarized in Table VI-7. Ratios are also shown for future conditions with and without real fuel escalation.

TABLE VI-7
CACHE LA POUDRE PROJECT
SUMMARY OF BENEFIT/COST RATIOS AND NET BENEFITS
(In Thousands of Dollars)

Item	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8
Average Annual Costs (Table VI-1)	11,370	33,800	33,760	36,620	40,720	58,570	31,000	8,500
Average Annual Benefits								
Hydropower Peaking		33,020	29,030	31,900	37,010	52,960	25,200	
Run-of-the-River Energy	2,760	4,300	5,900	3,800	5,970	6,880	5,250	3,070
Subtotal Hydropower	2,760	37,320	34,930	35,700	42,980	59,840	30,450	3,070
Municipal and Industrial Water Supply	3,060	3,060	3,060	3,060	3,060	3,060	3,060	3,060
Irrigation (@ $30/AF)	480	420	410	380	330	390	390	430
Improved Management (50,000 AF @$5/AF)	250	250	250	250	250	250	250	250
Other (flood control, recreation, etc.)	NE [1]	NE	NE	NE	NE	NE	NE	NE
Total Annual Benefits	6,550	41,050	38,650	39,390	46,620	63,540	34,150	6,810
Benefit-Cost Ratio (w/real fuel escal.)	.58	1.21	1.14	1.08	1.14	1.08	1.10	.80
Net Benefits (w/real fuel escal.)	-4,820	7,250	4,890	2,770	5,900	4,970	3,150	-1,690
(Total Annual Benefits W/O Real Fuel Escalation)	(5,910)	(39,490)	(36,800)	(37,970)	(44,620)	(61,540)	(32,510)	(6,100)
(Benefit/Cost Ratio W/O Real Fuel Escal.)	(.52)	(1.17)	(1.09)	(1.04)	(1.10)	(1.05)	(1.05)	(.72)
(Net Benefits W/O Real Fuel Escal.)	(-5,460)	(5,690)	(3,040)	(1,350)	(3,900)	(2,970)	(1,150)	(-2,400)

[1] Not estimated.

4. Net Direct Economic Benefits

It is common practice in water resource economic analysis to use measures of net direct economic benefits -- project benefits less project costs -- in the formulation and evaluation process. The general rule in scoping projects is to maximize the net benefits. This theoretically produces the greatest stockpile of goods and services from the development of a limited resource base. A project with the highest benefit-cost ratio does not necessarily produce the highest net benefits, as maximization of net benefits presumes that separable segments are added where practicable, until associated benefits and costs are equal. Where the starting base of the project is well above unity, these additions could reduce the average benefit-cost ratios but still increase the net benefits so long as each separable segment of cost is exceeded by benefits produced by that segment.

For convenience and comparison with benefit-cost ratios, the derivation of net benefits is also summarized on Table VI-7. The first set of total annual benefits, benefit-cost ratios and net benefits were calculated with real fuel escalation effects included because it is common practice to do so in the electric utility industry. Another set of total annual benefits, benefit-cost ratios and net benefits were calculated without real fuel escalation effects for comparison purposes and shown in the Table.

Net direct benefits have been discounted, using a 7.5 percent interest rate, to the present (1982) to achieve comparability among alternatives. This is done because benefits would not begin to accrue until 11 to 17 years in the future, depending upon the complexity of constructing an alternative, and would then continue to accrue over the life of an alternative. Thus, benefits accruing in each year of project life are discounted to the present and then summed to yield the present worth of total project benefits. The present worth values are shown in Table VI-8.

The present worth estimate of benefits cannot be compared directly with investment costs shown for each alternative since they reflect different times of occurrence. Total costs, as well as the net benefits, would have to be comparably discounted to make such comparisons.

5. Cost Effectiveness

A comparison of the unit costs in terms of product output or physical capacity can provide useful information in comparing alternatives where such common denominators exist. Two obvious units of measure stand out among the eight alternative projects: (1) dollars per kilowatt of installed electric capacity and (2) costs per acre-foot of reservoir storage capacity. The cost per kilowatt of installed capacity is important to Preliminary Alternatives 2 through 7 as hydropower is the predominant purpose served after conservation storage is provided at a project terminal storage reservoir. The unit cost per acre-foot of storage measures the relative water storing efficiency of the major dams and reservoir sites for the various alternatives.

Comparisons of construction costs per kilowatt of installed capacity and per acre-foot of storage capacity are summarized on Table VI-9.

TABLE VI-8

CACHE LA POUDRE PROJECT

SUMMARY OF NET BENEFITS DISCOUNTED TO PRESENT WORTH

(In Thousands of Dollars)

Item	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8
Assumed On-Line Date	1993	1997	1997	1999	1999	1999	1997	1993
No. of Years Discounted	11	15	15	17	17	17	15	11
Present Worth Factor @ 7.5%	.451	.338	.338	.292	.292	.292	.338	.451
Annual Net Benefits Before Discounting	$-4,820	$7,250	$4,890	$2,770	$5,900	$4,970	$3,150	$-1,690
Discounted Annual Net Benefits	$-2,200	$2,400	$1,700	$800	$1,700	$1,500	$1,100	$-762

TABLE VI-9

CACHE LA POUDRE PROJECT

SUMMARY OF COST EFFECTIVENESS 1/

Item	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8
Installed Power Capacity 2/ ($ per kilowatt)	$670	$1,980	$2,260	$2,770	$2,740	$2,660	$2,890	$640
Reservoir Storage ($ per acre-foot)	$575	$498	$493	$452	$513	$650	$375	$418

1/ Based on construction cost.

2/ Power plant costs only for Alternatives 1 and 8; Terminal storage costs only are excluded from Alternatives 2 through 7 as remaining costs are considered essentially separable power costs.

Average storage costs for each of the seven major reservoirs, and variations in capacity for two of those reservoirs are detailed in Table VI-10. It is noted that in computing costs per kilowatt that all costs, excluding the terminal storage reservoir, were included as representing essentially single-purpose hydropower costs. Also included in making that computation were the power plant costs only at either Grey Mountain or New Seaman Reservoirs.

Comparisons of the relative costs of reservoir storage, shown in Table VI-9, provides limited information as it averages the cost of two or more reservoirs, except in Preliminary Alternatives 1 and 8 where only one reservoir makes up the project. Additional insight into the relative storage cost components of the various plans is provided in the previously cited Table VI-10.

C. NON-MONETARY EVALUATION CRITERIA

As explained in Chapter I, this study does not include an analysis of the environmental impacts which a Cache la Poudre Project would have. Thus, the non-monetary criteria employed in this evaluation do not reflect such project effects as changes in recreational opportunities, fish and wildlife populations and habitat conditions, etc. Rather, the non-monetary criteria have been limited to two selected engineering and physical factors: (1) geologic considerations and (2) physical impacts from inundation.

1. Geologic Considerations

At this stage of the investigation, the relative degree of geologic confidence in each of the six alternative projects is a function of the following geologic considerations: 1) the number of major geologic problems identified, 2) the availability of geologic field data at each major damsite, 3) the number of major dams, 4) the miles of tunnel and, 5) the number of minor structures.

As stated in Chapter V, and shown on Table VI-11, no significant geologic or geotechnic problems that would preclude construction of any potential facility included as part of the preliminary alternative projects have been identified. This statement is based on available information as was noted in Geological and Geotechnical Investigations, Pre-Reconnaissance Study, April 1982, done by Tudor Engineering Company.

Investigations at the major damsites range from previous feasibility level work done by the U.S. Bureau of Reclamation at the Grey Mountain, Idylwilde, and Rockwell damsites to a review of geologic maps and aerial photographs done at the other major damsites. The degree of certainty in the geologic conditions at sites of the potential facilities is partially a function of the previous studies done at the respective sites and the field data available from these previous studies. Table VI-11 shows a subjective relative description of field data availability for the sites of the major dams included in each preliminary alternative project.

TABLE VI-10

CACHE LA POUDRE PROJECT

CONSTRUCTION COST PER ACRE-FOOT OF STORAGE

Reservoir	Alterna-tive	Construction Cost ($1,000)	Storage Capacity (1,000 A.F.)	Cost Acre-Foot ($)
Grey Mountain	1,2,3,6	115,000	200.0	575
Idylwilde	2	84,000	200.0	420
Elkhorn	3,7,8	82,000	196.0	418
Indian Meadows	4	79,000	190.0	416
Indian Meadows	5,6	36,000	58.0	621
Rockwell	4	47,200	40.0	1,180
Rockwell	5	72,600	86.0	844
Rockwell	6	54,300	50.4	1,077
New Seaman	4,5,7	68,000	200.0	340
Upper Poudre	6	58,000	97.0	560

TABLE VI-11
CACHE LA POUDRE PROJECT
SUMMARY OF GEOLOGIC CONSIDERATIONS

Alternative	Major Dams	Field Data Availability	Number of Major Dams	Degree of Geologic Certainty	Miles of Tunnel	Degree of Geologic Certainty	Number of Minor Structures	Degree of Geologic Certainty	Major Identifiable Problems	Relative Degree of Overall Geologic Confidence
1	Grey Mountain	Highest	1	Highest	0	Highest	0	Highest	None	Highest
2	Grey Mountain Idylwilde	Highest High	2	High	7.7	High	3	Low	None	High
3	Grey Mountain Elkhorn	Highest Low	2	High	8.3	High	0	Highest	None	High
4	New Seaman Indian Meadows Rockwell	Moderate Low High	3	Moderate	11.3	Moderate	1	High	None	Moderate
5	New Seaman Indian Meadows Rockwell	Moderate Low High	3	Moderate	17.0	Low	2	Moderate	None	Low
6	Grey Mountain Indian Meadows Rockwell Upper Poudre	Highest Low High Moderate	4	Low	23.4	Lowest	4	Lowest	None	Lowest
7	New Seaman Elkhorn	Moderate Low	2	Moderate	9.7	Moderate	0	Highest	None	Moderate
8	Elkhorn	Low	1	Moderate	0	Highest	0	Highest	None	High

Seven of the eight preliminary alternative projects would include either the Grey Mountain Dam or the New Seaman Dam. Geology in the area of both of these sites has been investigated in relatively more detail than the other major damsites. Geologic considerations at these two sites are very similar and at this point neither can be termed preferable. The other five major damsites (Indian Meadows, Idylwilde, Rockwell, Elkhorn, Upper Poudre) all appear to be good sites with only minor differences. Previous investigations at the Idylwilde and Rockwell damsites add to the certainty of the geologic conditions as compared to the other three sites. As shown in Table VI-11, the degree of geologic certainty decreases proportional to the number of these major damsites included in the preliminary alternative project.

The tunnels represent major potential facilities. Some of the tunnels, as presently aligned, could require significant amounts of structural support and lining. However, with more detailed study, realignment of the tunnels is possible and should reduce the amount of support and lining that would be required, although probably not completely eliminating it. In general, the tunnelling conditions would be similar throughout the region. The degree of geologic certainty, however, decreases with the length of the tunnel. Table VI-11 shows a subjective comparison of the degree of geologic certainty relative to the length of tunnels for each preliminary alternative project.

The power plant sites and smaller damsites would also present site specific problems. Although most of them have been visited, minimal field work has been done at these sites. Therefore, a fair degree of uncertainty exists with respect to these sites. Because of their size, remedies to any geologic problems encountered should be relatively easy; however, the degree of geologic certainty decreases with the number of minor structures. Table VI-11 shows a subjective comparison of the degree of geologic certainty relative to the number of minor structures for each preliminary alternative project.

The final column of Table VI-11 shows a subjective, relative degree of overall geologic confidence among the eight preliminary alternative projects, incorporating the five geologic considerations mentioned above. It should be emphasized that the relative description of each geologic consideration and the degree of overall geologic confidence is subjective. It is based on previous experience in projects of a similar nature in similar conditions. Also, the highest-to-lowest ranking scale only illustrates the relative difference among the alternatives and may not indicate the absolute geologic certainty of each alternative.

2. Physical Impacts

The physical impacts of the preliminary alternative projects have been expressed in terms of the land areas and facilities that would be inundated. A very brief description of the possible impacts of each preliminary alternative project follows, with these data being summarized in Table VI-12. They represent preliminary rough estimates based on recent maps of the area.

TABLE VI-12
CACHE LA POUDRE PROJECT
SUMMARY OF IMPACTS ON PHYSICAL FEATURES

Alternative and Major Dams	River Miles Inundated	Miles of Major Hwy. Inundated	Acres Inundated: Private Land	Acres Inundated: Public Land	Acres Inundated: Designated Wilderness Land	Acres Inundated: Total	Developed Recreational Facilities Inundated	Potential Campground Sites Inundated	Number of Buildings Inundated	Other Major Development Inundated
Alternative 1										
Grey Mountain	7.4	6	1,170	500	--	1,670	1	--	55	Fort Collins Water Treatment Plant
Alternative 2										
Grey Mountain	7.4	6	1,170	500	--	1,670	1	--	55	Fort Collins Water Treatment Plant
Idylwilde	8.3	7	1,020	680	--	1,700	5	--	74	State Fish Hatchery
TOTAL	15.7	13	2,190	1,380		3,370	6	--	129	
Alternative 3										
Grey Mountain	7.4	6	1,170	500	--	1,670	1	--	55	Fort Collins Water Treatment Plant
Elkhorn	7.0	7	30	1,390	213	1,420	7	1	9	None
TOTAL	14.4	13	1,200	1,890	213	3,090	8	1	64	
Alternative 4										
New Seaman	4.5	-	660	980	--	1,640	--	--	4	None
Indian Meadows	5.6	5	910	390	--	1,300	2	2	130	Communities of Indian Meadows and Rustic
Rockwell	2.6	3	50	450	50	500	--	--	8	None
TOTAL	12.7	8	1,620	1,820	50	3,440	2	2	152	
Alternative 5										
New Seaman	4.5	--	660	980	--	1,640	--	--	4	None
Indian Meadows	4.0	3	430	190	--	620	2	2	42	Community of Indian Meadows
Rockwell	3.1	4	100	840	122	940	--	--	12	None
TOTAL	11.6	7	1,190	2,010	122	3,200	2	2	58	
Alternative 6										
Grey Mountain	7.4	6	1,170	500	--	1,670	1	--	55	Fort Collins Water Treatment Plant
Indian Meadows	4.0	3	430	190	--	620	2	2	42	Community of Indian Meadows
Upper Poudre	4.0	--	--	680	680	680	--	--	--	None
Rockwell	2.6	3	50	450	50	500	--	--	8	None
TOTAL	18.0	12	1,650	1,820	730	3,470	3	2	105	
Alternative 7										
New Seaman	4.5	--	660	980	--	1,640	--	--	4	None
Elkhorn	7.0	7	30	1,390	213	1,420	7	1	9	None
TOTAL	11.5	7	690	2,370	213	3,060	7	1	13	
Alternative 8										
Elkhorn	7.0	7	30	1,390	213	1,420	7	1	9	None

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Preliminary Alternative 1 - This preliminary alternative project would inundate about 7.4 miles of the mainstem, over 6 miles of a major highway, and nearly 1,700 acre with the proposed Grey Mountain Reservoir. The only developed recreational facility inundated would be the Greyrock Trailhead. The Fort Collins water treatment plant and an estimated 55 buildings would also be inundated.

Preliminary Alternative 2 - This preliminary alternative project includes the Grey Mountain Reservoir and the Idylwilde Reservoir. The two reservoirs would inundate about 15.7 miles of the mainstem, 13 miles of major highway, and nearly 3,400 acres of land. Grey Mountain Reservoir would inundate the Greyrock Trailhead, some 55 buildings and the Fort Collins water treatment plant. Idylwilde Reservoir would inundate Sleeping Elephant Campground, Big Bend Campground, Crown Point-Zimmerman Lake Trailhead, the Kinikinik rest area, the Home Moraine Interpretive Site, some 74 buildings and the State fish hatchery.

Preliminary Alternative 3 - This preliminary alternative project includes the Grey Mountain Reservoir and the Elkhorn Reservoir. The two reservoirs would inundate more than 14 miles of the river's corridor of which approximately 1.3 miles would be on the South Fork. Some 13 miles of major highway and just under 3,100 acres of land, of which 213 acres is in designated wilderness area, would also be inundated. Grey Mountain Reservoir would inundate the Greyrock Trailhead, some 55 buildings, and the Fort Collins water treatment plant. Elkhorn Reservoir would inundate some 9 buildings, the Narrows picnic ground, and the Kreuter-Mt. McConnell Trailhead; as well as the Narrows Cooperative, Dutch George Flats, Mountain Park, Kelley Flats and Eggers Campgrounds. It would inundate the potential Dutch George Flats recreation site, one of three potential recreation sites identified in the National Forest land use plan [4].

Preliminary Alternative 4 - This preliminary alternative project includes the New Seaman Reservoir, a large Indian Meadows Reservoir and a small Rockwell Reservoir. The three reservoirs would inundate approximately 4.5 miles of the North Fork, 5.6 miles of the mainstem, 2.6 miles of the South Fork, 8 miles of major highways, and over 3,400 acres of land including 50 acres of wilderness area. New Seaman Reservoir would have a negligible impact on developed recreational facilities. Indian Meadows Reservoir would inundate the Fish Creek and Little South Campgrounds, two potential recreation sites identified in the National Forest land use plan at Indian Meadows and Hombres Ranch [4], and some 130 buildings, including the communities of Rustic and Indian Meadows. Rockwell Reservoir would inundate some eight buildings.

Preliminary Alternative 5 - This preliminary alternative project includes the New Seaman Reservoir, a smaller Indian Meadows Reservoir, and a larger Rockwell Reservoir. The three reservoirs would inundate approximately 4.5 miles of the North Fork, 4 miles of the mainstem, 3.1 miles of the South Fork, 7 miles of major highway, and 3,200 acres of land of which 122 acres is designated wilderness area. The New Seaman Reservoir would have a negligible impact on developed recreational facilities. The Indian Meadows Reservoir would inundate two potential recreation sites at Indian Meadows and Hombres

Ranch and some 42 buildings including the community of Indian Meadows. Rockwell Reservoir would inundate the Fish Creek and Little South Campgrounds and some 12 buildings. This preliminary alternative project would also include Hague Diversion Dam in the wilderness area and a tunnel under the wilderness area.

Preliminary Alternative 6 - This preliminary alternative project includes the Grey Mountain Reservoir, a small Indian Meadows Reservoir, an Upper Poudre Reservoir, and a small Rockwell Reservoir. The reservoirs and facilities in this alternative would inundate approximately 15.4 miles of the mainstem, 2.6 miles of the South Fork, 12 miles of major highways, and nearly 3,500 acres of which 730 acres would be in designated wilderness areas. The Grey Mountain Reservoir would inundate the Greyrock Trailhead, some 55 buildings and the Fort Collins water treatment plant. Indian Meadows Reservoir would inundate two potential recreation sites at Indian Meadows and Hombres Ranch, and some 42 buildings including the community of Indian Meadows. An Upper Poudre Reservoir would have no impact on any developed recreational facilities or other major development. Rockwell Reservoir would inundate the Fish Creek and Little South Campgrounds and some eight buildings.

Preliminary Alternative 7 - This preliminary alternative project includes New Seaman Reservoir and Elkhorn Reservoir. The two reservoirs would inundate approximately 4.5 miles of the North Fork, 5.7 miles of the mainstem and 1.3 miles of the South Fork. Some 7 miles of major highway and less than 3,100 acres of land, of which 213 acres is designated wilderness area, would also be inundated. New Seaman Reservoir would have a negligible impact on developed recreational facilities while Elkhorn Reservoir would inundate some nine buildings, the Narrows Picnic Ground, and the Kreuter - Mt. McConnell Trailhead, as well as the Narrows Cooperative, Dutch George Flats, Mountain Park, Kelley Flats and Eggers Campgrounds. It would inundate the potential Dutch George Flats recreation site.

Preliminary Alternative 8 - This preliminary alternative project would consist of only the Elkhorn Reservoir. It would inundate approximately 7 miles of stream, including about 1.3 miles on the South Fork. Some 7 miles of major highway and just over 1,400 acres of land, of which 213 acres is designated wilderness area, would also be inundated. Some 9 buildings, the Narrows Picnic Ground, and the Kreuter - Mt. McConnell Trailhead, as well as the Narrows Cooperative, Dutch George Flats, Mountain Park, Kelley Flats and Eggers Campgrounds would be inundated. It would inundate the potential Dutch George Flats recreation site.

D. COMPARATIVE EVALUATION

1. General

In the preceding sections the effects of the eight preliminary alternative projects have been evaluated in terms of six criteria. Also, the yield of water which would be newly developed by each preliminary alternative was determined in the preceeding chapter. All of these factors have been summarized in Table VI-13, with the alternatives listed in the left column and

TABLE VI-13
CACHE LA POUDRE PROJECT
SUMMARY OF EVALUATION OF PRELIMINARY ALTERNATIVE PROJECTS

Prel. Alt. No.	Major Facilities	Yield of New Water (Acre-Feet per Year)	Project Costs: Total Initial Investment	Project Costs: Total Average Annual Costs	Benefit-Cost Ratios	Present Worth of Net Benefits Discounted to 1982	Cost Effectiveness: $ Per Kilowatt	Cost Effectiveness: $ Per Acre-Foot Storage	Geologic Considerations: Ident. Major Prob.	Geologic Considerations: Degree of Confid.	Impacts from Inundation: Area (Acres)	Impacts from Inundation: Major Highway (Miles)	Impacts from Inundation: Stream (Miles)	Impacts from Inundation: No. of Bldgs.	Impacts from Inundation: Major Facilities and Communities
1	Grey Mountain Res.	16,300	$146,000,000	$11,370,000	.58	$-2,200,000	$670	$575	None	Highest	1,670	6	7.4	55	Ft. Collins Treatment Plant
2	Grey Mountain Res. Idylwilde Res.	14,300	$426,000,000	$33,800,000	1.21	2,400,000	1,980	498	None	High	3,370	13	15.7	129	Ft. Collins Treatment Plant State Fish Hatchery
3	Grey Mountain Res. Elkhorn Res.	14,000	430,000,000	33,760,000	1.14	1,700,000	2,260	493	None	High	3,090	13	14.4	64	Ft. Collins Treatment Plant
4	New Seaman Res. Indian Meadows Res. Rockwell Res.	12,800	467,000,000	36,620,000	1.08	800,000	2,770	452	None	Moderate	3,440	8	12.7	130	Communities of Indian Meadows and Rustic
5	New Seaman Res. Indian Meadows Res.	11,300	518,000,000	40,720,000	1.14	1,700,000	2,740	513	None	Low	3,200	7	11.6	58	Community of Indian Meadows
6	Grey Mountain Res. Indian Meadows Res. Rockwell Res.	13,000	745,000,000	58,570,000	1.08	1,500,000	2,660	650	None	Lowest	3,470	12	18.0	105	Ft. Collins Treatment Plant Community of Indian Meadows
7	New Seaman Res. Elkhorn Res.	13,100	396,000,000	31,000,000	1.10	1,100,000	2,890	375	None	Moderate	3,060	7	12.5	13	None
8	Elkhorn Res.	14,400	108,000,000	8,500,000	.80	-762,000	640	418	None	High	1,420	7	7.0	9	None

the evaluation criteria arrayed across the column headings. The following discussion provides analytical comments and observations to assist the reader in making comparative evaluations among the preliminary alternatives based on these criteria.

2. **Increased Yield of Water**

One purpose of a Cache la Poudre project would be to make more water available and conserve it for use by Colorado interests. This would be accomplished through new storage of high flows not presently regulated or diverted.

A preliminary estimate of the "new" water yield of the various alternatives was made in the operation studies. The yield, measured as the difference in average irrigation water shortages with and without the alternative project, varied from a high of 16,300 acre-feet per year with Preliminary Alternative 1 to a low of 11,300 acre-feet per year with Preliminary Alternative 5. Preliminary Alternatives 2, 3 and 8 yield approximately 14,000 acre-feet per year, while Preliminary Alternatives 4, 6 and 7 yield approximately 13,000 acre-feet per year on the average. With any of the eight preliminary alternative projects, yields are relatively small compared to the average annual native river flow of 271,000 acre-feet. The lower yields of Preliminary Alternatives 2 through 7 as compared to Preliminary Alternative 1 are primarily due to increased evaporation losses from upstream reservoirs for power generation. It is possible that further refinement of plans for these alternatives could reduce these losses and thus increase the yields.

3. **Monetary Evaluation Criteria**

a. Project Costs

Project costs provide information on the relative fiscal burden on the entity or entities which might develop a project. However, project costs do not necessarily reflect net cash flow requirements since some alternatives, though costing more, produce greater vendible outputs than others. Some insight into net cash flow requirements can be gleaned subsequently from the discussions on benefit-cost ratios and net benefits.

The relative magnitude of the initial investment which would be required is a direct function of the number of major reservoirs and associated structures. They range from $108 million in the single reservoir Preliminary Alternative 8 to $745 million for Preliminary Alternative 6, which has the greatest number of structures. The other single reservoir alternative, Preliminary Alternative 1, has the next lowest requirement with a cost of $146 million. Preliminary Alternative 7, with one major mainstem reservoir ranks next with a financial requirement of about $400 million. The preliminary alternative projects with two major mainstem reservoirs, Preliminary Alternatives 2 and 3, generate the next lowest financial requirement with essentially the same outlay of some $430 million. Preliminary Alternatives 4 and 5 follow with a requirement of about $470 million and $520 million, respectively. There are two significant breaks, about $280 million between Preliminary Alternative 1 and Preliminary Alternatives 2 and 3, and $230 million between the two highest (Preliminary Alternatives 5 and 6).

b. Benefit-Cost Ratios and Net Benefits

In arraying the eight alternatives, benefit-cost ratios and net benefits are closely correlated, with Preliminary Alternative 2 being highest at 1.21 and $7.25 million, respectively. Preliminary Alternatives 3 and 5 follow fairly close behind with benefit-cost ratios of 1.14 and about $5 to $6 million, respectively, in net benefits.

All alternatives exceed unity except Preliminary Alternatives 1 and 8 which, without major power benefits, fall below unity at .58 and .80, respectively. Annual costs exceed benefits by $4.8 million with Preliminary Alternative 1 and $1.7 million with Preliminary Alternative 8. The benefit-cost ratio for Preliminary Alternative 1 would likely gain the most from better estimates of the effects of improved management and flood control.

The importance of peaking power benefits to Preliminary Alternatives 2 through 7 are quite obvious as they represent from 90 to 95 percent of the total benefits. The relaxation of the conservative assumption that power capacity had to be available 100 percent of the time rather than the more conventional 90 percent would increase the installed capacity and thus increase power benefits. It is doubtful, however, that this would change the relative economic position of Preliminary Alternatives 2 through 7. Eliminating the real fuel escalation factor, which moderately reduces benefit-cost ratios and net benefits, also should not realign the relative economic position of those 6 alternatives.

As indicated previously in this chapter, net benefits were discounted to the present (1982). This required an estimate of the on-line date for each alternative. Alternatives with fewer major project features could be completed ahead of others requiring greater structural efforts. Rough estimates of on-line dates extended from 1993 for Preliminary Alternatives 1 and 8 to 1999 for the more complex projects, Preliminary Alternatives 4, 5, and 6. An intermediate date of 1997 was estimated for Preliminary Alternatives 2, 3 and 7.

Discounting for the occurrence of values 11 to 17 years in the future at the specified 7.5 percent discount rate resulted in present worth values of 45 to 29 cents on the dollar. These discounts apply to total costs and total benefits as well. There was, as expected, some shift in the relative magnitude of net benefits because of time differentials. The relative economic positions of the alternatives, however, were not changed significantly.

c. Cost Effectiveness

The estimated cost per kilowatt of installed capacity for the power intensive Preliminary Alternatives 2 through 7 range from a low of $2,000 per kilowatt for Preliminary Alternative 2 to a high of $2,900 for Preliminary Alternative 7. Preliminary Alternative 3 at $2,300 per kilowatt, ranks second lowest. These costs per kilowatt correlate well with the benefit-cost ratios and net benefits. Preliminary Alternatives 4, 5, and 6 cluster at $2,700 to $2,800 per kilowatt. This suggests that increased complexity and size of a project result in increased incremental cost, thus raising average unit costs. The low of $670 and $640 per kilowatt for Preliminary Alternatives 1 and 8 are not very meaningful for comparison purposes. It does indicate that small run-of-the-river energy producing plants appear to be relatively inexpensive additions.

Total reservoir costs divided by storage capacity resulted in unit costs of between $375 to $650 per acre-foot. There was poor correlation with benefit-cost ratios and net benefits. More meaningful would be the comparison of unit storage costs for individual reservoirs as presented earlier in Table VI-10. This table shows New Seaman (component of Preliminary Alternatives 4, 5 and 6) as the lowest cost at $340 per acre-foot with the small Rockwell (Preliminary Alternative 6) the highest at $1,080. The three large upper mainstem reservoirs, Idylwilde, Elkhorn, and Indian Meadows (Preliminary Alternatives 2, 3, and 4 respectively) were somewhat more costly than New Seaman, from $410 to 420 per acre-foot.

4. Non-Monetary Evaluation Criteria

a. Geologic Considerations

One of the important findings is that there are no major identifiable geologic problems at facilities included in any of the eight preliminary alternative projects. The relative degree of overall geologic confidence is considered proportionate to the availability of data and the increasing number of structures and miles of tunnels. This accounts for the rather subjective rating of "highest" for Preliminary Alternative 1 and "high" for Preliminary Alternatives 2, 3, and 8 and "low" and "lowest" for Preliminary Alternatives 5 and 6. Lack of data and increasing construction complexity combine to lower the relative confidence rating for the latter.

b. Physical Impacts

A true ranking of the relative impacts due to inundation resulting from project development requires some qualitative judgments. This is especially true where social and esthetic aspects, which are beyond the scope of this study, can be important weighting factors. On the other hand, there is some correlation of relative impact in terms of sheer numbers, such as in the estimates of buildings displaced. This suggests that Preliminary Alternative 4 would have the largest effect as it would inundate an estimated 130 buildings and the two communities of Indian Meadows and Rustic. Preliminary Alternative 6 would inundate an estimated 105 buildings including the community of Indian Meadows and the Fort Collins Treatment Plant. Preliminary Alternatives 2 and 3 appear to occupy a middle range of effects, while Preliminary Alternatives 5 and 1 appear to have a lesser effect. Preliminary Alternatives 7 and 8 appear to have the least physical impacts of any of the preliminary alternative projects.

CHAPTER VII
SELECTION AND FORMULATION OF ALTERNATIVE PROJECTS (PHASE II)

A. INTRODUCTION

This chapter discusses the basis for the selection of alternative projects for reconnaisance level evaluation during Phase II of the study, describes the alternative projects and presents the estimates for construction costs for the alternative projects.

B. SELECTION OF ALTERNATIVE PROJECTS

The original intent of the study was to select one or two alternative projects for evaluation at a reconnaissance level of study. Evaluation during Phase I of the study did not yield a large relative difference among the eight preliminary alternatives considered. As can be seen in Table VI-13, the comparative evaluation considering estimates of increased yield of water, monetary evaluation criteria and non-monetary evaluation criteria did not clearly indicate superiority of one project as opposed to the others. Considering the preliminary nature of the formulation and evaluation, differences in estimated project outputs and measure of these outputs and other impacts are considered to be relatively minor.

As a result, a clear consensus of opinion did not emerge at the completion of Phase I of the study from the study advisory committee or from the public favoring any particular alternative or set of alternatives. The single area of consensus appeared to be a desire to minimize the impacts of possible development in the upper basin.

In August 1982 the CWCB, at its regular bi-monthly meeting, reviewed the results of Phase I of the Cache la Poudre study as published in the Interim Report on the Cache la Poudre Project Study, dated July 1982 and the Addendum to the Interim Report, dated August 1982. After discussing the Phase I analyses and hearing public comments on the study, the Board selected Alternatives 2, 7 and 8 for further analysis in Phase II of the study.

Alternative 2 was selected on the basis of the monetary evaluation factors which indicated this alternative had the largest net benefits, the highest benefit-cost ratio and a high level of cost effectiveness both in terms of hydropower production and storage costs. Alternatives 7 and 8 were selected primarily on the basis of the non-monetary evaluation factors which indicated that these alternatives would have the lowest level of impact from inundation on existing development. Alternative 8 was also selected because it was important to carry forward in Phase II the concept of a single reservoir system.

Following the August meeting of the CWCB, it became apparent that an important opportunity for comparative analysis would be lost if Alternative 1 were not included as an alternative single reservoir project. Consequently, the CWCB staff recommended that Alternative 1 be added as a fourth alternative and the Board adopted the recommendation.

The decision to investigate four alternative projects, rather than one or two, during Phase II of the study necessitated a change in the level of detail of investigation originally intended for Phase II as explained in the following sections.

C. FORMULATION OF ALTERNATIVE PROJECTS

1. General

The decision to investigate four alternative projects during Phase II of the study rendered it impossible, within constraints of budget and time, to develop the level of detail initially intended. Therefore, reformulation of the alternative projects was limited primarily to upgrading designs and cost estimates for the project facilities to achieve a reconnaisance level of detail.

2. Operation Studies

The operation studies performed during Phase I of the study were used as the basis for the estimates of benefits in the evaluation during Phase II. The sizing of project reservoirs and other facilities were not optimized as was originally envisioned. The result is that project reservoirs are probably oversized, resulting in construction costs that are conservatively high. The criteria for dependable capacity as a basis for peaking power benefits used in Phase I required that capacity be available 100 percent of the time to qualify as dependable capacity was also not revised and relaxed for Phase II as intended. Change of this criteria to a more accepted 90 percent availability would result in greater installed capacities at the peaking power plants and an accompanying increase in peaking power benefits. Assumptions regarding water rights were not revised from those in Phase I of the study; however, additional analysis was performed to verify the assumed negligible effects on a Cache la Poudre Project which would result from a Lower South Platte River Project development.

3. Description of Major Project Features

a. General

The major project features that are included in the alternative projects are as follows: Grey Mountain Dam; New Seaman Dam, Elkhorn Dam; Idylwilde Dam; Elkhorn Conduit and Cache la Poudre Power Plant; and Elkhorn Tunnel and New Seaman Power Plant. Conceptual layout studies were conducted for these major project features, and these features are described below.

The geologic data and geologic evaluations for the four major reservoir sites were upgraded during Phase II to the extent necessary to develop reconnaissance level designs and cost estimates. Specific layouts for the four major dams and reservoir sites were refined and upgraded and preliminary inflow design flood routing was performed to enable reconnaissance level cost estimates to be made. As was previously mentioned, reservoir sizes and other facilities were not optimized; therefore, dam heights, power plant sizes, tunnel sizes, etc. are subject to revision as a result of future, more detailed studies. Similarly, further studies could result in the selection of different concepts of dam design. For the comparative analysis of the present study, roller compacted concrete gravity dams were assumed. Further study could result in a decision favoring a rockfill dam, conventional concrete gravity dam, or concrete arch dam at the selected sites.

b. General Geology

(1) General Setting

The portion of the Cache la Poudre drainage basin being studied, the upper basin, is almost entirely contained within uplifted, very old Precambrian basement crystalline rocks. These uplifted crystalline rocks form part of the easternmost mountain range in Colorado, referred to as the Front Range. The elevations in the upper basin range from 5,000 feet in the east near Fort Collins, to over 10,000 feet in the western part of the drainage basin. Steeply dipping, younger Paleozoic and Mesozoic sedimentary rocks flank the old crystalline rocks at the eastern edge of the Front Range. At this crystalline-sedimentary contact, the topography changes from steep high mountains to the flat Great Plains. Locally resistant sandstone and limestone beds form hogbacks parallel to the eastern edge of the mountains. These hogbacks give way to relatively flat lying sedimentary rocks that underlie the Great Plains.

(2) Historical Geology

In early Precambrian time, deposition of shales, sandstones, graywackes, and volcanic rocks occurred in a major trough, or geosyncline. Regional metamorphism and deformation occurred about 1,800 million years ago (M.Y.A.), transforming the sedimentary rocks into gneisses, schists and migmatites and transforming the lava flows into amphibolites. These metasediments and meta-basalts now form what is referred to in the project area as the Idaho Springs Formation. The late Precambrian was a time of felsic or granitic intrusions, such as the Log Cabin Batholith and associated pegmatites.

The Paleozoic Era in Colorado (225 to 570 M.Y.A.) was marked by marine and continental sedimentary deposition. During Pennsylvanian time (265 to 310 M.Y.A.), the area was uplifted and erosion stripped the relatively thin pre-Pennsylvanian sediments from the developing highlands. Pre-Pennsylvanian rocks are absent on the surface and in the subsurface in northeastern Colorado. Thus, the younger Pennsylvanian and Permian rocks lie directly on the ancient Precambrian surface in the upper basin. The Peleozoic Fountain Formation, a typical, coarse red sandstone, was deposited at this time in the upper basin directly upon the Precambrian rocks.

The Mesozoic Era in Colorado (65 to 225 M.Y.A.) was also marked by both marine and continental deposition. Later, near the end of the Cretaceous Period (65 M.Y.A.), uplift occurred again. The sediments were uplifted, faulted and folded over the rising Precambrian basement. Movement occurred along Precambrian faults and along new faults which cross from younger sedimentary rocks into the ancient metamorphics.

In late Cretaceous to early Tertiary time, the Front Range was formed by approximately east-west compression during the Laramide Orogeny. The folding and east to northeast trending shearing that occurred is a result of complicated poly-phase deformation. The resulting Front Range in existence today is due to the Laramide Orogeny.

During and after the Laramide Orogeny, erosion occurred on the uplifted Front Range. All of the sediments have been eroded and the ancient Precambrian surface is exposed, except on the eastern boundary of the upper basin.

Pleistocene mountain glaciation has most recently shaped the Cache la Poudre drainage basin, eroding stream valleys and depositing moraines.

(3) Structural Geology

The major structural features in the upper basin are associated with the ancient Precambrian metamorphism and the later Laramide Orogeny. Tight isoclinal folding of gneisses and schists, migmitization, faulting jointing and intrusions are all visible Precambrian structural features. Uplift during the Laramide Orogeny produced faulting and folding of the younger Paleozoic and Mesozoic sedimentary rocks. At the eastern extent of the Front Range, the sedimentary beds are now upturned and the more resistant beds among them form prominent hogbacks flanking the Precambrian crystalline rocks.

(4) Rock Types

The upper basin includes a large variety of rock types. From oldest to youngest they are: Precambrian crystalline metamorphic and igneous basement rock; Paleozoic and Mesozoic sedimentary rocks; and unconsolidated fluvial and glacial deposits of the Quaternary Period. The Precambrian metamorphic rocks are approximately 1.7 billion years old and are composed of biotite gneiss, schist and migmatite (primarily derived from sedimentary rocks) and felsic and hornblende gneisses (primarily derived from volcanic rocks). The Precambrian igneous rocks are approximately 1.4 billion years old and are composed of granites and quartz monozonites. Although foliated and jointed, both igneous and metamorphic Precambrian rocks form generally hard massive, dark varicolored outcrops. Deep weathering occurs only in locally fractured areas.

There are a variety of Paleozoic and Mesozoic sedimentary rocks in the eastern edge of the upper basin, including sandstones, siltstones, shales and limestones. The sandstones and siltstones vary in color from buff to pink or red, and are generally massively bedded although often badly broken; and may exhibit cross-bedding. The shales vary in color from black to red-brown and are generally thin-bedded and often interbedded with the siltstones and sandstones. Limestone is either found as resistant light-colored beds or as carbonaceous zones within the shales and sandstones. Near the upper basin eastern boundary, the Niobara Formation limestone forms a hogback ridge which is being quarried for a cement plant.

Cenozoic rocks in the area are limited to Quaternary fluvial and glacial deposits. The unconsolidated fluvial deposits consist of sand, gravel and cobbles along the present Cache la Poudre stream valley. Locally, earlier alluvial terraces flank portions of the river valley. Glacial moraines consisting of unconsolidated sand, gravel and cobbles are also found in specific areas of the upper basin.

(5) Geomorphology

The Cache la Poudre River flows northward from its origin high in the Front Range of northern Colorado. The river then changes course near Kinikinik and flows eastward across the mountains to the easternmost extent of the Front Range where the river changes course again and flows southeastward to its confluence with the South Platte River near Greeley, Colorado. Along its course across the mountains, the river flows through alternating narrow steep-sided canyons and alluvial valleys a few hundred feet wide. The river is flanked locally by alluvial terraces and glacial moraines.

Glaciation has played an important role in forming the region's present topographic features. Mountain glaciation producing typical U-shaped valley cross-sections and moraines found within the drainage basin indicate that glacial advances once occurred. The dominant landforms in the upper basin include the rugged Precambrian mountains and the younger steeply dipping Paleozoic and Mesozoic soft sedimentary formations that form the conspicuous hogbacks that flank the eastern extent of the Front Range, where it joins the Great Plains.

c. Grey Mountain Dam

The Grey Mountain Damsite is located on the mainstem of the Cache la Poudre River approximately two miles downstream from the City of Fort Collins water treatment plant. The proposed Grey Mountain Dam is one of the major project features included in Alternatives 1 and 2. The reservoir created by the dam will have a total storage capacity of 200,000 acre-feet of which 190,000 acre-feet will be active storage.

For the purposes of this study, a conceptual layout was prepared for a concrete gravity dam that could be constructed by roller-compacted methods. The general plan for the dam and the reservoir characteristics are shown on Figure VII-1. As shown, this project feature will include a concrete gravity dam with a maximum height of about 400 feet, an ungated spillway, a low-level and high-level outlet works, and a power plant with an installed capacity of 12 megawatts.

(1) Geology

The Grey Mountain Damsite is located on Precambrian metamorphic rocks in a relatively narrow canyon. Braddock and Cole [16] describe the rock as "principally derived from sedimentary rocks, locally containing interbedded hornblende gneiss, calc-silicate rock, quartz rich rock and metaconglomerate." Also found througout the area are pegmatite, diorite and granodiorite dikes. The foliation of the rocks generally strike west of northeast, and as a result of tight folding, dip steeply. According to Braddock et. al. [18], a fault parallel to the stream channel crosses the dam axis. The presence of this fault locally controls regional foliation. According to the drilling program and joint survey as mentioned by Cast [27], joints are common througout the area but at depth they are tight and in good condition. The abutments at the damsite have similar jointing. In Cast's report it was concluded that the foundation conditions are suitable for a concrete dam.

The stream section has an average width of about 200 feet. It consists of streambed deposits such as gravels, cobbles and boulders up to 15 cubic yards maximum size. Alluvial materials encountered in the bore holes were coarse and permeable. The bedrock-alluvium interface is sharp as good rock is encountered at the river bottom. Packer tests indicated no water losses except for a zone of poor recovery or broken rock encountered in one drill hole. The north-south trending fault parallel to the stream which occurs near the base of the left abutment was intersected by a drill hole. Moderate water losses were encountered here. About 38 feet to 50 feet of alluvium would have to be removed in the stream section. In addition, extra grouting in the zones of broken rock and shear zones may be necessary to eliminate water loss routes. However, because the bedrock is generally good, no unusual excavation into the bedrock will be required once the alluvial gravels are removed.

The reservoir will lie entirely upon Precambrian metamorphic gneisses and schists. Joints at the surface are abundant throughout the area, however, these are expected to be tight at depth permitting no seepage to occur. According to Cast [27], water loss along the faults and shears that interest the reservoir is not probable because: 1) the metamorphic rocks are insoluble, 2) the shears contain a high percentage of "fines", 3) the seepage paths are long. The metamorphic rocks forming the reservoir are impermeable and insoluble, therefore, it is anticipated that the reservoir will be watertight.

(2) Dam

The general plan for the proposed Grey Mountain Dam is shown on Figure VII-1. This conceptual layout shows a concrete gravity dam that will have a maximum height of about 400 feet with a crest length of 1,530 feet. The concrete volume will be about 1,300,000 cubic yards.

(3) Spillway

The spillway will consist of an ungated overflow crest located in the dam as shown on Figure VII-1. The crest length will be approximately 550 feet. The spillway capacity will be 535,000 cubic feet per second, which will be sufficient to pass the maximum probable flood. The spillway flows will be discharged away from the dam by a flip bucket.

(4) Outlet Works

Both a high-level and low-level outlet works will be provided. The high-level outlet works will be controlled by a slide gate on the upstream face of the dam, and the low-level outlet works will be controlled both by butterfly valves in the gallery chamber and a fixed cone valve on the downstream end of the conduit. The fixed cone valve facility will be incorporated into the power plant structure.

(5) Power Plant

The power plant structure will be located at the downstream toe of the dam on the right abutment. The outlet conduit will be utilized as the waterway and penstock for the plant. The power plant equipment will include two Francis-type turbines and the total installed capacity will be 12 megawatts.

(6) Diversion During Construction

Diversion during construction will be provided by outlet conduits installed in the lower portion of the dam in the left side of the stream channel. After the spillway for the dam is completed and low-level outlet works is operable, the diversion conduits will be bulkheaded, then plugged with concrete and grouted.

d. New Seaman Dam

The New Seaman Damsite is located on the North Fork of the Cache la Poudre River just upstream from the confluence of the North Fork and the mainstem of the Cache la Poudre. The proposed New Seaman Dam is one of the major project features included in Alternative 7. The reservoir created by the dam will have a total storage capacity of 200,000 acre-feet of which 190,000 acre-feet will be active storage.

For the purposes of this study, a conceptual layout was prepared for a concrete gravity dam that could be constructed by roller-compacted methods. The general plan for the dam and the reservoir characteristics are shown on Figure VII-2. As shown, this project feature will include a concrete gravity dam with a maximum height of about 390 feet, an ungated spillway in the dam, a low-level and high-level outlet works, and a power plant with an installed capacity of 8 megawatts.

(1) Geology

The New Seaman Damsite lies approximately 1,000 feet south of the existing Milton Seaman Dam and, the bedrock in the area consists of Precambrian gneisses and schists with local intrusions of granitic dikes. The valley is asymetrical at the damsite and the depth to bedrock in the stream channel may be up to 30 feet. Previous work in the area includes a report on the geology and foundation of the existing Seaman spillway area by Woodward-Clyde-Sherard and Associates [22]; an engineering feasibility study by International Engineering Company [28], and Ph.D. geologic studies by Connor [19] and Wohlford [20].

The right abutment consists of biotite gneiss. Biotite-rich layers produce a foliation that strikes about N85° W and dips 75° S. The right abutment is relatively steep, not covered by overburden, and outcrops are massive. Joints are spaced between 5 and 20 feet and are probably tight at depth. Required excavation on this abutment could be up to 20 feet. One diorite dike and two pegmatite dikes have been mapped on this abutment.

The stream valley is about 400 feet wide and covered with alluvium. Depth to bedrock could be over 30 feet. In the stream valley, the bedrock changes from the biotite gneiss of the right abutment to a sillimamite gneiss. This contact is anticipated to be a gradational mineralogic change and not a structural contact (fault).

The left abutment consists of sillimanite gneiss and exhibits a more gentle slope than the right abutment. The foliation and jointing change little from the right to the left abutment. Required excavations here could be up to 25 feet.

The dam axis crosses no faults or shears, however, the North Fork Fault and two associated smaller faults are located about 1,000 feet upstream from the dam axis. Also, a small fault on the right abutment about 400 feet downstream of the dam axis has been mapped by Connor [19].

The reservoir associated with the New Seaman Dam will not encounter any conditions different from the existing Milton Seaman Reservoir. The reservoir will be entirely upon Precambrian gneisses and schists, with associated small intrusions. The present reservoir seems to be tight. No fractures, pervious alluvium or other potential seepage paths have been found. Also, no seepage has occurred along the North Fork fault which is a shear zone intersecting the present reservoir. The New Seaman Reservoir is anticipated to be watertight based upon the history of the present reservoir. Although the head will be increased, no seepage is expected along the newly inundated portion of the North Fork fault because the seepage path will also be lengthened.

(2) Dam

The general plan for the proposed New Seaman Dam is shown on Figure VII-2. As shown, this concrete gravity dam will have a maximum height of about 390 feet and a crest length of about 1,400 feet. The concrete volume will be about 1,500,000 cubic yards. The existing Milton Seaman Dam will be inundated by the reservoir.

(3) Spillway

The spillway will consist of an ungated overflow crest located in the dam and a flip bucket to discharge the flows a safe distance downstream from the dam. The crest length of the spillway will be about 300 feet. The spillway capacity will be about 216,000 cubic feet second, which will be sufficient to pass the maximum probable flood.

(4) Outlet Works

Both a high-level and low-level outlet works will be provided. The high-level outlet works will be controlled by a slide gate on the upstream face of the dam, and the low-level outlet works will be controlled both by butterfly valves in the gallery chamber and a fixed cone valve on the downstream end of the conduit. The fixed cone valve facility will be incorporated into the power plant structure.

(5) Power Plant

The power plant structure will be located at the downstream toe of the dam on the left abutment. The outlet conduit will be utilized as the waterway and penstock for the plant. The power plant equipment will include two Francis-type turbines and the total installed capacity will be eight megawatts.

(6) Diversion During Construction

Diversion during construction will be provided by outlet conduits installed in the lower portion of the dam in the left side of the stream channel. After the spillway for the dam is completed and low-level outlet works is operable, the diversion conduits will be bulkheaded, then plugged with concrete and grouted.

e. Elkhorn Dam

The Elkhorn Damsite is located on the mainstem of the Cache la Poudre River just upstream of the Big Narrows and about two miles downstream from the mainstem's confluence with the South Fork. The proposed Elkhorn Dam is one of the major project features included in Alternatives 7 and 8. The reservoir created by the dam will have a total storage capacity of 196,000 acre-feet of which 186,000 acre-feet will be active storage.

For the purposes of this study, a conceptual layout was prepared for a concrete gravity dam that could be constructed by roller-compacted methods. The general plan for the dam and the reservoir characteristics are shown on Figure VII-3. As shown, this project feature will include a concrete gravity dam with a maximum height of about 460 feet, an ungated spillway in the dam, a low-level and high-level outlet works, and a power plant with an installed capacity of 14 megawatts for the single reservoir alternative, Alternative 8. A 1.3 megawatt power plant is included in Alternative 7.

(1) Geology

This site is located downstream from Dutch George Flats in the Big Narrows section of the Cache la Poudre River. The river valley is very narrow and little channel alluvium is present. Bedrock is exposed on both abutments and overburden is minimal. The outcrops on both abutments are massive. No previous detailed site investigations have been done, however, Abbott [17], has mapped this area.

The foundation rock consists of Precambrian granitic gneiss. The rock is fine- to coarse-grained and poorly-foliated to well-foliated. The foliations are defined by discontinuous seams of biotite and, locally, by the alignment of mineral grains. The foliations strike generally NW-SE and are steeply dipping.

This site appears to be well suited for a concrete gravity dam. There is little change in foliation, jointing, overburden and outcrop between the abutments. The abutments are massive and minimal weathering is evident. Jointing appears to be relatively tight and excavations of less than 15 feet will be required on both abutments and in the stream valley.

The Elkhorn Reservoir will be entirely contained within Precambrian gneisses and schists. In general, these rocks are impermeable and insoluble. No seepage is anticipated along joint networks. However, about one mile upstream from the damsite, the Poudre River shear zone intersects the proposed reservoir. This shear zone represents a possible seepage path from the reservoir. No evidence of large-scale strike-slip motion is apparent, however, vertical displacement has been widely proposed by other Front Range researchers. The seepage path is about 2,000 feet and the apparent gradient is about 1:10. If this shear zone is permeable, then seepage from the reservoir could occur. Blanketing the area where the shear zone intersects the reservoir could solve any seepage problems by lengthening the seepage path. The shear zone has been mapped with a width of about 300 feet where it intersects the reservoir. Other than this large shear zone, the Elkhorn Reservoir should be watertight.

(2) Dam

The general plan for the proposed Elkhorn Dam is shown on Figure VII-3. As shown, this concrete gravity dam will have a maximum height of about 460 feet and a crest length of about 1,500 feet. The concrete volume will be about 1,200,000 cubic yards.

(3) Spillway

The spillway will consist of an ungated overflow crest in the dam, a chute on the downstream slope of the dam with converging training walls, and a flip bucket. The flip bucket will project the jet to the river a safe distance downstream from the dam. The spillway capacity will be about 354,000 cubic feet per second, which will be sufficient to pass the probable maximum flood.

(4) Outlet Works

Both a high-level and low-level outlet works will be provided. The high-level outlet works will be controlled by a slide gate on the upstream face of the dam, and the low-level outlet works will be controlled both by butterfly valves in the gallery chamber and a fixed cone valve on the downstream end of the conduit. The fixed cone valve facility will be incorporated into the power plant structure.

(5) Power Plant

The power plant structure will be located at the downstream toe of the dam on the right abutment. The outlet conduit will be utilized as the waterway and penstock for the plant. The power plant equipment will include two Francis-type turbines and the total installed capacity will be 14 megawatts for Alternative 8 and 1.3 megawatts for the single Francis-type turbine in Alternative 7.

(6) Diversion During Construction

Diversion during construction will be provided by outlet conduits installed in the lower portion of the dam in the right side of the stream channel. After the spillway for the dam is completed and low-level outlet works are operable, the diversion conduits will be bulkheaded, then plugged with concrete and grouted.

f. Idylwilde Dam

The Idylwilde Damsite is located on the mainstem of the Cache la Poudre River approximately five miles upstream of the town of Rustic. The proposed Idylwilde Dam is one of the major project features included in Alternative 2. The reservoir created by the dam will have a total storage capacity of 200,000 acre-feet of which 183,000 acre-feet will be active storage.

For the purposes of this study, a conceptual layout was prepared for a concrete gravity dam that could be constructed by roller-compacted methods. The general plan for the dam and the reservoir characteristics are shown on Figure VII-4. As shown, this project feature will include a concrete gravity dam with a maximum height of about 320 feet, an earthfill dam in the right bank saddle, an ungated spillway in the dam, a low-level and high-level outlet works, and a power plant with an installed capacity of 24 megawatts.

(1) Geology

This site is located in a relatively narrow asymetrical canyon at the head of the Idylwilde Valley. The bedrock is Precambrian gneissic schist with local granite and pegmatite dikes. An extensive geological site investigation was completed by the USBR [23].

The bedrock on both abutments appears massive in outcrop, however, jointing produces blocky and slabby breakage. According to the USBR [23], the foliation generally strikes N 70° W and dips steeply. In addition, the USBR notes that there is a conchoidal flow structure along which the more foliated rocks cleave. The right (eastern) abutment is an erosion monadnock of schist and granite gneiss. Joint systems in the area are parallel to the foliation, strike N 15° E and dip 76° E, and strike NE and dip 30° NW. The jointing forms a blocky appearance. Scattered outcrops exist. However, drill core data indicate overburden is only about four feet deep. The abutment is flanked by talus slopes.

The stream valley is composed of glacial and fluvial gravels and boulders. Towards the western side of the stream, terrace deposits consisting of rounded boulders of maximum size, 9 feet in diameter in a sandy soil matrix are found to a depth of 23 feet. The left (western) abutment also consists of schists and granite gneiss. Jointing is similar to the right abutment except the foliation dips 60° SW. The lower portion of the abutment is covered with slope wash and talus blocks up to 20 feet across. Glacial striations parallel to the stream are found on the upper outcrops. Just downstream of the abutment, the rock is more massive with flat jointing. One system of joints strikes N 38° W and dips vertically, and another system strikes N 76° E and dips vertically. The jointing in this abutment is generally tight. Required excavations on the abutments and in the stream valley are estimated to be about 15 feet and more than 30 feet, respectively.

The Idylwilde Reservoir is contained within impermeable, insoluble Precambrian metamorphic rocks. No seepage is anticipated through the rock or joint systems. Also, no large scale shears or faults intersect the reservoir. However, about 1,000 feet upstream from the dam axis on the right abutment, an erosional saddle is found. Information gained from the digging of test pits in the saddle (USBR, [23]) strongly suggest that a tongue of the main glacier may have entered this area and together with its outwash scoured a deep channel, thus forming the saddle. Test pits were dug to 41 feet without encountering bedrock. The overburden in the saddle appears pervious. Therefore, this saddle represents a seepage path from the reservoir. Blanketing of the reservoir slope to increase the seepage path or a positive cutoff to the bedrock will probably be required to eliminate the potential seepage problem.

(2) Dam

The general plan for the proposed Idylwilde Dam is shown on Figure VII-4. As shown, this project feature will include a concrete gravity dam with a maximum height of about 320 feet. The crest length will be approximately 1,480 feet, and the concrete volume will be about 1,200,000 cubic yards.

(3) Spillway

The spillway will consist of an ungated overflow crest located in the dam, a chute with training walls on the downstream slope of the dam, and a flip bucket. The crest length of the spillway will be about 400 feet. The spillway capacity will be about 235,000 cubic feet per second, which will be sufficient to pass the probable maximum flood.

(4) Saddle Dam

This structure will be an earthfill dam located on the right bank about 1,000 feet upstream from the axis of Idylwilde Dam. The dam with a maximum height of about 90 feet will be a zoned embankment with a central impervious core. The central core will connect to an impervious blanket that will blanket an area upstream of the saddle dam as shown on Figure VII-4. The impervious blanket will be necessary to lengthen and block a short seepage path. The embankment volume will be approximately 260,000 cubic yards, and the blanket volume will be 130,000 cubic yards.

(5) Outlet Works

Both a high-level and low-level outlet works will be provided. The high-level outlet works will be controlled by a slide gate on the upstream face of the dam, and the low-level outlet works will be controlled both by butterfly valves in the gallery chamber and a fixed cone valve on the downstream end of the conduit. The fixed cone valve facility will be incorporated into the power plant structure.

(6) Power Plant

The power plant structure will be located at the downstream toe of the dam on the right abutment. The outlet conduit will be utilized as the waterway and penstock for the plant. The power plant equipment will include two Francis-type turbine-generator sets and the total installed capacity will be 24 megawatts.

(7) Diversion During Construction

Diversion during construction will be provided by outlet conduits installed in the lower portion of the dam in the left side of the stream channel. After the spillway for the dam is completed and low-level outlet works is operable, the diversion conduits will be bulkheaded, then plugged with concrete and grouted.

g. Elkhorn Conduit and Grey Mountain Power Plant

This major project feature will include the following facilities: Rustic Diversion Dam; a conveyance system of tunnels and pipelines from the Rustic Diversion Dam to the Cache la Poudre Forebay; the dam and appurtenances associated with the Cache la Poudre Forebay; an intake tunnel and penstock shaft for the power plant; the Grey Mountain Power Plant, tailrace tunnel and access tunnel, as shown in Figure VII-7.

(1) Geology

The tunnels included in the Elkhorn Conduit will lie completely within Precambrian crystalline metamorphic and igneous rock. The Precambrian rocks that will be crossed by the tunnels include: felsic hornblende gneiss, biotite schist, quartz monzonite, granite gneiss, and amphibolite. The tunneling characteristics of the various rock types should be relatively similar, however, the characteristics could change in areas of high schistosity or areas of dense jointing. The Elkhorn Conduit will cross several shear zones. To minimize the area of the shear zones crossed by the tunnel, its alignment will be as close to perpendicular to the shears as possible. It is anticipated that steel ribs and concrete lining will be required to support the tunnel sections where shear zones are crossed. In sound crystalline rock, it is anticipated that no tunnel supports will be required except for shotcrete and rockbolt support. When a contact between two rock types is encountered, one hundred feet of support is anticipated to alleviate assumed poor rock conditions near the contact.

A better indication of the tunneling conditions will be gleaned from the exploratory tunnel that should be driven into one of the Elkhorn damsite abutments. Also, drilling of the shear zones in the various reservoir areas will yield a better indication of the physical characteristics of the shear zones. From this information, the extent of the support that will be required where the tunnel crosses the shears can be estimated. It is anticipated that no major problems will be encountered that will preclude the construction of this tunnel.

(2) Rustic - Cache la Poudre Forebay Conveyance

This conveyance system will include 7.8 miles of tunnel and 3.9 miles of pipeline. An intake structure will be included at the entrance of the main tunnel which will be located at the Rustic Diversion Dam. This tunnel will be a partially concrete-lined pressure tunnel 12 feet in diameter. The pipeline will be 10 feet in diameter and the pipe will either be steel or concrete prestressed cylinder pipe.

(3) Cache la Poudre Forebay and Saddle Dam

These structures will be earthfill dams located two miles north of the Town of Poudre Park and about 1,100 feet in elevation above the Grey Mountain Power Plant. The main dam and the saddle dam, with a maximum height of about 140 feet and 70 feet, respectively, will be zoned embankment with central impervious cores. The enbankment volumes will be approximately 900,000 and 90,000 cubic yards, respectively. No spillway will be required as the drainage is less than a 0.5 square mile and any runoff could be stored in the reservoir.

The intake structure for the power plant intake conduit will be incorporated into the left side of the Cache la Poudre Forebay dam and also act as reservoir outlet works. A fixed wheel gate will be provided to control flows to the conduit and a bypass and fixed cone valve will be provided for emergency releases to the creek.

(4) Grey Mountain Power Plant

The underground power plant will be located 700 feet north of Grey Mountain reservoir. The intake conduit connecting to the Cache la Poudre Forebay will consist of 300 feet of either steel or concrete prestressed cylinder pipe, 10 feet in diameter and 5,700 feet of concrete and steel-lined pressure tunnel, 12 feet in diameter. The tunnel will consist of 4,300 feet of horizontal alignment and 1,400 feet of 55° inclined tunnel. An underground vertical surge chamber, 20 feet in diameter and 40 feet high is provided at the beginning of the inclined tunnel to protect the tunnel from over-pressurization and to augment plant start-up. An underground cavity, approximately 60 feet by 15 feet by 130 feet high will house the power plant equipment including two Francis-type turbine-generator sets with a total installed capacity of 81.5 megawatts. A 12-foot diameter, 700 foot long tailrace tunnel will discharge flows to Grey Mountain Reservoir. A 24-foot diameter horseshoe-shaped tunnel, 2,800 feet long will provide access to the power plant.

h. Elkhorn-New Seaman Conduit and New Seaman Power Plant

This major project feature will include the following facilities: an intake structure at Elkhorn Reservoir, a conveyance system of tunnels and pipelines from Elkhorn Reservoir to the New Seaman power plant, New Seaman power plant, tailrace tunnel and access tunnel as shown on Figure VII-8.

(1) Geology

The tunnels included in the Elkhorn Conduit will lie completely within Precambrian crystalline metamorphic and igneous rock. The Precambrian rocks that will be crossed by the tunnels include: felsic hornblende gneiss, biotite schist, quartz monzonite, granite gneiss, and amphibolite. The tunneling characteristics of the various rock types should be relatively similar, however, the characteristics could change in areas of high schistosity or areas of dense jointing. The Elkhorn Conduit will cross several shear zones. To minimize the area of the shear zones crossed by the tunnel, its alignment will be as close to perpendicular to the shears as possible. It is anticipated that steel ribs and concrete lining will be required to support the tunnel sections where shear zones are crossed. In sound crystalline rock, it is anticipated that no tunnel supports will be required except for shotcrete and rockbolt support. When a contact between two rock types is encountered, one hundred feet of support is anticipated to alleviate assumed poor rock conditions near the contact.

A better indication of the tunneling conditions will be gleaned from the exploratory tunnel that should be driven into one of the Elkhorn damsite abutments. Also, drilling of the shear zones in the various reservoir areas will yield a better indication of the physical characteristics of the shear zones. From this information, the extent of the support that will be required where the tunnel crosses the shears can be estimated. It is anticipated that no major problems will be encountered that will preclude the construction of this tunnel.

(2) Elkhorn-New Seaman Conveyance

This conveyance system will include 8.4 miles of tunnel and 1.5 miles of pipeline. An intake structure will be located about a mile upstream and north of Elkhorn Dam. The first 8.8 miles of conveyance consists of 8.1 miles of partially concrete-lined pressure tunnel 16 feet in diameter interspersed with 0.7 miles of either steel or concrete prestressed cylinder pipe, 12 feet in diameter and leads to an underground vertical surge chamber 28 feet in diameter and 450 feet high. Continuing to the power plant is 1.5 miles of pipeline 12 feet in diameter and 0.3 miles of fully-lined pressure tunnel 12 feet in diameter, as shown in Figure VII-8.

(3) New Seaman Power Plant

The underground power plant will be located 0.3 miles west of New Seaman Reservoir. An underground cavity approximately 60 feet by 150 feet by 130 feet high will house the power plant equipment including two Francis-type turbine-generator sets with a total installed capacity of 79 megawatts. A 16-foot diameter 1,700-foot long tailrace tunnel will discharge flows to New Seaman Reservoir. A 24-foot diameter horseshoe-shaped tunnel 600 feet long will provide access to the power plant.

4. Description of Alternative Projects

The general arrangement of Alternative Projects 1, 8, 2, and 7 is shown on the maps of Figures VII-5 through VII-8, respectively.

Since reformulation of the four selected alternative projects during Phase II was limited by constraints of budget and time, the description of the alternative projects remains the same as that given for the preliminary alternative projects in Chapter V. Alternative 1 is described in Chapter V.D.4.a., Alternative 8 in Chapter V.D.4.h., Alternative 2 in Chapter V.D.4.b. and Alternative 7 in Chapter V.D.4.g.

5. Staged Development Considerations

The four alternative projects include two - Alternatives 1 and 8 - which represent the single reservoir conservation storage concept and two - Alternatives 2 and 7 - which represent the multiple reservoir, conservation storage plus peaking power, concept. The selection of these four alternative projects will also permit an examination of the possibility of phased project development. The initial construction of Grey Mountain Reservoir - Alternative 1 - could be followed at a later date by construction of Idylwilde Reservoir and other facilities required to expand it into a multiple reservoir project for peaking power production resulting in Alternative 2. Likewise, the initial construction of Elkhorn Reservoir for conservation storage only - Alternative 8 - could be followed at a later date by construction of New Seaman Reservoir and other facilities required to expand the project into a multiple reservoir project for peaking power production, resulting in Alternative 7. In this event, New Seaman would then become the conservation storage reservoir and Elkhorn Reservoir operation would change to that of storing flows for peaking power production.

6. Cost of Alternative Projects

a. Capital Costs

Upgrading of geologic evaluations, specific layouts for the four major dams and preliminary inflow design flood routing enables reconnaissance level cost estimates to be made for the four alternative projects. Construction cost estimates are based on estimated quantities, recent bid prices, and cost estimating curves developed by the U.S. Army Corps of Engineergs, U.S. Bureau of Reclamation, and Tudor Engineering Company. Summaries of the estimated capital costs for the various features making up the four alternative projects are shown on Tables VII-1 through VII-4. Twenty-five percent has been added to the total field construction cost to account for unlisted items and uncertainties of construction conditions commensurate with reconnaissance level designs.

b. Operation, Maintenance and Replacement Costs

Annual operation, maintenance and replacement costs for the four selected alternative projects were estimated and are shown on Tables VII-1 through VII-4. Estimates for operation and maintenance costs for major facilities were estimated as a percentage of the construction cost using Bureau of Reclamation criteria. Operation and maintenance costs for large peaking power plants were estimated from cost curves developed by the Bureau of Reclamation and for smaller run-of-the-river power plants from cost data developed by Tudor Engineering Company. Replacement costs were estimated as a percentage of the construction cost of the various facilities using Bureau of Reclamation criteria.

TABLE VII-1

CACHE LA POUDRE PROJECT

CAPITAL COSTS

ALTERNATIVE 1

GREY MOUNTAIN ONLY

PROJECT FEATURE	COST
Grey Mountain Dam and Reservoir	$ 56,300,000
Grey Mountain Dam Power Plant	4,940,000
Fort Collins Treatment Plant Relocation	10,100,000
Road Relocations	8,680,000
U.S. Forest Service Facilities Access	190,000
Land and Building Relocations	14,070,000
Subtotal	$ 94,280,000
Contingencies (25%)	23,520,000
Field Cost	117,800,000
General Administration, Legal, etc.	1,200,000
Engineering 1/	11,800,000
Total Capital Cost	$130,800,000
Annual Operation Maintenance and Replacement	$ 200,000

1/ Includes:

Feasibility Studies/FERC License Application, EIS	$1,100,000
Final Designs and Specifications	$3,600,000
Engineering Services During Construction	$7,100,000

TABLE VII-2
CACHE LA POUDRE PROJECT
CAPITAL COSTS
ALTERNATIVE 2
IDYLWILDE - GREY MOUNTAIN

PROJECT FEATURE	COST
Idylwilde Dam and Reservoir	$ 57,200,000
Idylwilde Dam Power Plant	9,060,000
Kinikinik Afterbay Dam and Reservoir	1,530,000
Kinikinik Dam Power Plant	1,160,000
Rustic Diversion Dam and Reservoir	3,100,000
Elkhorn Conduit	46,500,000
Cache la Poudre Forebay Dam and Reservoir	10,100,000
Cache la Poudre Intake Conduit	9,100,000
Grey Mountain Power Plant	23,100,000
Access Tunnel	5,100,000
Tailrace Tunnel	800,000
Transmission Facilities	2,600,000
Grey Mountain Dam and Reservoir	56,300,000
Grey Mountain Dam Power Plant	4,940,000
State Fish Hatchery Relocation	800,000
Fort Collins Treatment Plant Relocation	10,100,000
Road Relocations	19,500,000
U.S. Forest Service Facilities Access	640,000
Land and Building Relocations	27,300,000
Subtotal	$288,930,000
Contingencies (25%)	72,270,000
Field Cost	361,200,000
General Administration, Legal, etc.	3,500,000
Engineering 1/	36,100,000
Total Capital Cost	$400,800,000
Annual Operation Maintenance and Replacement	$ 1,690,000

1/ Includes:

Feasibility Studies/FERC License Application, EIS	$ 3,400,000
Final Designs and Specifications	$11,000,000
Engineering Services During Construction	$21,700,000

TABLE VII-3

CACHE LA POUDRE PROJECT

CAPITAL COSTS

ALTERNATIVE 7

ELKHORN - NEW SEAMAN

PROJECT FEATURE	COST
Elkhorn Dam and Reservoir	$ 50,800,000
Elkhorn Dam Power Plant	1,030,000
Elkhorn Tunnel	72,400,000
New Seaman Power Plant	22,900,000
Access Tunnel	2,700,000
Tailrace Tunnel	1,600,000
Transmission Facilities	1,300,000
New Seaman Dam and Reservoir	64,000,000
New Seaman Dam Power Plant	3,510,000
Fort Collins Treatment Plant Relocation	10,100,000
Road Relocations	10,100,000
U.S. Forest Service Facilities Access	1,440,000
Land and Building Relocations	13,200,000
Subtotal	$255,080,000
Contingencies (25%)	63,820,000
Field Cost	318,900,000
General Administration, Legal, etc.	3,500,000
Engineering 1/	31,900,000
Total Capital Cost	$354,300,000
Annual Operation Maintenance and Replacement	$ 1,160,000

1/ Includes:

Feasibility Studies/FERC License Application, EIS	$ 2,900,000
Final Designs and Specifications	$10,000,000
Engineering Services During Construction	$19,000,000

TABLE VII-4

CACHE LA POUDRE PROJECT

CAPITAL COSTS

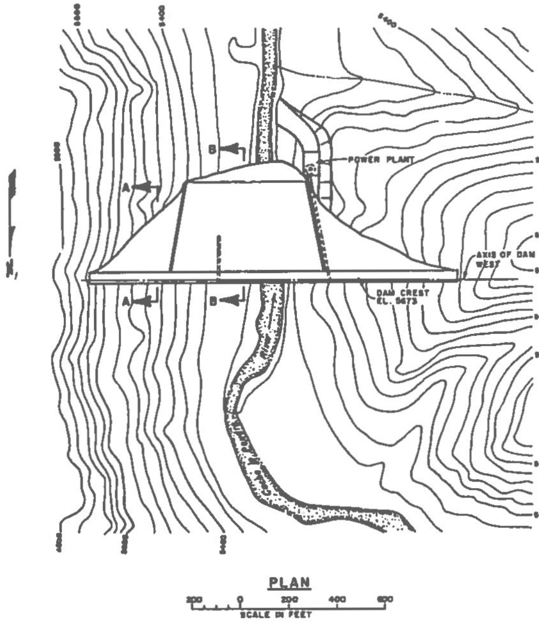
ALTERNATIVE 8

ELKHORN ONLY

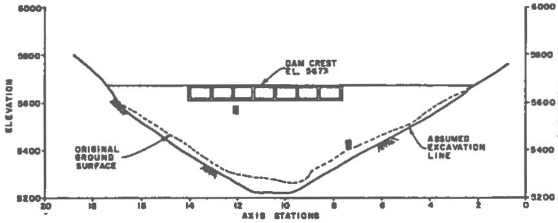
PROJECT FEATURE	COST
Elkhorn Dam and Reservoir	$ 50,800,000
Elkhorn Dam Power Plant	5,780,000
Road Relocations	10,100,000
U.S. Forest Service Facilities Access	1,440,000
Land and Building Relocations	10,700,000
Subtotal	78,820,000
Contingencies (25%)	19,700,000
Field Cost	98,520,000
General Administration, Legal, etc.	1,200,000
Engineering 1/	9,880,000
Total Capital Cost	$109,600,000
Annual Operation Maintenance and Replacement	$ 235,000

1/ Includes:

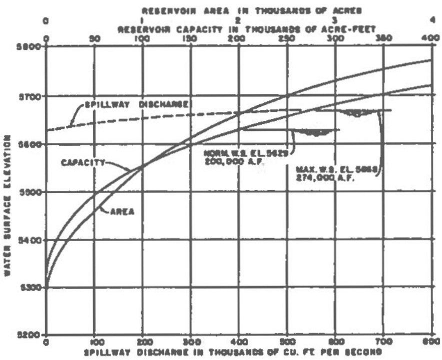
Feasibility Studies/FERC License Application, EIS	$1,100,000
Final Designs and Specifications	$3,000,000
Engineering Services During Construction	$5,780,000



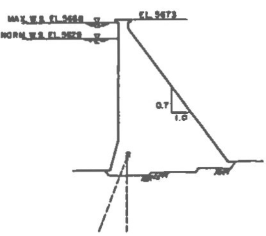
PLAN



PROFILE ALONG AXIS OF DAM

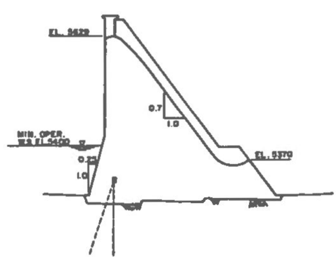


AREA-CAPACITY-DISCHARGE CURVES



SECTION A-A

TYPICAL NON-FLOW SECTION



SECTION B-B

TYPICAL SPILLWAY SECTION

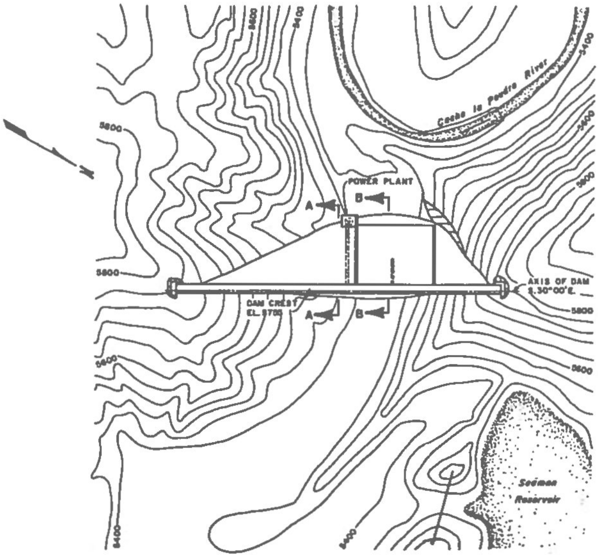
COLORADO WATER CONSERVATION BOARD

CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

GREY MOUNTAIN DAM

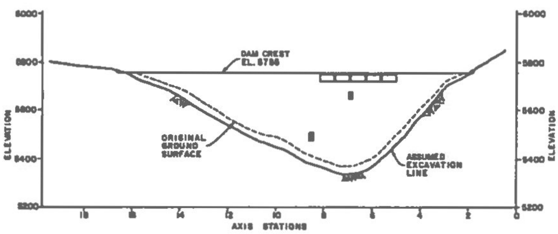
TUDOR ENGINEERING COMPANY

FIGURE: VII - 1

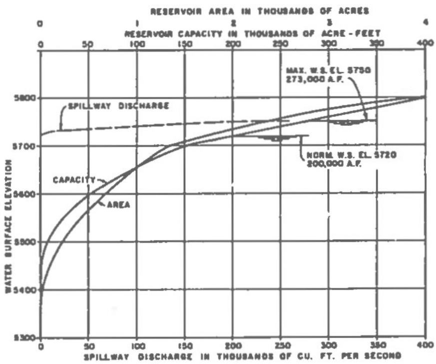


PLAN

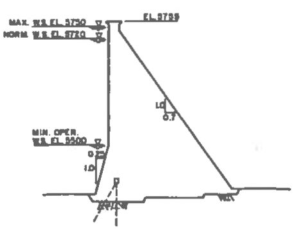
200 0 200 400 600
SCALE IN FEET



PROFILE ALONG AXIS OF DAM



AREA - CAPACITY - DISCHARGE CURVES



SECTION A-A

TYPICAL NON-OVERFLOW SECTION

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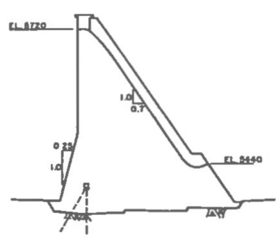
SCALE IN FEET



SECTION B-B

TYPICAL SPILLWAY SECTION

100 0 100 200 300
SCALE IN FEET

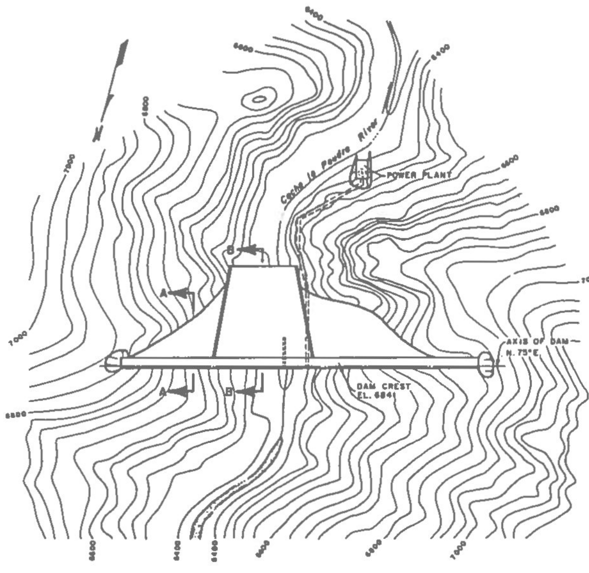
COLORADO WATER CONSERVATION BOARD

CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

NEW SEAMAN DAM

TUDOR ENGINEERING COMPANY

FIGURE - VII - 2



PLAN

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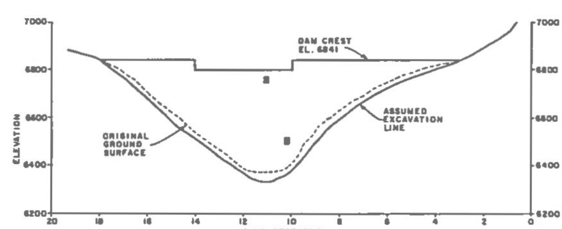
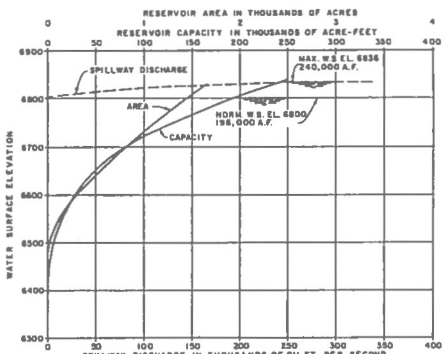
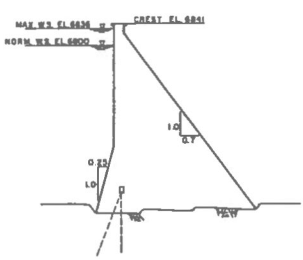
SCALE IN FEET



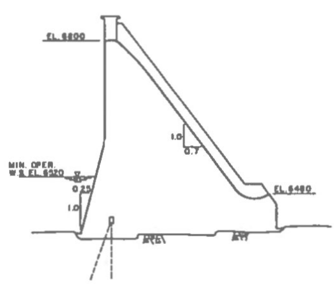
PROFILE ALONG AXIS OF DAM



AREA CAPACITY DISCHARGE CURVES



SECTION A-A
TYPICAL NON-OVERFLOW SECTION
100 0 100 200 300
SCALE IN FEET



SECTION B-B
TYPICAL SPILLWAY SECTION
100 0 100 200 300
SCALE IN FEET

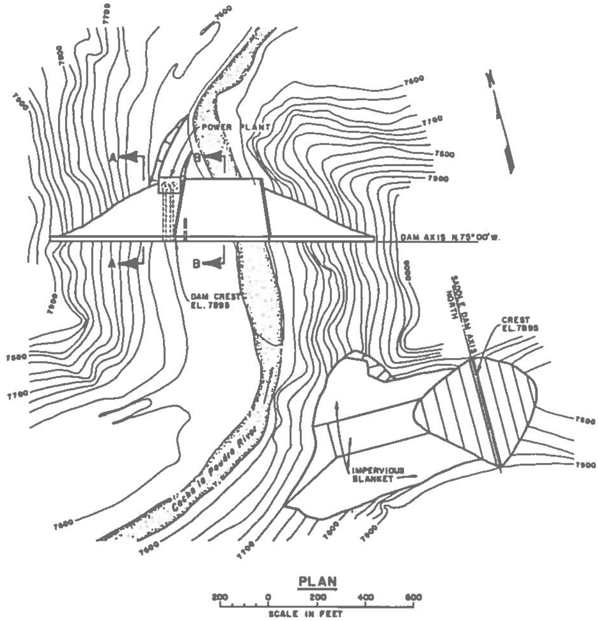
COLORADO WATER CONSERVATION BOARD

CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

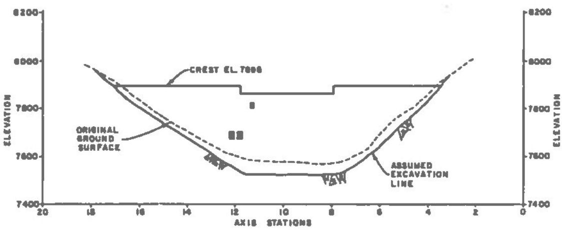
ELKHORN DAM

TUDOR ENGINEERING COMPANY

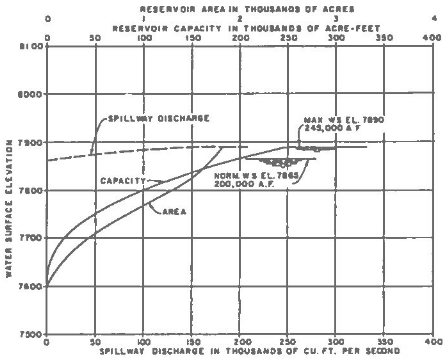
FIGURE VII-3



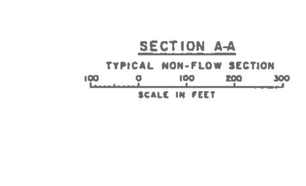
PLAN



PROFILE ALONG AXIS OF DAM



AREA - CAPACITY - DISCHARGE CURVES

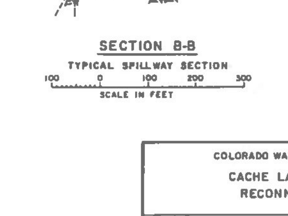


SECTION A-A

TYPICAL NON-FLOW SECTION

100 0 100 200 300

SCALE IN FEET



SECTION B-B

TYPICAL SPILLWAY SECTION

100 0 100 200 300

SCALE IN FEET

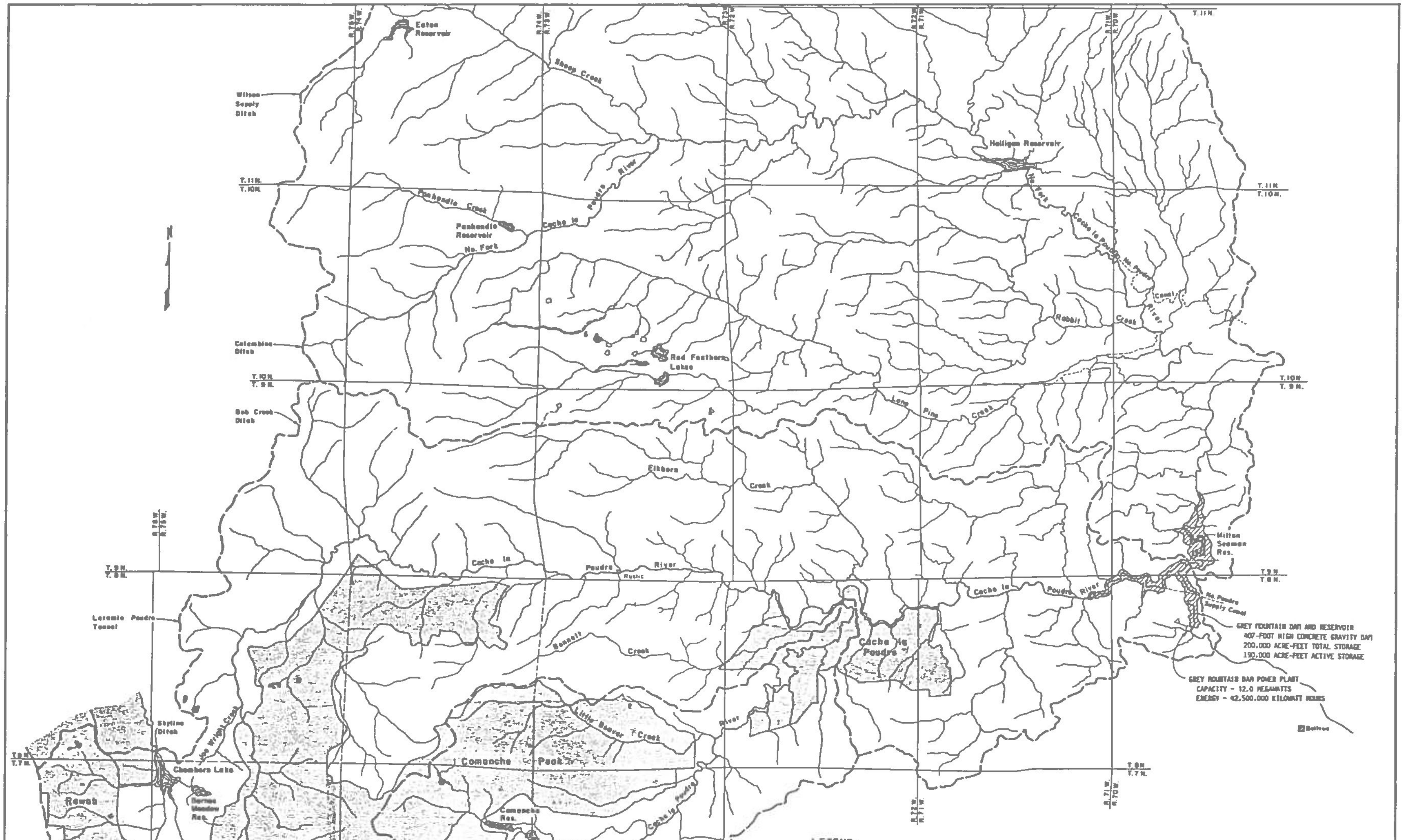
COLORADO WATER CONSERVATION BOARD

CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

IDYLWILDE DAM

TUDOR ENGINEERING COMPANY

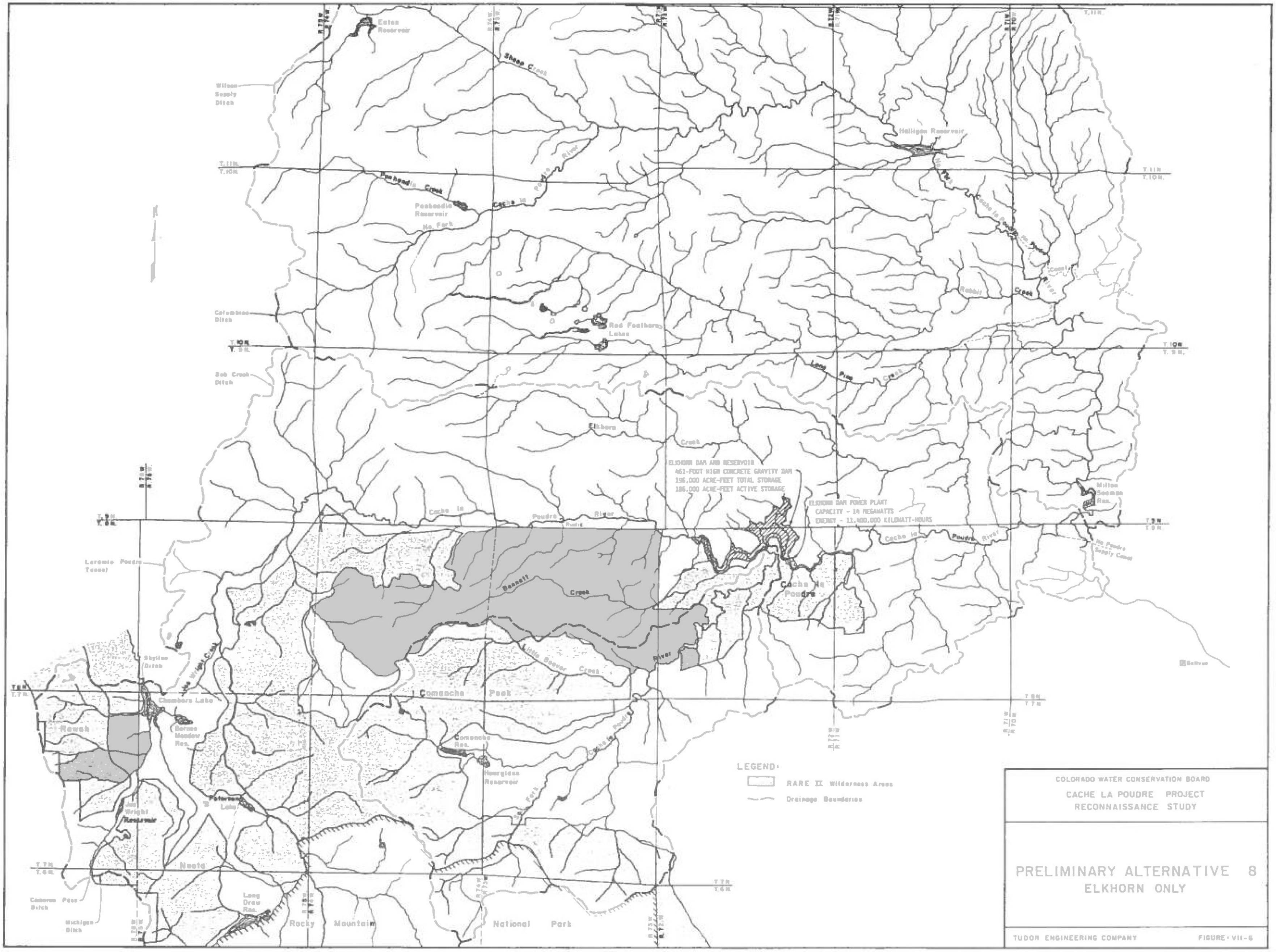
FIGURE - VII - 4



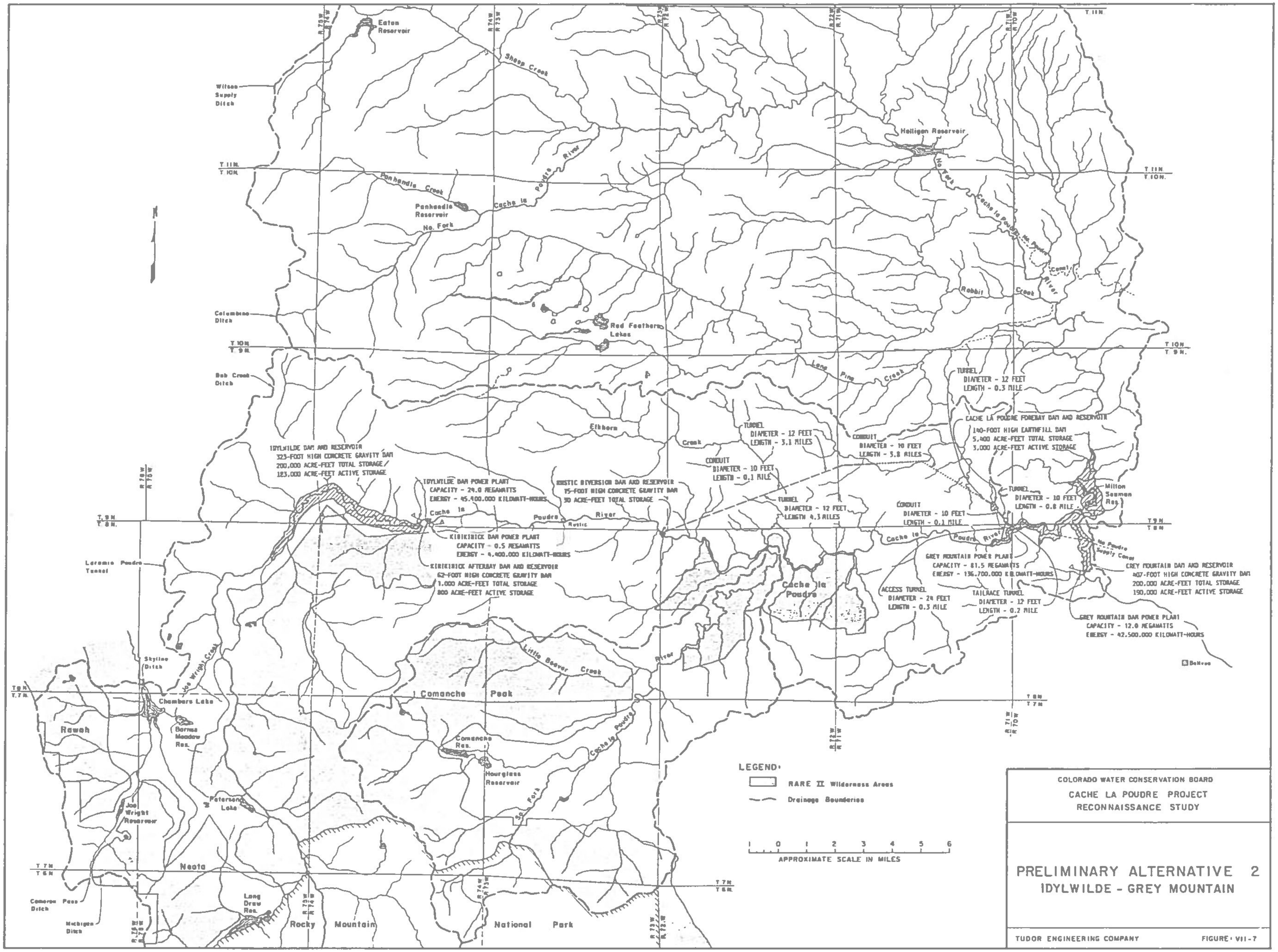
COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

PRELIMINARY ALTERNATIVE I
GREY MOUNTAIN ONLY

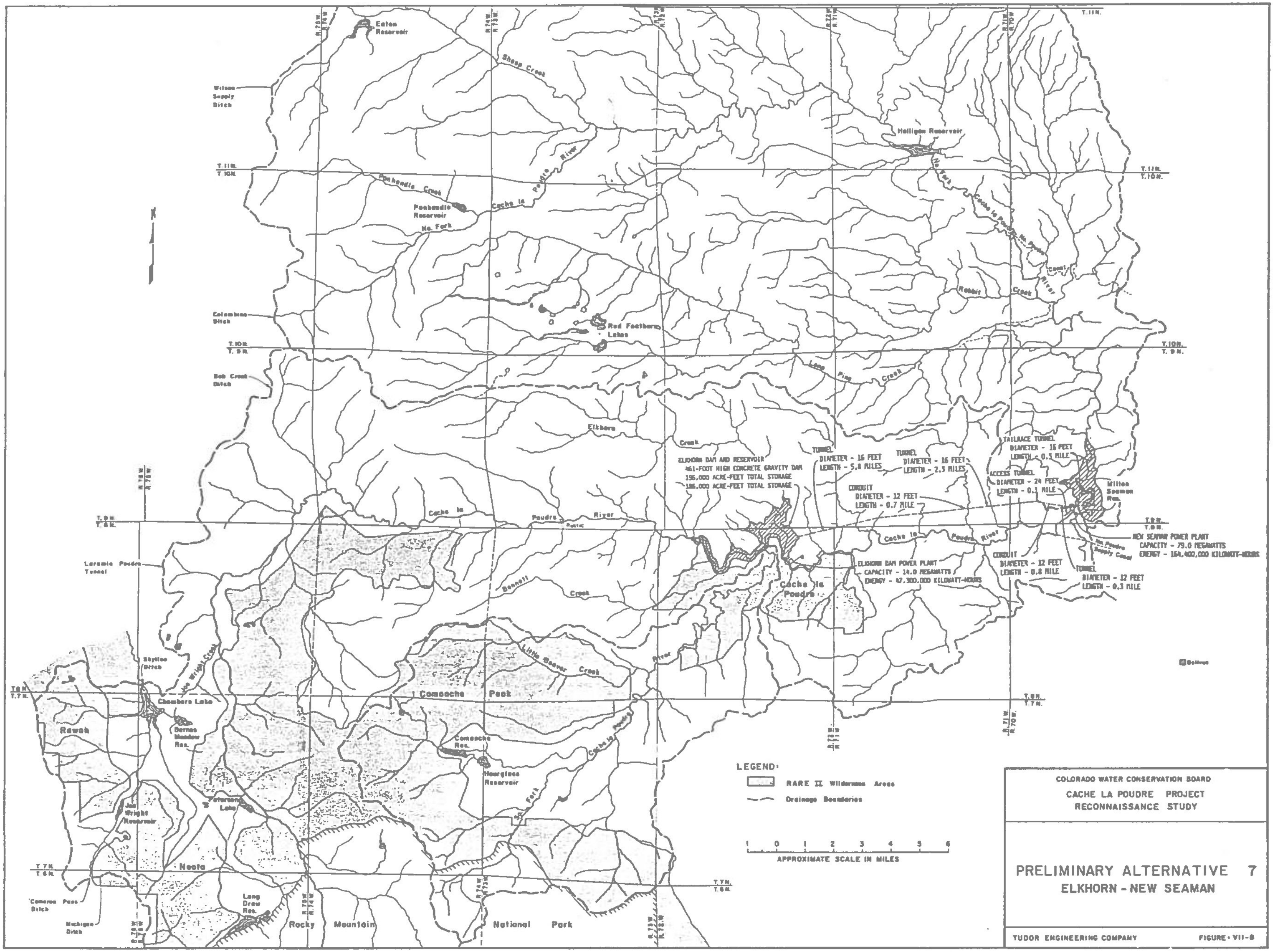
TUDOR ENGINEERING COMPANY FIGURE VII-5



Eaton Reservoir
Sheep Creek
Wilson Supply Ditch
Halligan Reservoir
Peabody Creek
Peabody Reservoir
No. Fork
Cache la Poudre River
Rabbit Creek
Red Feather Lakes
Columbine Ditch
Lone Pine Creek
Bob Creek Ditch
Elkhorn Creek
ELKHORN DAM AND RESERVOIR
461-FOOT HIGH CONCRETE GRAVITY DAM
196,000 ACRE-FEET TOTAL STORAGE
186,000 ACRE-FEET ACTIVE STORAGE
ELKHORN DAM POWER PLANT
CAPACITY - 14 MEGAWATTS
ENERGY - 11,400,000 KILOWATT-HOURS
Milton Seaman Res.
No. Poudre Supply Canal
Laramie Poudre Tunnel
Bennett Creek
Little Beaver Creek
Skyline Ditch
Chambers Lake
Comanche Peak
Barnes Meadow Res.
Rawah
Comanche Res.
Hourglass Reservoir
Joe Wright Reservoir
Peterson Lake
Neota
Long Draw Res.
Cameron Pass Ditch
Michigan Ditch
Rocky Mountain National Park
Bellvue
LEGEND:
RARE II Wilderness Areas
Drainage Boundaries
COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY
PRELIMINARY ALTERNATIVE 8
ELKHORN ONLY
TUDOR ENGINEERING COMPANY
FIGURE VII-6



IDYLWILDE DAM AND RESERVOIR
323-FOOT HIGH CONCRETE GRAVITY DAM
200,000 ACRE-FEET TOTAL STORAGE
123,000 ACRE-FEET ACTIVE STORAGE
IDYLWILDE DAM POWER PLANT
CAPACITY - 24.0 MEGAWATTS
ENERGY - 45,400,000 KILOWATT-HOURS
RUSTIC DIVERSION DAM AND RESERVOIR
75-FOOT HIGH CONCRETE GRAVITY DAM
30 ACRE-FEET TOTAL STORAGE
KINIKINICK DAM POWER PLANT
CAPACITY - 0.5 MEGAWATTS
ENERGY - 4,400,000 KILOWATT-HOURS
KINIKINICK AFTERBAY DAM AND RESERVOIR
62-FOOT HIGH CONCRETE GRAVITY DAM
1,000 ACRE-FEET TOTAL STORAGE
800 ACRE-FEET ACTIVE STORAGE
TUNNEL
DIAMETER - 12 FEET
LENGTH - 0.3 MILE
CACHE LA POUDRE FOREBAY DAM AND RESERVOIR
140-FOOT HIGH EARTHFILL DAM
5,400 ACRE-FEET TOTAL STORAGE
3,000 ACRE-FEET ACTIVE STORAGE
TUNNEL
DIAMETER - 12 FEET
LENGTH - 3.1 MILES
CONDUIT
DIAMETER - 10 FEET
LENGTH - 3.8 MILES
CONDUIT
DIAMETER - 10 FEET
LENGTH - 0.1 MILE
TUNNEL
DIAMETER - 12 FEET
LENGTH 4.3 MILES
CONDUIT
DIAMETER - 10 FEET
LENGTH - 0.1 MILE
TUNNEL
DIAMETER - 10 FEET
LENGTH - 0.8 MILE
GREY MOUNTAIN POWER PLANT
CAPACITY - 81.5 MEGAWATTS
ENERGY - 136,700,000 KILOWATT-HOURS
GREY MOUNTAIN DAM AND RESERVOIR
407-FOOT HIGH CONCRETE GRAVITY DAM
200,000 ACRE-FEET TOTAL STORAGE
190,000 ACRE-FEET ACTIVE STORAGE
ACCESS TUNNEL
DIAMETER - 24 FEET
LENGTH - 0.3 MILE
TAILRACE TUNNEL
DIAMETER - 12 FEET
LENGTH - 0.2 MILE
GREY MOUNTAIN DAM POWER PLANT
CAPACITY - 12.0 MEGAWATTS
ENERGY - 42,500,000 KILOWATT-HOURS
Eaton Reservoir
Sheep Creek
Wilson Supply Ditch
Halligan Reservoir
No. Fork
Cache la Poudre
Panhandle Creek
Panhandle Reservoir
Cache la Poudre River
Columbine Ditch
Red Feather Lakes
Rabbit Creek
Lone Pine Creek
Bob Creek Ditch
Elkhorn Creek
Milton Seaman Res.
Cache la Poudre River
Rustic
No. Poudre Supply Canal
Laramie Poudre Tunnel
Cache la Poudre
Bellvue
Skyline Ditch
Joe Wright Creek
Little Beaver Creek
Comanche Peak
Chambers Lake
Rawah
Barnes Meadow Res.
Comanche Res.
Hourglass Reservoir
So. Fork
Peterson Lake
Joe Wright Reservoir
Neota
Cameron Pass Ditch
Michigan Ditch
Long Draw Res.
Rocky Mountain National Park
T 11 N.
T 10 N.
T 9 N.
T 8 N.
T 7 N.
T 6 N.
R 75 W
R 74 W
R 73 W
R 72 W
R 71 W
R 70 W
LEGEND:
RARE II Wilderness Areas
Drainage Boundaries
0 1 2 3 4 5 6
APPROXIMATE SCALE IN MILES
COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY
PRELIMINARY ALTERNATIVE 2
IDYLWILDE - GREY MOUNTAIN
TUDOR ENGINEERING COMPANY
FIGURE: VII-7


Eaton Reservoir
Sheep Creek
Wilson Supply Ditch
Halligan Reservoir
Panhandle Creek
Panhandle Reservoir
No. Fork
Cache la Poudre River
Cache la Poudre No. Fork
Rabbit Creek
Colombine Ditch
Red Feather Lakes
Bob Creek Ditch
Lone Pine Creek
Elkhorn Creek
ELKHORN DAM AND RESERVOIR
461-FOOT HIGH CONCRETE GRAVITY DAM
195,000 ACRE-FEET TOTAL STORAGE
186,000 ACRE-FEET TOTAL STORAGE
TUNNEL
DIAMETER - 16 FEET
LENGTH - 5.8 MILES
TUNNEL
DIAMETER - 16 FEET
LENGTH - 2.3 MILES
CONDUIT
DIAMETER - 12 FEET
LENGTH - 0.7 MILE
TAILRACE TUNNEL
DIAMETER - 16 FEET
LENGTH - 0.3 MILE
ACCESS TUNNEL
DIAMETER - 24 FEET
LENGTH - 0.1 MILE
Milton Seaman Res.
NEW SEAMAN POWER PLANT
CAPACITY - 79.0 MEGAWATTS
ENERGY - 164,400,000 KILOWATT-HOURS
No. Poudre Supply Canal
ELKHORN DAM POWER PLANT
CAPACITY - 14.0 MEGAWATTS
ENERGY - 47,300,000 KILOWATT-HOURS
CONDUIT
DIAMETER - 12 FEET
LENGTH - 0.8 MILE
TUNNEL
DIAMETER - 12 FEET
LENGTH - 0.3 MILE
Cache la Poudre River
Laramie Poudre Tunnel
Bennett Creek
Cache la Poudre
Little Beaver Creek
Comanche Peak
Skyline Ditch
Joe Wright Creek
Chambers Lake
Rawah
Barnes Meadow Res.
Comanche Res.
Hourglass Reservoir
Peterson Lake
Joe Wright Reservoir
So. Fork
Neota
Long Draw Res.
Cameron Pass Ditch
Michigan Ditch
Rocky Mountain National Park
Bellvue
T.11N.
T.10N.
T.9N.
T.8N.
T.7N.
T.6N.
R.76W. R.75W. R.74W. R.73W. R.72W. R.71W. R.70W.
LEGEND:
RARE II Wilderness Areas
Drainage Boundaries
0 1 2 3 4 5 6
APPROXIMATE SCALE IN MILES
COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY
PRELIMINARY ALTERNATIVE 7
ELKHORN - NEW SEAMAN
TUDOR ENGINEERING COMPANY
FIGURE - VII-8

CHAPTER VIII

EVALUATION OF ALTERNATIVE PROJECTS (PHASE II)

A. INTRODUCTION

This Chapter sets forth the evaluation criteria and summarizes the results of comparative analyses of the four selected alternative projects during Phase II. Summary tabulations and exhibits are provided to permit relative appraisal of the findings from application of both monetary and non-monetary criteria. The monetary evaluation criteria were modified and extended by the Colorado Water Conservation Board from those used in Phase I studies after careful review of comments received at public hearings and at meetings of the Advisory Committee. The non-monetary criteria remain essentially the same as those applied in Phase I, with some upgrading and revision where additional information was developed or made available subsequent to the completion of Phase I.

It should be again emphasized that this level of study does not provide definitive answers as to absolute magnitude of effects. The engineering and cost data are of greater relative reliability than the estimates of the value of project outputs and associated effects, whether they are of a positive or adverse nature. For example, effects on fish, wildlife and recreation are not included. Also, the estimated effects of improved system management are based on very preliminary estimates and sophisticated and costly system studies would be required to disclose the true effects. In addition, the effects of flood control have not been evaluated. The data, however, do give a general perspective on the relative magnitude of costs for the alternative projects, the amounts of benefits that would need to be generated for economic justification, the revenues that would need to be realized for financial feasibility and the relative physical impacts which could result from development of the alternative projects.

B. EVALUATION CRITERIA

1. Monetary

The evaluation criteria measured in terms of dollars consist of three basic parts. First, an economic evaluation was performed including analyses to show conventional benefit-cost ratios and net annual benefits for the base conservation storage component and the incremental addition of run-of-the-river hydropower for each of the alternative projects. The economic evaluation also included analyses to show the level of peaking power benefits needed to break even with the separable costs of peaking power facilities for the multiple reservoir alternative projects. Second, a financial analysis was performed to show the level of investment required assuming either state funding or issuance of revenue bonds. Third, the cost burden that would be placed on peaking power, representing the revenues that would need to be realized from that source, were computed.

2. Non-Monetary

The non-monetary criteria focus on the physical impacts which could result from development of the alternative projects. Further refinement and review of the engineering aspects of dams and reservoirs resulted in the upgrading of the estimates of acres of land and numbers of facilities that would be inundated and effects on recreational access and sites over those used in the Phase I evaluation.

C. ECONOMIC EVALUATION

The criteria governing the economic estimates of benefits and costs for the four alternative projects are similar to those previously set forth in the evaluation of the eight preliminary alternative projects during Phase I with the following exceptions. Peaking power benefits estimated in Phase I were not employed, but instead, the separable costs of peaking power were calculated. This was done to determine the level of peaking power benefits needed to offset associated costs on a one-for-one basis, referred to as the "break-even" cost of peaking power. Thus, overall benefit-cost ratios for those multiple reservoir alternative projects having peaking power facilities, Alternatives 2 and 7, were not developed, however, benefit-cost ratios and net annual benefits for the base conservation storage component and for the base conservation storage plus run-of-the-river hydropower were developed. The economic evaluation was performed with a 7 1/2 percent discount rate. The results using this discount rate are shown as the primary information display on Table VIII-1.

Additional discount rates of 5 percent and 10 percent were applied in order to provide a sensitivity test. As in the Phase I analysis, constant January 1982 dollar prices provided a basis for the evaluation and a 100-year economic life was assumed in establishing the period of analysis.

1. Derivation of Costs

The derivation of the base conservation storage cost, the separable cost of run-of-the-river hydropower and the separable cost of peaking power facilities for each alternative project is shown on Table VIII-1.

Run-of-the-river hydropower is common to all the selected alternative projects, serving an attractive though incidental addition. The separable cost of run-of-the-river hydropower facilities is easily identified and when "peeled off" from the total project cost leaves the project cost to serve conservation purposes and peaking power. For the single reservoir alternative projects, Alternatives 1 and 8, this remainder represents the base conservation storage cost, since these alternative projects do not include peaking power as a project purpose.

All four selected alternative projects have the basic major objective of serving conservation purposes. This is performed in the single reservoir alternative projects, Alternatives 1 and 8, by storage in Grey Mountain Reser-

TABLE VIII-1
CACHE LA POUDRE PROJECT
SUMMARY OF ECONOMIC EVALUATION AT 7.5 PERCENT DISCOUNT RATE
(100 YEAR PERIOD - 1982 PRICES)
(IN THOUSANDS OF DOLLARS)

	ALTERNATIVE 1 GREY MOUNTAIN ONLY	ALTERNATIVE 8 ELKHORN ONLY	ALTERNATIVE 2 IDYLWILDE-GREY MOUNTAIN	ALTERNATIVE 7 ELKHORN-NEW SEAMAN
COSTS				
TOTAL PROJECT COST				
TOTAL CAPITAL COST	130,800	109,600	400,800	354,300
INTEREST DURING CONSTRUCTION	14,715	12,330	60,120	53,145
TOTAL ECONOMIC INVESTMENT COST	145,515	121,930	460,920	407,445
ANNUALIZED ECONOMIC INVESTMENT COST	10,920	9,150	34,590	30,580
ANNUAL O,M,&R COST	200	235	1,690	1,160
TOTAL ANNUAL ECONOMIC COST	11,120	9,385	36,280	31,740
SEPARABLE COST OF RUN-OF-RIVER HYDRO				
CAPITAL COST	6,860	8,040	8,420	6,310
INTEREST DURING CONSTRUCTION	515	605	630	475
TOTAL ECONOMIC INVESTMENT COST	7,375	8,645	9,050	6,785
ANNUALIZED ECONOMIC INVESTMENT COST	555	650	680	510
ANNUAL O,M,&R COST	155	190	220	175
ANNUAL ECONOMIC COST	710	840	900	685
BASE CONSERVATION STORAGE COST				
CAPITAL COST	123,940	101,560	123,940	101,560
INTEREST DURING CONSTRUCTION	13,945	11,425	13,945	11,425
TOTAL ECONOMIC INVESTMENT COST	137,885	112,985	137,885	112,985
ANNUALIZED ECONOMIC INVESTMENT COST	10,350	8,480	10,350	8,480
ANNUAL O,M,&R COST	45	45	45	45
ANNUAL ECONOMIC COST	10,395	8,525	10,395 1/	8,525 2/
SEPARABLE COST OF PEAKING POWER				
CAPITAL COST	N/A	N/A	268,440	246,430
INTEREST DURING CONSTRUCTION	N/A	N/A	40,265	36,965
TOTAL ECONOMIC INVESTMENT COST	N/A	N/A	308,705	283,395
ANNUALIZED ECONOMIC INVESTMENT COST	N/A	N/A	23,170	21,270
ANNUAL O,M,&R COST	N/A	N/A	1,425	940
ANNUAL ECONOMIC COST	N/A	N/A	24,595	22,210
BENEFITS-ANNUAL				
CONSERVATION PURPOSES				
MUNICIPAL AND INDUSTRIAL WATER SUPPLY	3,060	3,060	3,060	3,060
IMPROVED SYSTEM MANAGEMENT	250	250	250	250
SUPPLEMENTAL IRRIGATION WATER SUPPLY	480	430	420	390
SUBTOTAL (CONSERVATION PURPOSES)	3,790	3,740	3,730	3,700
RUN-OF-RIVER HYDRO	2,760	3,070	3,050	2,650
ECONOMIC ANALYSES				
BENEFIT-COST RATIO FOR CONSERVATION PURPOSES ONLY	0.36	0.44	0.36	0.43
INCREMENTAL BENEFIT-COST RATIO FOR RUN-OF-RIVER	3.89	3.65	3.39	3.87
BENEFIT-COST RATIO - CONSERVATION PLUS RUN-OF-RIVER	0.59 3/	0.73 3/	0.60	0.69
NET ANNUAL BENEFITS FOR CONSERVATION PURPOSES ONLY	-6,605	-4,785	-6,665	-4,825
NET ANNUAL BENEFITS - CONSERVATION PLUS RUN-OF-RIVER	-4,555 3/	-2,555 3/	-4,515	-2,860
BREAKEVEN VALUE OF PEAKING POWER (ANNUAL)	N/A	N/A	24,595	22,210
DOLLARS PER KILOWATT-YEAR	N/A	N/A	238	281
MILLS PER KILOWATT-HOUR	N/A	N/A	135	135

1/ EQUIVALENT TO ALTERNATIVE 1.

2/ EQUIVALENT TO ALTERNATIVE 8.

3/ REPRESENTS TOTAL PROJECT

voir and Elkhorn Reservoir, respectively. Addition of another reservoir and peaking power facilities expands these single reservoir alternative projects into companion multiple reservoir alternative projects. The addition of Idylwilde Reservoir and peaking power facilities to Grey Mountain Reservoir expands Alternative 1 into its companion multiple reservoir alternative project, Alternative 2. The addition of New Seaman Reservoir and peaking power facilities to Elkhorn Reservoir expands Alternative 8 into its companion multiple reservoir alternative project, Alternative 7.

Because of these relationships; the base conservation storage cost for the multiple reservoir alternative projects is equated to the base conservation storage cost of its companion single reservoir alternative project - the base conservation storage cost for Alternative 2 is equivalent to the base conservation storage cost for Alternative 1. Similarly, the base conservation storage cost for Alternative 7 is equivalent to the base conservation storage cost for Alternative 8.

For the multiple reservoir alternative projects, Alternatives 2 and 7, the remainder, after "peeling off" the costs of run-of-the-river hydropower and the cost of the base conservation storage, represents the separable cost of peaking power facilities.

All costs were converted to annual economic costs by annualizing the economic investment costs consisting of the capital costs and interest during construction and then adding annual operation, maintenance and replacement costs.

2. Benefit-Cost Ratios

The stream of annual economic costs for the base conservation storage was compared with the annual stream of benefits for conservation purposes as derived in Phase I. The conservation benefits consisted of those related to municipal and industrial water supply, improved system management, and supplemental irrigation water supply and are shown on Table VIII-1. (A lump sum present worth analysis could have also been constructed by simply capitalizing annual operation, maintenance and replacement costs, adding them to the economic investment costs and comparing them to the capitalized present worth of annual benefits. The resulting benefit-cost relationships would be identical. Also, a further discounting from the on-line date to the January 1982 base would change the absolute amounts of both benefits and costs in the same relative proportions and thus would not affect the ratios.)

The resulting benefit-cost ratios for the project base serving conservation purposes only are 0.36 for Alternative 1, 0.44 for Alternative 8, 0.36 for Alternative 2 and 0.43 for Alternative 7.

The estimated separable costs for the addition of run-of-the-river hydropower and the estimated benefits based on power values derived in Phase I are shown on Table VIII-1. The resulting incremental benefit-cost ratios for run-of-the-river hydropower, also shown on the Table, are all in excess of 3 to 1, showing it to be a logical addition to any of the four alternative projects. When costs and benefits for run-of-the-river hydropower are added to costs and benefits for the base conservation storage, the benefit-cost ratios for the combined purposes increase to 0.59 for Alternative 1, 0.73 for Alternative 8, 0.60 for Alternative 2 and 0.69 for Alternative 7. For the single reservoir alternative projects, this represents the benefit-cost ratio for the total project, since these are all the purposes served by these alternative projects.

3. Net Annual Benefits

As indicated by the below unity benefit-cost ratios, there are significant shortfalls in the estimated total benefits from conservation purposes when compared to associated base conservation storage costs. The net differences are shown on Table VIII-1. The shortfalls or negative net annual benefits are $6,605,000 for Alternative 1, $4,765,000 for Alternative 8, $6,665,000 for Alternative 2 and $4,825,000 for Alternative 7.

When run-of-the-river hydropower is added as a project purpose, the amount of shortfall or negative net annual benefits decreases algebraically to $4,555,000, $2,555,000, $4,515,000 and $2,860,000 for Alternatives 1, 8, 2 and 7, respectively. For the single reservoir alternative projects these represent net benefits for the total project.

Changes in the conservation benefits, which could result from refinement of the estimates developed in Phase I of the study and applied here in Phase II would, of course, affect the shortfall or negative net annual benefits. A review of the basis for the benefit estimates follows which may provide some insight on the potential for changes.

The municipal and industrial water supply benefits reflect the average annual costs that the City of Fort Collins would be willing to pay for 10,000 acre-feet of storage at what was considered by the City as the likely source of storage; a small reservoir at the Rockwell Site. At this level of study, other alternative storage sources were not investigated and the possibility exists that associated costs could be somewhat higher or lower; however, it is not expected that the change would be significant.

Refined studies could result in significant change in the estimates of improved system management benefits. If there were some assurance that storage from a Cache la Poudre Project would indeed be available in the reasonable future as a substitute for alternative storage now being considered by one of the irrigation districts, significant savings in anticipated upstream storage construction costs could result and be credited as a benefit to the alternative projects. More definitive system studies on integration of the complex plains reservoirs and conveyance systems could also increase benefits. The present assumption of a benefit of $250,000 annually amounts to only $1 per acre when averaged over the total irrigated lands in the Basin. More detailed optimization studies would likely result in either an important increase in benefits or a reduction in services provided by the availability of 50,000 acre-feet anticipated in alternative projects conservation storage reservoirs. The overall opportunities here would appear to be either a significant increase in improved management benefits or a decrease in associated project storage costs.

The $30 per acre-foot assumption for value of supplemental irrigation water supply probably has limited opportunity for change. In fact, if the agricultural economy continues to reflect conditions of the recent past, this value for supplemental irrigation water may be considered optimistic.

Flood control aspects and the economic impacts on recreation and fishery resources are other unknown factors, which along with those discussed above could influence project benefits and cost and thereby, the net benefits. A more detailed study of all the impacts, as well as possible impacts of the comprehensive integration with adjacent basin needs and opportunities, would be necessary in order to provide more reliable evaluations of economic feasibility.

4. Breakeven Value of Peaking Power

As discussed previously, the cost of the base conservation storage for the multiple reservoir alternative projects is equated to the cost of the base conservation storage for the companion single reservoir alternative project - the single reservoir Alternative 1 being companion to the multiple reservoir Alternative 2 and the single reservoir Alternative 8 being companion to the multiple reservoir Alternative 7. When the costs for the base conservation storage and the separable cost of run-of-the-river hydropower are deducted from the total project cost, the remaining cost is the separable cost of peaking power for the multiple reservoir alternative projects. As shown on Table VIII-1, the resulting annual cost for peaking power is $24,595,000 for Alternative 2 and $22,210,000 for Alternative 7. This reflects the relative magnitude of peaking power benefits needed to offset the separable cost of the peaking power facilities, referred to here as the breakeven value of peaking power. When this annual cost is divided by the installed peaking capacity, 103.5 megawatts for Alternative 2 and 79.0 megawatts for Alternative 7, it averages $238 and $281 per kilowatt-year, respectively, for the two alternative projects. When the annual cost is divided by the average annual energy produced by the peaking facilities (both firm and non-firm energy), 182.1 gigawatt-hours for Alternative 2 and 164.4 gigawatt-hours for Alternative 7, 135 mills per kilowatt-hour is derived for both alternative projects.

It is noted that these are composite values including both the energy and the capacity component as discussed in Chapter VI on power benefits. To provide perspective, the comparable composite values derived for the coal-cycling plant representing the likely thermal alternative amounts to $324 per kilowatt-year or 185 mills per kilowatt-hour, as shown in Table VI-2.

5. Sensitivity Analysis of Varying Discount Rates

The appropriate discount rate for economic analysis of water resource projects has been the subject of a wide range of opinions. To demonstrate the effect of different discount rate assumptions, Colorado Water Conservation Board criteria called for the testing of rates 2.5 points lower and 2.5 points higher than the 7.5 percent rate, which was the basis for the primary information displays. The primary rate of 7.5 percent is comparable to the rate used by Federal agencies for water resource investigations assuming January 1982 prices. A summary of the effects of the different discount rates is shown on Table VIII-2. Details of the calculations are provided in Table VIII-3 for 5 percent and Table VIII-4 for 10 percent.

a. Five Percent Discount Rate

As can be seen from the results on Table VIII-3, the overall effect of applying the lower discount rate of 5 percent was to generally increase the benefit-cost ratios. The benefit-cost ratios for conservation purposes only are 0.56, 0.67, 0.55 and 0.67 for Alternatives 1, 8, 2 and 7, respectively. The incremental benefit-cost ratios for run-of-the-river hydropower are all on the order of 5 to 1. When run-of-the-river hydropower is considered along with the base conservation storage, the benefit-cost ratios for these combined project purposes are 0.90, 1.10, 1.10 and 0.95 for Alternatives 1,8,2 and 7, respectively. This represents the total project for the single reservoir alternative projects, Alternatives 1 and 8, since they serve only those project purposes.

The application of the 5 percent discount rate had generally the same effect on net benefits as on the benefit-cost ratios. For conservation purposes only, there remains a shortfall or negative net benefit for all alternative projects. When run-of-the-river hydropower is considered along with the base conservation storage, the shortfall of net benefits from these combined project purposes decreases algebraically, and shows positive net benefits for Alternatives 8 and 7. For Alternatives 1 and 8, these net benefits represent the total project, since these single reservoir alternative projects serve only those project purposes.

b. Ten Percent Discount Rate

As expected, the effect of application of the 10 percent discount rate was to generally decrease the benefit-cost ratios. The results are shown on Table VIII-4. The benefit-cost ratios for conservation purposes only are 0.27, 0.32, 0.26 and 0.32 for Alternatives 1, 8, 2 and 7, respectively. The incremental benefit-cost ratios for run-of-the-river hydropower remain high, on the order of 3 to 1. When run-of-the-river hydropower is considered along with the base conservation storage, the benefit-cost ratios for these combined project purposes are 0.43, 0.53, 0.44 and 0.50 for Alternatives 1, 8, 2 and 7, respectively. This represents the total project for the single reservoir alternative projects, Alternatives 1 and 8, since they serve only these project purposes.

The application of the 10 percent discount rate had generally the same effect on net benefits as on the benefit-cost ratios. There is a significant shortfall or negative net benefit for all alternative projects, even with the combined purposes of conservation and run-of-the-river hydropower.

TABLE VIII-2
CACHE LA POUDRE PROJECT
SUMMARY OF DISCOUNT RATE SENSITIVITY TEST

ITEM	Alt. 1 Grey Mountain Only	Alt. 8 Elkhorn Only	Alt. 2 Idylwilde-Grey Mountain	Alt. 7 Elkhorn-New Seaman
BENEFIT-COST RATIO FOR CONSERVATION PURPOSES ONLY				
5%	0.56	0.67	0.55	0.67
7.5%	0.36	0.44	0.36	0.43
10%	0.27	0.32	0.26	0.32
INCREMENTAL BENEFIT-COST RATIO FOR RUN-OF-RIVER HYDROPOWER				
5%	5.31	4.99	4.59	5.20
7.5%	3.89	3.65	3.39	3.87
10%	3.03	2.86	2.66	3.05
BENEFIT-COST RATIO - CONSERVATION PLUS RUN-OF-THE-RIVER HYDROPOWER 1/				
5%	0.90	1.10	1.10	0.95
7.5%	0.59	0.73	0.60	0.69
10%	0.43	0.53	0.44	0.50
NET ANNUAL BENEFITS FOR CONSERVATION PURPOSES ONLY				
5%	$-2,970,000	$-1,805,000	$-3,030,000	$-2,895,000
7.5%	-6,605,000	-4,785,000	-6,665,000	-4,825,000
10%	-10,510,000	-7,985,000	-10,570,000	8,025,000
NET ANNUAL BENEFITS - CONSERVATION PLUS RUN-OF-THE-RIVER HYDROPOWER 1/				
5%	$-730,000	$650,000	$-645,000	$295,000
7.5%	-4,555,000	-2,555,000	-4,515,000	-2,860,000
10%	-8,660,000	-5,990,000	-8,665,000	-6,245,000
BREAKEVEN VALUE OF PEAKING POWER				
In Dollars Per Kilowatt-Year				
5%	n/a	n/a	157	185
7.5%	n/a	n/a	238	281
10%	n/a	n/a	325	386
In Mills Per Kilowatt-Hour				
5%	n/a	n/a	90	89
7.5%	n/a	n/a	135	135
10%	n/a	n/a	185	186

1/ Represents total project for the single reservoir alternative projects, Alternatives 1 and 8.

TABLE VIII-3
CACHE LA POUDRE PROJECT
SUMMARY OF ECONOMIC EVALUATION AT 5 PERCENT DISCOUNT RATE
(100 YEAR PERIOD - 1982 PRICES)
(IN THOUSANDS OF DOLLARS)

	ALTERNATIVE 1 GREY MOUNTAIN ONLY	ALTERNATIVE 8 ELKHORN ONLY	ALTERNATIVE 2 IDYLWILDE-GREY MOUNTAIN	ALTERNATIVE 7 ELKHORN-NEW SEAMAN
COSTS				
TOTAL PROJECT COST				
TOTAL CAPITAL COST	130,800	109,600	400,800	354,300
INTEREST DURING CONSTRUCTION	9,810	8,220	40,080	35,430
TOTAL ECONOMIC INVESTMENT COST	140,610	117,820	440,880	389,730
ANNUALIZED ECONOMIC INVESTMENT COST	7,085	5,935	22,210	19,635
ANNUAL O,M,&R COST	200	235	1,690	1,160
TOTAL ANNUAL ECONOMIC COST	7,285	6,170	23,900	20,795
SEPARABLE COST OF RUN-OF-RIVER HYDRO				
CAPITAL COST	6,860	8,040	8,420	6,310
INTEREST DURING CONSTRUCTION	345	400	420	315
TOTAL ECONOMIC INVESTMENT COST	7,205	8,440	8,840	6,625
ANNUALIZED ECONOMIC INVESTMENT COST	365	425	445	335
ANNUAL O,M,&R COST	155	190	220	175
ANNUAL ECONOMIC COST	520	615	665	510
BASE CONSERVATION STORAGE COST				
CAPITAL COST	123,940	101,560	123,940	101,560
INTEREST DURING CONSTRUCTION	9,295	7,615	9,295	7,615
TOTAL ECONOMIC INVESTMENT COST	133,235	109,175	133,235	109,175
ANNUALIZED ECONOMIC INVESTMENT COST	6,715	5,500	6,715	5,500
ANNUAL O,M,&R COST	45	45	45	45
ANNUAL ECONOMIC COST	6,760	5,545	6,760 1/	5,545 2/
SEPARABLE COST OF PEAKING POWER				
CAPITAL COST	N/A	N/A	268,440	246,430
INTEREST DURING CONSTRUCTION	N/A	N/A	26,845	24,645
TOTAL ECONOMIC INVESTMENT COST	N/A	N/A	295,285	271,075
ANNUALIZED ECONOMIC INVESTMENT COST	N/A	N/A	14,875	13,660
ANNUAL O,M,&R COST	N/A	N/A	1,425	940
ANNUAL ECONOMIC COST	N/A	N/A	16,300	14,600
BENEFITS-ANNUAL				
CONSERVATION PURPOSES				
MUNICIPAL AND INDUSTRIAL WATER SUPPLY	3,060	3,060	3,060	3,060
IMPROVED SYSTEM MANAGEMENT	250	250	250	250
SUPPLEMENTAL IRRIGATION WATER SUPPLY	480	430	420	390
SUBTOTAL (CONSERVATION PURPOSES)	3,790	3,740	3,730	3,700
RUN-OF-RIVER HYDRO	2,760	3,070	3,050	2,650
ECONOMIC ANALYSES				
BENEFIT-COST RATIO FOR CONSERVATION PURPOSES ONLY	0.56	0.67	0.55	0.67
INCREMENTAL BENEFIT-COST RATIO FOR RUN-OF-RIVER	5.31	4.99	4.59	5.20
BENEFIT-COST RATIO - CONSERVATION PLUS RUN-OF-RIVER	0.90 3/	1.10 3/	1.10	0.95
NET ANNUAL BENEFITS FOR CONSERVATION PURPOSES ONLY	-2,970	-1,805	-3,030	-2,895
NET ANNUAL BENEFITS - CONSERVATION PLUS RUN-OF-RIVER	-730 3/	+650 3/	-645	+295
BREAKEVEN VALUE OF PEAKING POWER (ANNUAL)	N/A	N/A	16,300	14,600
DOLLARS PER KILOWATT-YEAR	N/A	N/A	157	185
MILLS PER KILOWATT-HOUR	N/A	N/A	90	89

1/ EQUIVALENT TO ALTERNATIVE 1.

2/ EQUIVALENT TO ALTERNATIVE 8.

3/ REPRESENTS TOTAL PROJECT.

TABLE VIII-4
CACHE LA POUDRE PROJECT
SUMMARY OF ECONOMIC EVALUATION AT 10 PERCENT DISCOUNT RATE
(100 YEAR PERIOD - 1982 PRICES)
(IN THOUSANDS OF DOLLARS)

	ALTERNATIVE 1 GREY MOUNTAIN ONLY	ALTERNATIVE 8 ELKHORN ONLY	ALTERNATIVE 2 IDYLWILDE-GREY MOUNTAIN	ALTERNATIVE 7 ELKHORN-NEW SEAMAN
COSTS				
TOTAL PROJECT COST				
TOTAL CAPITAL COST	130,800	109,600	400,800	354,300
INTEREST DURING CONSTRUCTION	19,620	16,440	80,160	70,860
TOTAL ECONOMIC INVESTMENT COST	150,420	126,040	480,960	425,160
ANNUALIZED ECONOMIC INVESTMENT COST	15,045	12,605	48,100	42,520
ANNUAL O,M,&R COST	200	235	1,690	1,160
TOTAL ANNUAL ECONOMIC COST	15,245	12,840	49,790	43,680
SEPARABLE COST OF RUN-OF-RIVER ANNUAL ECONOMIC COST				
CAPITAL COST	6,860	8,040	8,420	6,310
INTEREST DURING CONSTRUCTION	685	805	840	630
TOTAL ECONOMIC INVESTMENT COST	7,545	8,845	9,260	6,940
ANNUALIZED ECONOMIC INVESTMENT COST	755	885	925	695
ANNUAL OM&R COST	155	190	220	175
ANNUAL ECONOMIC COST	910	1,075	1,145	870
BASE CONSERVATION STORAGE COST				
CAPITAL COST	123,940	101,560	123,940	101,560
INTEREST DURING CONSTRUCTION	18,590	15,230	18,590	15,230
TOTAL ECONOMIC INVESTMENT COST	142,530	116,790	142,530	116,790
ANNUALIZED ECONOMIC INVESTMENT COST	14,255	11,680	14,255	11,680
ANNUAL O,M,&R COST	45	45	45	45
ANNUAL ECONOMIC COST	14,300	11,725	14,300 1/	11,725 2/
SEPARABLE COST OF PEAKING POWER				
CAPITAL COST	N/A	N/A	268,440	246,430
INTEREST DURING CONSTRUCTION	N/A	N/A	53,690	49,285
TOTAL ECONOMIC INVESTMENT COST	N/A	N/A	322,130	295,715
ANNUALIZED ECONOMIC INVESTMENT COST	N/A	N/A	32,215	29,575
ANNUAL O,M,&R COST	N/A	N/A	1,425	940
ANNUAL ECONOMIC COST	N/A	N/A	33,640	30,515
BENEFITS-ANNUAL				
CONSERVATION PURPOSES				
MUNICIPAL AND INDUSTRIAL WATER SUPPLY	3,060	3,060	3,060	3,060
IMPROVED SYSTEM MANAGEMENT	250	250	250	250
SUPPLEMENTAL IRRIGATION WATER SUPPLY	480	430	420	390
SUBTOTAL (CONSERVATION PURPOSES)	3,790	3,740	3,730	3,700
RUN-OF-RIVER HYDRO	2,760	3,070	3,050	2,650
ECONOMIC ANALYSES				
BENEFIT-COST RATIO FOR CONSERVATION PURPOSES ONLY	0.27	0.32	0.26	0.32
INCREMENTAL BENEFIT-COST RATIO FOR RUN-OF-RIVER	3.03	2.86	2.66	3.05
BENEFIT-COST RATIO - CONSERVATION PLUS RUN-OF-RIVER	0.43 3/	0.53 3/	0.44	0.50
NET ANNUAL BENEFITS FOR CONSERVATION PURPOSES ONLY	-10,510	-7,985	-10,570	-8,025
NET ANNUAL BENEFITS - CONSERVATION PLUS RUN-OF-RIVER	-8,660 3/	-5,990 3/	-8,665	-6,245
BREAKEVEN VALUE OF PEAKING POWER (ANNUAL)	N/A	N/A	33,640	30,515
DOLLARS PER KILOWATT-YEAR	N/A	N/A	325	386
MILLS PER KILOWATT-HOUR	N/A	N/A	185	186

1/ EQUIVALENT TO ALTERNATIVE 1.

2/ EQUIVALENT TO ALTERNATIVE 8.

3/ REPRESENTS TOTAL PROJECT.

D. INVESTMENT COST ANALYSIS

To provide information on the financial demand for funds that would be required to make the alternative projects operational, an analysis of the levels of investment required was performed. Using the January 1982 capital cost estimate as a starting base, estimates were made of the total investment requirements as of the on-line date for each alternative project using two funding approaches: (1) State funding and (2) revenue bonding. Both funding approaches recognize an annual compound price inflation rate of 8 percent beginning January 1982 and extending up to the projected on-line date of the particular project being analyzed.

The analysis included determination of the on-line investment requirements which consist of the total sum that would need to be borrowed to meet the escalated capital cost plus related funding costs, where applicable. Also included in the analysis is the first year on-line total annual costs which represent the level of annual revenues needed in the first year of operation to meet the annual debt service plus total annual operating expenses. These total annual costs are also expressed in January 1982 dollars in order to provide some perspective in terms of current conditions.

A projected schedule of development activities for each project was developed which became the time frame for determining annual expenditures on a year-by-year basis, beginning in mid-1983 and continuing to the estimated on-line date for the project. The year 1983 was considered as the beginning of the initiation of planning and feasibility studies. The scheduled activities cover preconstruction, design and construction and include the time required for feasibility studies, environmental impact studies, Federal Energy Regulatory Commission licensing, final design specifications and engineering and construction services. The summary schedules are presented in Figure VIII-1. A graphic example of a conceptual cash flow diagram for a typical project is presented in Figure VIII-2.

1. State Funding Approach

Under the state funding approach, it was assumed that appropriations authorized by the Colorado General Assembly through the Colorado Water Conservation Board construction fund would be the source of funds. Costs for short-term financing and interest during construction were not included under the assumption that funds would be provided as needed each year, nor were costs of issuing bonds included.

The annual debt service of the total escalated capital costs required to construct the project assumed levelized annual amortization (or a uniform debt service) reflecting an interest rate of 5 percent over a 40-year period beginning at the on-line date for the project. The escalated average annual cost of operation, maintenance and replacement computed at the on-line date is added to the annual debt service to derive the first year on-line total annual costs. The annual amount was also expressed in January 1982 dollars in order to provide some perspective in terms of current conditions.

A summary presenting the results of the analysis using the State funding approach is presented on Table VIII-5. Figures in that Table show the substantial increase when project capital costs are escalated from January 1982 price levels to the on-line date. The cost of the single reservoir alternative projects increases 2.2 times by the 1994 on-line date - Alternative 1 increases from $130.8 million to $292 million and Alternative 8 increases from $109.6 million to $244 million. The cost of the multiple reservoir alternative projects increases 2.9 times by the 1998 on-line date - Alternative 2 increases from $400.8 million to $1,166 million and Alternative 7 increases from $354.3 million to $1,032 million.

Total annual funding requirements as of the on-line dates are $17.5 million and $14.8 million for the single reservoir Alternatives 1 and 8, respectively, and $73.7 and $64.1 million for the multiple reservoir Alternatives 2 and 7, respectively. These first year on-line total annual costs represent the level of revenues that must be collected to cover the cost of the first year of operation. Expressed in terms of 1982 dollars, the first year annual costs are $7.8 million, $6.6 million, $25.0 million and $21.8 million, respectively, for Alternatives 1, 8, 2 and 7.

2. Revenue Bonding Approach

Under the revenue bonding approach, it was assumed that revenue bonds would be issued to cover the costs of construction of the alternative projects. The annual debt service of the total escalated capital costs required to construct the project assumed a uniform debt service reflecting an interest rate of 12 percent over a 30-year period beginning at the on-line date for the project.

There are several important differences in deriving the total investment requirements for the revenue bonding approach, summarized in Table VIII-6. Although the escalated capital cost is identical, three additional factors must be considered in order to determine the total on-line investment requirements. First, it was assumed that the funds would be borrowed for preconstruction activities and that these funds carry an interest charge. It was assumed that this short-term financing would be available at 10 percent, which is somewhat less than the 12 percent assumed as the long-term revenue bond average coupon rate. These financing costs reflect compounding of interest and are covered under the item, Interest During Construction.

Second, a bond reserve fund was added equal to one year of bond debt service. This is a common requirement of revenue bonds. Depending on the relative risk and arbitrage potentials, this requirement sometimes exceeds the amount of one year of debt service. It is noted that, (1) this does not reflect a true cost as interest is earned each year on the reserve, at a rate considered to be equal to the cost of bond money, which goes to reduce annual expenditures and, (2) the reserve fund is available to make the final payment in retirement of the assumed 30-year bond issue.

A third addition is bond administration and sales cost. An amount equal to some 2 1/2 percent of the bond size was added to cover this item. For projects of this magnitude, this is probably on the high side.

TABLE VIII-5
CACHE LA POUDRE PROJECT
SUMMARY OF FINANCIAL REQUIREMENTS
STATE FUNDING APPROACH, 5 PERCENT 40 YEARS
(IN THOUSANDS OF DOLLARS)

	ALTERNATIVE 1 GREY MOUNTAIN ONLY	ALTERNATIVE 8 ELKHORN ONLY	ALTERNATIVE 2 IDYLWILDE-GREY MOUNTAIN	ALTERNATIVE 7 ELKHORN-NEW SEAMAN
TOTAL PROJECT COST				
TOTAL CAPITAL COST (JAN 1982 DOLLARS)	130,800	109,600	400,800	354,300
SCHEDULE OF TOTAL CAPITAL COST				
1983	303	293	729	617
1984	545	558	1,467	1,248
1985	628	628	1,492	1,348
1986	57	57	1,216	1,061
1987	61	61	168	168
1988	66	66	181	181
1989	2,262	1,906	196	196
1990	4,887	4,117	212	212
1991	66,464	53,171	332	332
1992	133,855	115,678	11,803	10,681
1993	82,430	67,650	15,265	14,053
1994	ON-LINE	ON-LINE	153,618	133,729
1995			379,249	331,207
1996			409,578	357,694
1997			190,171	178,961
1998			ON-LINE	ON-LINE
TOTAL CAPITAL COST (ESCALATED)	291,558	244,185	1,165,677	1,031,688
INTEREST DURING CONSTRUCTION	N/A	N/A	N/A	N/A
BOND RESERVE FUND	N/A	N/A	N/A	N/A
BOND ADMINISTRATION AND SALES COST	N/A	N/A	N/A	N/A
ON-LINE INVESTMENT REQUIREMENTS	291,558	244,185	1,165,677	1,031,688
ANNUAL PROJECT FUNDING REQUIREMENTS				
ANNUAL DEBT SERVICE (AS OF ON-LINE DATE)	16,992	14,231	67,936	60,127
ANNUAL O.M. &R (AS OF ON-LINE DATE)	500	590	5,790	3,970
LESS INTEREST ON BOND RESERVE	N/A	N/A	N/A	N/A
FIRST YEAR ON-LINE TOTAL ANNUAL COSTS	17,492	14,821	73,726	64,097
ANNUAL DEBT SERVICE (JAN 1982 DOLLARS)	7,623	6,387	23,359	20,649
ANNUAL O.M. & R (JAN 1982 DOLLARS)	200	235	1,690	1,160
LESS INTEREST ON BOND RESERVE	N/A	N/A	N/A	N/A
FIRST YEAR JANUARY 1982 TOTAL ANNUAL COSTS	7,823	6,622	25,049	21,809
COST BURDEN ON PEAKING POWER (JAN 1982 DOLLARS)				
TOTAL ANNUAL COSTS (JAN 1982 DOLLARS)	N/A	N/A	25,049	21,809
LESS POTENTIAL REVENUES				
CONSERVATION PURPOSES				
MUNICIPAL AND INDUSTRIAL WATER SUPPLY	N/A	N/A	3,060	3,060
IMPROVED SYSTEM MANAGEMENT	N/A	N/A	250	250
SUPPLEMENTAL IRRIGATION WATER SUPPLY	N/A	N/A	420	390
RUN-OF-RIVER HYDRO	N/A	N/A	3,050	2,650
TOTAL REVENUES	N/A	N/A	6,780	6,350
REQUIRED ANNUAL REVENUES FROM PRODUCTION OF PEAKING POWER	N/A	N/A	18,269	15,459
DOLLARS PER KILOWATT-YEAR	N/A	N/A	177	196
MILLS PER KILOWATT-HOUR	N/A	N/A	100	94

When all of these additions are added to the escalated total capital costs, the on-line investment requirement is enlarged from 37 to 44 percent over the escalated capital cost. This on-line investment requirement amounts to $398.9 million, $334.5 million, $1,680.2 million and $1,484.8 million for Alternatives 1, 8, 2 and 7 in that order. The first year on-line total annual costs, which cover the levelized debt service for 30 years; escalated annual operation, maintenance and replacement; and credits for interest earnings on the bond reserve fund amount to $44.1 million, $37.1 million, $189.3 million and $166.2 million, respectively, for Alternatives 1, 8, 2 and 7. This, as stated in the preceeding section, is the level of revenues that must be collected to cover the first year of operations. The first year total annual costs are also expressed in 1982 dollars for perspective in terms of current conditions. This amounts to $19.9 million, $16.7 million, $65.6 million and $57.6 million, respectively, for Alternatives 1, 8, 2, and 7.

E. COST BURDEN ON PEAKING POWER

For the multiple reservoir alternative projects, Alternatives 2 and 7, additional calculations were performed to estimate the cost burden on peaking power. The cost burden is defined here as the value that the peaking power would have to attain, along with the revenues from all other project purposes, to retire the total project costs for the multiple reservoir alternative projects.

Using the project outputs and the unit values for project outputs, as developed in the economic analyses, the annual revenues were estimated for each major project purpose (with the exception of peaking power). These estimated annual revenues were then subtracted from the total annual costs (as defined above) to estimate the amount of revenues which would have to be provided by peaking power. Required annual peaking power revenues were then divided by the installed peaking capacity to derive the composite power and energy rate in terms of dollars per kilowatt-year that would be required to produce these annual revenues. The required annual peaking power revenues were also divided by the average annual energy produced by the peaking facilities to derive the composite power and energy rate in terms of mills per kilowatt-hour that would be required to produce these annual revenues. The results assuming state funding are shown on Table VIII-5 and the results assuming revenue bonding are shown on Table VIII-6.

As shown in Tables VIII-5 and VIII-6, the estimated total annual revenues from project purposes other than peaking power for the multiple reservoir alternative projects, $6.8 million for Alternative 2 and $6.4 million for Alternative 7, were deducted from the total annual costs for the projects leaving an annual cost burden on peaking power of $18.3 million for Alternative 2 and $15.5 million for Alternative 7 with the state funding approach and $58.9 million for Alternative 2 and $51.3 million for Alternative 7 with the revenue bonding approach. When divided by the respective installed peaking capacity, 103.5 megawatts for Alternative 2 and 29.0 megawatts for Alternative 7, this converts to a composite unit rate of $157 and $185 per kilowatt-year, respectively, for the State funding approach and $569 and $649 per kilowatt-year, respectively, for the revenue bonding approach. When divided by the

TABLE VIII-6
CACHE LA POUDRE PROJECT
SUMMARY OF FINANCIAL REQUIREMENTS
REVENUE BOND APPROACH, 12 PERCENT 30 YEARS
(IN THOUSANDS OF DOLLARS)

	ALTERNATIVE 1 GREY MOUNTAIN ONLY	ALTERNATIVE 8 ELKHORN ONLY	ALTERNATIVE 2 IDYLWILDE-GREY MOUNTAIN	ALTERNATIVE 7 ELKHORN-NEW SEAMAN
TOTAL PROJECT COST				
TOTAL CAPITAL COST (JAN 1982 DOLLARS)	130,800	109,600	400,800	354,300
SCHEDULE OF TOTAL CAPITAL COST				
1983	303	293	729	617
1984	545	558	1,467	1,248
1985	628	628	1,492	1,348
1986	57	57	1,216	1,061
1987	61	61	168	168
1988	66	66	181	181
1989	2,262	1,906	196	196
1990	4,887	4,117	212	212
1991	66,464	53,171	332	332
1992	133,855	115,678	11,803	10,681
1993	82,430	67,650	15,265	14,053
1994	ON-LINE	ON-LINE	153,618	133,729
1995			379,249	331,207
1996			409,578	357,694
1997			190,171	178,961
1998			ON-LINE	ON-LINE
TOTAL CAPITAL COST (ESCALATED)	291,558	244,185	1,165,667	1,031,688
INTEREST DURING CONSTRUCTION @ 10%	47,944	40,348	264,727	232,418
BOND RESERVE FUND (1 YR. DEBT SERVICE)	49,520	41,502	208,577	184,329
BOND ADMINISTRATION AND SALES COST	9,881	8,280	41,194	36,414
ON-LINE INVESTMENT REQUIREMENTS	398,903	334,515	1,680,175	1,484,849
ANNUAL PROJECT FUNDING REQUIREMENTS				
ANNUAL DEBT SERVICE (AS OF ON-LINE DATE)	49,520	41,502	208,577	184,329
ANNUAL O.M. &R (AS OF ON-LINE DATE)	500	590	5,790	3,970
LESS INTEREST ON BOND RESERVE	-5,942	-4,980	-25,029	-22,119
FIRST YEAR ON-LINE TOTAL ANNUAL COSTS	44,078	37,112	189,338	166,180
ANNUAL DEBT SERVICE (JAN 1982 DOLLARS)	22,352	18,756	72,687	64,167
ANNUAL O.M. & R (JAN 1982 DOLLARS)	200	235	1,690	1,160
LESS INTEREST ON BOND RESERVE	-2,682	-2,251	-8,722	-7,700
FIRST YEAR JANUARY 1982 TOTAL ANNUAL COSTS	19,870	16,740	65,655	57,627
COST BURDEN ON PEAKING POWER (JAN 1982 DOLLARS)				
TOTAL ANNUAL COSTS (JAN 1982 DOLLARS)	N/A	N/A	65,655	57,627
LESS POTENTIAL REVENUES				
CONSERVATION PURPOSES				
MUNICIPAL AND INDUSTRIAL WATER SUPPLY	N/A	N/A	3,060	3,060
IMPROVED SYSTEM MANAGEMENT	N/A	N/A	250	250
SUPPLEMENTAL IRRIGATION WATER SUPPLY	N/A	N/A	420	390
RUN-OF-RIVER HYDRO	N/A	N/A	3,050	2,650
TOTAL REVENUES	N/A	N/A	6,780	6,350
REQUIRED ANNUAL REVENUES FROM PRODUCTION OF PEAKING POWER	N/A	N/A	58,875	51,277
DOLLARS PER KILOWATT-YEAR	N/A	N/A	569	649
MILLS PER KILOWATT-HOUR	N/A	N/A	323	312

average annual energy produced by the peaking power facilities (both firm and non-firm energy), 182.1 gigawatt-hours for Alternative 2 and 164.4 gigawatt-hours for Alternative 7, it results in a composite unit rate of 100 and 94 mills per kilowatt-hour, respectively, for the State funding approach and 323 and 315 mills per kilowatt-hour, respectively, for the revenue bonding approach.

This obviously provides a wide range of values. Also, it should be recognized that this calculated cost burden on peaking power would recover all of the joint conservation costs not offset by the other purposes served. Again, as provided in the economic evaluation, it is noted that these are composite values including both the energy and the capacity component as discussed in Chapter VI on power benefits. These values compare with the $324 per kilowatt-year and the 185 mills per kilowatt-hour developed as a composite peaking power benefit consisting of both capacity and energy values in the Phase I evaluation, and shown in Table VI-2.

F. NON-MONETARY PHYSICAL FACTORS

Refinement of the engineering aspects of the major dams and reservoirs during Phase II resulted in a general upgrading of the physical factors which could be impacted as a result of development of the alternative projects. The physical impact information developed in Phase I was reviewed and some changes made in the estimates of features that would be inundated and the number of river miles affected. With regard to the miles of rivers impacted, segments of the tributaries inundated by each of the reservoirs were also included. Also, the miles of river above the mouth of the canyon whose historic flows would be altered by reservoir releases has been added as an evaluation factor. The data is presented in the lower section of Table VIII-7.

The predominant sources of impacts are from construction of the major dams and reservoirs. No determination has been made at this level of study as to whether these impacts would be of a positive or negative nature. Alteration of historic streamflow with releases for project dams and reservoirs could result in opportunities to enhance fish and wildlife resources and recreational uses.

The single reservoir Alternative 1 with only Grey Mountain Reservoir would inundate about 13 miles of river, 6 miles of highway, 1,670 acres of land, 1 developed recreational site, 75 buildings and the Fort Collins water treatment plant. The lands that would be inundated are predominantly privately owned lands. Historic streamflows in two miles of stream, between Grey Mountain Dam and the mouth of the canyon, would be altered by releases from Grey Mountain Dam.

The single reservoir Alternative 8 with only Elkhorn Reservoir would inundate about 9 miles of river, 7 miles of highway, 1,420 acres of land, 7 developed recreational sites, and 9 buildings. The lands that would be inundated are predominantly public lands, including over 200 acres of designated wilderness area. Historic streamflows in 19 miles of stream, between Elkhorn Dam and the mouth of the canyon, would be altered by releases from Elkhorn Dam.

TABLE VIII-7
CACHE LA POUDRE PROJECT
SUMMARY OF EVALUATION OF ALTERNATIVE PROJECTS
PHASE II

Item	ALT 1 Grey Mountain Only	ALT 8 Elkhorn Only	ALT 2 Grey Mountain-Idylwilde	ALT 7 Elkhorn-New Seaman
Base Data				
Storage Capacity	200,000 AF	196,000 AF	400,000 AF	396,000 AF
Yield of New Water	16,300 AF	14,400 AF	14,300 AF	13,100 AF
Installed Electric Run-of-River and Intermittent Capacity	12 MW	14 MW	14 MW	9 MW
Installed Electric Peaking Capacity	0	0	103 MW	79 MW
Average Annual Generation	42 million kWh	47 million kWh	229 million kWh	205 million kWh
Capital Cost (Jan. 1982 prices)	$130,800,000	$109,600,000	$400,800,000	$354,300,000
Annual OM&R Costs (Jan. 1982 prices)	$200,000	$235,000	$1,690,000	$1,160,000
Projected On-Line Date	1994	1994	1998	1998
Economic Evaluation				
Benefit-Cost Ratios (7 1/2% discount rate)				
Conservation Purposes Only	.36	.44	0.36	0.48
Incremental Run-of-River Hydropower	3.89	3.65	3.39	3.87
Conservation Plus Run-of-River Hydropower	.59 1/	.73 1/	0.60	0.69
Net Benefits (7 1/2% discount rate)				
Conservation Purposes Only	$-6,600,000	$-4,800,000	$-6,700,000	$-4,800,000
Conservation Plus Run-of-River Hydropower	$-4,600,000	$-2,600,000	$-4,500,000	$-2,900,000
Breakeven Value of Peaking Power (7 1/2% discount rate)				
Total Annual	N/A	N/A	$24,600,000	$22,200,000
Per Kilowatt-Year	N/A	N/A	$238	$281
Per Kilowatt-Hour	N/A	N/A	135 mills	135 mills
Sensitivity Analysis (5 and 10% interest)				
Benefit-Cost Ratios-Conservation Plus Run-of-River				
At 5% Interest	.90 1/	1.10 1/	1.10	0.95
At 10% Interest	.43 1/	.53 1/	0.44	0.50
Breakeven Value of Peaking Power				
At 5% Interest				
Per Kilowatt-Year	N/A	N/A	$157	$185
Per Kilowatt-Hour	N/A	N/A	90 mills	89 mills
At 10% Interest				
Per Kilowatt-Year	N/A	N/A	$325	$386
Per Kilowatt-Hour	N/A	N/A	185 mills	186 mills
Financial Evaluation				
State Funding Approach (5%, 40 years)				
On-Line Investment Requirements	$292,000,000	$244,000,000	$1,166,000,000	$1,032,000,000
First Year On-Line Total Annual Costs	$17,500,000	$14,800,000	$73,700,000	$64,100,000
First Year Jan 1982 Total Annual Costs	$7,800,000	$6,600,000	$25,000,000	$21,800,000
Cost Burden on Peaking Power-Annual (Jan 1982 costs)	N/A	N/A	$18,269,000	$15,459,000
Per Kilowatt-Year	N/A	N/A	$177	$196
Per Kilowatt-Hour	N/A	N/A	100 mills	94 mills
Revenue Bonding (12%, 30 years)				
On-Line Investment Requirements	$399,000,000	$335,000,000	$1,680,000,000	$1,485,000,000
First Year On-Line Total Annual Costs	$44,000,000	$37,000,000	$189,000,000	$166,000,000
First Year Jan 1982 Total Annual Costs	$19,900,000	$16,700,000	$65,700,000	$51,600,000
Cost Burden on Peaking Power-Annual (Jan 1982 costs)	N/A	N/A	$58,825,000	$51,277,000
Per Kilowatt-Year	N/A	N/A	$569	$649
Per Kilowatt-Hour	N/A	N/A	323 mills	312 mills
Physical Factors Evaluation				
Inundation Impacts				
River 12.8 mi.	8.9 mi.	21.8 mi.	19.3 mi.	
Highway	6.0 mi.	7.0 mi.	13.5 mi.	7.0 mi.
Areas, Total	1,670 acres	1,420 acres	3,370 acres	3,060 acres
(Private Lands)	(1,170 acres)	(30 acres)	(2,190 acres)	(690 acres)
(Public Lands)	(500 acres)	(1,390 acres)	(1,380 acres)	(2,370 acres)
(Designated Wilderness Areas)	(-0-)	(213 acres)	(-0-)	(213 acres)
Developed Recreational Sites	1	7	6	7
Buildings	75	9	149	13
Other Major Improvements	Wtr Trfat/Plant	None	Wtr Treat/Plant & Fish Hatchery	Wtr Treat/Plant
River Impacted by Altered Streamflows (excluding inundated areas)	2 mi.	19 mi.	30 mi.	19 mi.

1/ Represents total project.

The multiple reservoir Alternative 2, which includes Idylwilde Reservoir in addition to Grey Mountain Reservoir, would inundate about 22 miles of river, about 14 miles of highway, 3,370 acres of land, 6 developed recreational sites, 149 buildings, the Fort Collins water treatment plant and the State fish hatchery. The lands that would be inundated are predominantly privately owned lands. Historic streamflows in 30 miles of stream, from Idylwilde Dam to the mouth of the canyon would be altered by releases from Idylwilde Dam and Grey Mountain Dam.

The multiple reservoir Alternative 7, which includes New Seaman Reservoir in addition to Elkhorn Reservoir, would inundate about 19 miles of river, 7 miles of highway, 3,060 acres of land, 7 developed recreational sites, 13 buildings and the Fort Collins water treatment plant. The lands that would be inundated are predominantly public lands, including over 200 acres of designated wilderness area. Historic streamflows in 19 miles of stream, between Elkhorn Dam and the mouth of the canyon, would be altered by releases from Elkhorn Dam.

G. COMPARATIVE EVALUATION OF ALTERNATIVE PROJECTS

1. General

The evaluation factors, monetary and non-monetary, along with basic data for each of the selected alternatives are summarized for Phase II in Table VIII-7. Project costs, water yield, and physical factors are similar in character to those used for comparative purposes in Phase I. However, as mentioned, the economic evaluation has been modified and extended from the Phase I evaluation. Furthermore, financial evaluation factors have been added recognizing two possible funding approaches. The non-monetary factors remain, as in Phase I, the physical impacts which would result from inundation. A discussion of significant differences between alternatives is provided in the following sections to facilitate making comparisons among the four selected alternatives.

2. Increased Yield of Water

The comparisons in yield of new water were not changed from the Phase I evaluations. Because of the downstream location of Grey Mountain Reservoir, Alternative 1 provides the highest estimated yield of the two single reservoir alternative projects at 16,300 acre-feet per year. Alternative 8, with Elkhorn Reservoir, is estimated to produce 14,400 acre-feet per year.

The addition of another reservoir to expand the single reservoir alternative projects to multiple reservoir alternative projects results in a decrease in the yield. Alternative 2, including Grey Mountain Reservoir and Idylwilde Reservoir, yields 14,300 acre-feet per year, 2,000 acre-feet per year less than Alternative 1 with Grey Mountain Reservoir only. Alternative 7, including Elkhorn Reservoir and New Seaman Reservoir, yields 13,100 acre-feet per year, 1,300 acre-feet per year less than Alternative 8 with Elkhorn Reservoir only. In both cases, the reduced yield is due primarily to the greater evaporation from two reservoir surfaces.

3. **Monetary Evaluation**

a. Capital Costs

The alternative with the lowest capital cost in January 1982 prices is the single reservoir Alternative 8, with Elkhorn Reservoir, at about $110 million. This compares with the other single reservoir alternative, Alternative 1, with Grey Mountain Reservoir, estimated at $131 million. This is due to the more desirable damsite and reduced relocation requirements for Elkhorn Reservoir.

The addition of a second reservoir and associated facilities for peaking power increases the project costs by threefold, bringing the totals to $354 million for Alternative 7 with Elkhorn Reservoir and New Seaman Reservoir and $401 million for Alternative 2 with Grey Mountain Reservoir and Idylwilde Reservoir. This lower cost for Alternative 7 must be appraised in light of the difference in output where the higher cost Alternative 2 produces 103.5 megawatts in hydro peaking versus 79 megawatts for Alternative 7.

b. Economic Evaluation

In absolute terms, the total project benefit-cost ratios for the single reservoir alternatives, including conservation purposes and run-of-the-river hydropower, did not achieve unity after applying the mid-range discount rate of 7 1/2 percent for primary display purposes. Estimated annual benefits fell 30 to 40 percent shy of offsetting estimated total annual costs, with Alternative 8 with Elkhorn Reservoir at 0.73 showing the higher ratio of the two single reservoir alternatives. In relative benefit-cost ratio terms, Alternative 8, with Elkhorn Reservoir, was about 20 percent better than Alternative 1, with Grey Mountain Reservoir. Net annual benefits for the single reservoir alternative projects displayed the same relationships as the benefit-cost ratios. The inclusion or exclusion of run-of-the-river hydro generation had little influence on this relationship. Also, as mentioned subsequently, the application of a lower or higher discount rate did not change this relationship significantly.

The enlargement of the two single reservoir alternatives to include peaking power as a project purpose did not appear to yield a significant economic difference between the two multiple reservoir alternatives. Although the total annual cost was greater for Alternative 2, its higher output resulted in a derivation of the breakeven value of peaking power comparable with Alternative 7. At the 7 1/2 percent discount rate, the breakeven value of peaking power expressed in dollars per kilowatt-year for Alternative 2 was somewhat less, $238 versus $281, but Alternative 7 generated more energy per kilowatt resulting in comparable values per kilowatt-hour of 135 mills per kilowatt-hour for both. Without comprehensive marketing studies, it appears that the resulting breakeven values of peaking power do not significantly favor one multiple reservoir alternative project over the other.

The sensitivity analysis applying the 5 percent and 10 percent discount rates showed predictable changes in the total project benefit-cost ratios and net annual benefits for the single reservoir alternatives. Application of the 5 percent rate improved the benefit-cost ratios derived at a 7 1/2 percent discount rate by more than 50 percent. Application of the 10 percent rate reduced those ratios significantly. The breakeven value of peaking power for the multiple reservoir alternative projects was decreased about 50 percent for the 5 percent rate and increased about 40 percent for the 10 percent rate, as compared with the 7 1/2 percent discount rate. However, the unit breakeven values of peaking power for the two multiple reservoir alternatives remained comparable with each discount rate applied.

c. Financial Evaluation

Of the two single reservoir alternative projects; Alternative 8 with Elkhorn Reservoir showed a lower on-line investment requirement, both in total dollar costs and on-line total annual costs, than Alternative 1 with Grey Mountain Reservoir. This relationship was true with both the state funding approach and the revenue bonding approach. Of the two multiple reservoir alternative projects; Alternative 7 with Elkhorn Reservoir and New Seaman Reservoir showed similarly lower on-line investment requirements than Alternative 2 with Grey Mountain Reservoir and New Seaman Reservoir under both funding approaches. This relationship was also noted in the comparison of capital costs in the economic evaluation.

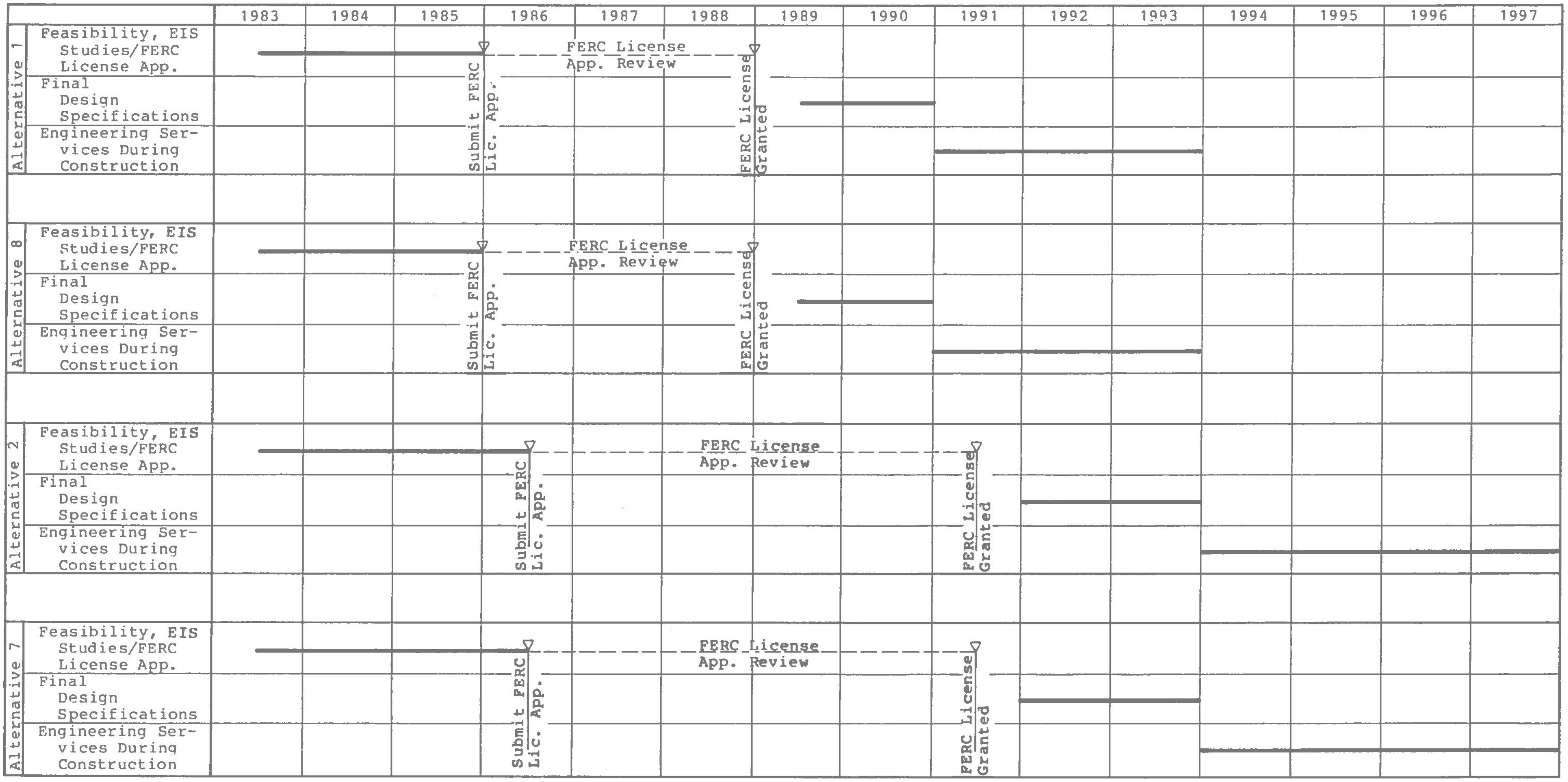
In terms of unit values, whether expressed in dollars per kilowatt-year or mills per kilowatt-hour, the cost burden on peaking power is quite comparable for either of the multiple reservoir alternative projects. This comparability was also noted in comparison of the breakeven value of peaking power in the economic evaluation. Under the state funding approach, the resulting rates, $177 to $196 per kilowatt-year or 94 to 100 mills per kilowatt-hour, are considered attractive for peaking power when compared to costs for alternative sources of peaking power derived during Phase I. The rates resulting from the revenue bonding approach, $569 to $649 per kilowatt-year or 312 to 323 mills per kilowatt-hour are significantly higher than the costs for alternative sources of peaking power derived during Phase I, suggesting that the peaking output would not be marketable under that funding approach.

4. Non-Monetary Physical Factors

With regard to physical impacts caused by inundation; for the single reservoir alternative projects, Alternative 8 with Elkhorn Reservoir would inundate less miles of river, less privately owned lands, significantly less buildings and less major improvements than would Alternative 1 with Grey Mountain Reservoir. Alternative 8, however, would inundate slightly more highway, more publically owned lands, including over 200 acres of designated wilderness area, and more developed recreational sites than would Alternative 1.

For the multiple reservoir alternative projects, Alternative 7 with Elkhorn Reservoir and New Seaman Reservoir would inundate less miles of river, less miles of highway, less privately owned lands, significantly less buildings, and less major improvements than would Alternative 2 with Grey Mountain Reservoir and Idylwilde Reservoir. Alternative 7, however, would inundate more acres of publically owned lands, including over 200 acres of designated wilderness area.

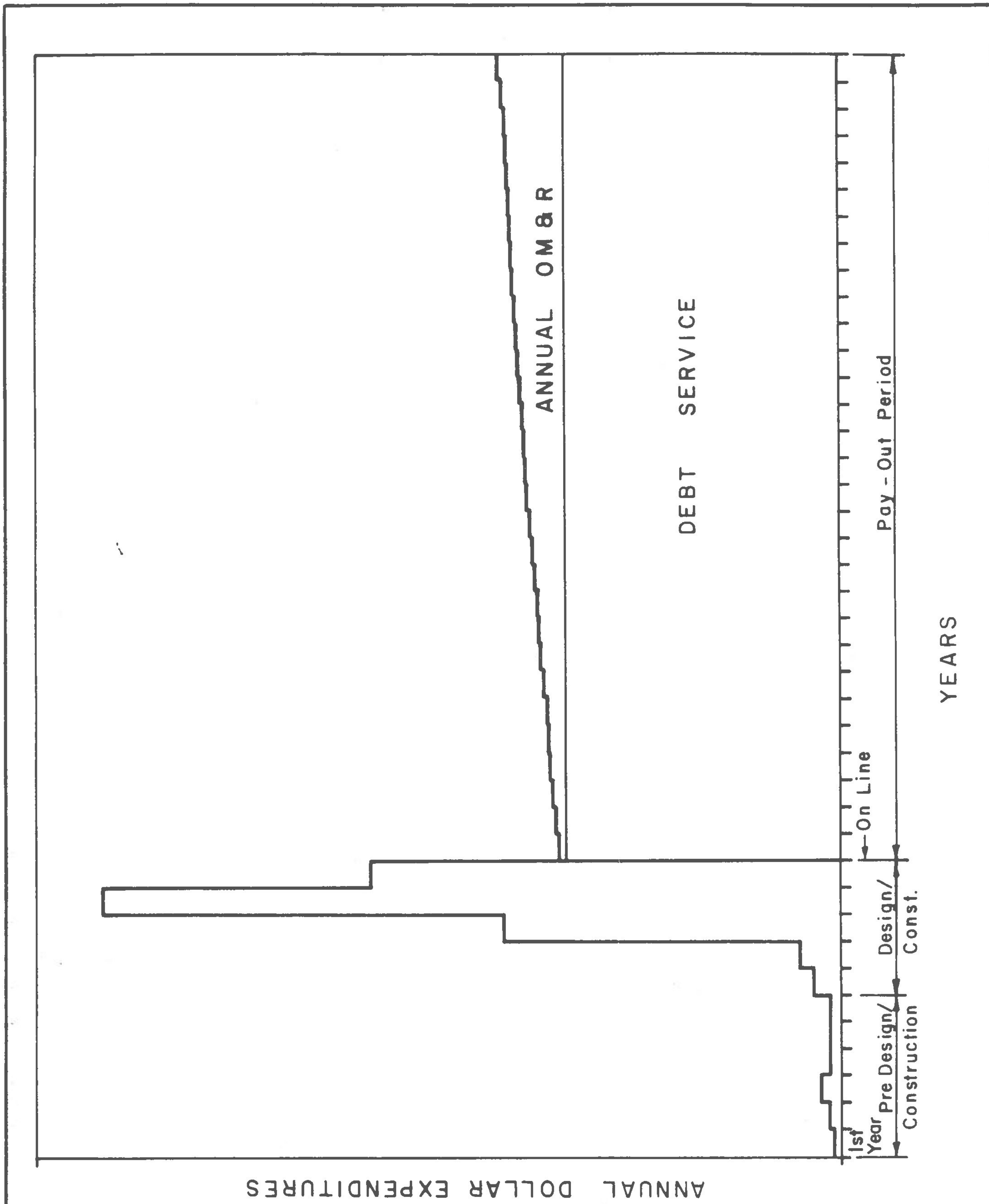
With regard to miles of river that would be impacted by alteration of historic streamflows with releases from project dams and reservoirs; for the single reservoir alternatives, Alternative 1 with Grey Mountain Reservoir would impact less stream than Alternative 8 with Elkhorn Reservoir. For the multiple reservoir alternative projects, Alternative 7 with Elkhorn Reservoir and New Seaman Reservoir would impact less stream than Alternative 2 with Grey Mountain Reservoir and Idylwilde Reservoir.



COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY,

PROJECTED SCHEDULE OF
DEVELOPMENT ACTIVITIES

TUDOR ENGINEERING COMPANY FIGURE: VIII-1



COLORADO WATER CONSERVATION BOARD
CACHE LA POUDRE PROJECT
RECONNAISSANCE STUDY

CONCEPTUAL CASH FLOW DIAGRAM

TUDOR ENGINEERING COMPANY

FIGURE: VIII-2

CHAPTER IX

CONCLUSIONS AND RECOMMENDATIONS

The engineering analyses conducted for this study provided a very preliminary indication of technical feasibility for a Cache la Poudre Project. Given the level of detail at which this study was conducted, however, these conclusions are not definitive.

From an engineering standpoint, no apparent reasons have been found that any of the four alternative projects cannot be constructed. No serious geologic problems that would preclude construction are evident.

Reservoir operation studies indicate that from 13,000 to 16,000 acre-feet of new useable water supply could be made available on an average annual basis from each of the four alternatives. Further detailed studies would likely prove these estimates to be quite conservative.

Further optimization of facilities designs will be necessary in any future study to develop more refined cost estimates and to better estimate project outputs. Additional studies will be necessary to evaluate the economic and financial value of the output. Additional impacts will need to be identified. For example, fish and wildlife and recreation effects, positive or adverse, have not been included in this study, nor have effects of flood control. The findings of this study, however, provide general perspective on the relative magnitude of costs, the amount of economic benefits and financial revenues that would need to be generated, and the non-monetary impacts for the four alternatives.

With respect to the economic analyses, the two single reservoir alternatives do not appear, at this time, to be viable projects. Benefits are estimated to be substantially less than the costs that would be incurred, except at a 5 percent discount rate. Since the benefits used in the economic analysis were limited to vendible outputs, the benefit-cost ratio is also an indication that project revenues would be insufficient to pay for either project. However, the viability of single reservoir projects of capacities other than 200,000 acre-feet is unknown since the study did not optimize sizing of the reservoirs.

The situation with respect to the two multiple reservoir projects is difficult to ascertain. The price per kilowatt-hour for which the peaking power from these two alternatives would have to be sold in order to make these two projects financially feasible (referred to as the "cost burden on peaking power") appears to be attractive with state funding; however, with revenue bonding, it is well beyond what the current market will bear. However, the issue is not present, but future, market conditions and power demands, since the multiple reservoir alternatives could not be on-line until 1998 at the earliest. Also, reservoir sizes and peaking power facilities have not been optimized.

In summary, the present study has developed useful information about large storage reservoirs in the upper Cache la Poudre Basin. Although the uncertainties associated with both the future demand for peaking power and the need for new reservoirs prevent one from arriving at firm conclusions as to what would or would not be feasible 10-15 years from now, the projects examined in this study appear to have been sufficiently analyzed for the present.

On the other hand, given the limitations placed upon the geographical scope of this study, many questions remain unanswered concerning the future water resources needs of the Cache la Poudre Basin and the alternative means available to meet various water resource development and management objectives. Questions regarding future water and power demands, the future of irrigated lands, the condition of the existing plains reservoirs and alternatives to large new storage projects in the canyon (which alternatives may include smaller capacity reservoir project(s) in the upper basin) all need to be addressed before decisions can be reached on what future projects and management actions might be feasible and desirable.

The best means of addressing these questions would be a carefully designed study of basin-wide scope (upper and lower basin) formulated with the participation of all interested parties in the basin. In March 1983, the Board recommended that the General Assembly authorize the expenditure of not more than $15,000 from the CWCB construction fund for the preparation by the Board of a detailed proposal for a basin-wide study of the Cache la Poudre. This authorization would cover operating costs for a public information program, consultation with interested parties and the printing and distribution of pertinent materials. The intent of the recommendation was that a detailed plan of study would be submitted to the General Assembly in 1984 for consideration and action as the legislature would deem appropriate.

In June 1983, House Bill 1102 was enacted by the Colorado General Assembly. Section 3 of H.B. 1102 contained the following provision relating to the Cache la Poudre Study:

> "The General Assembly recognizes that further resource development opportunities exist in the upper and lower Cache la Poudre River Basins. The Board is further authorized to study the development and management of the water resources of all or any portion of the Cache la Poudre River Basin should any agency, entity, or organization provide funds to the Board for that purpose; provided, however, that any such study or studies shall not include consideration of water development projects which would be located upstream from Kinikinik or upstream from the Rockwell damsite."

GLOSSARY

A

abutment - the support at the end of a dam, arch or bridge.

acre - a measure of area; equivalent to 43,560 square feet.

acre-foot (ac-ft) - the volume of water, equal to the quantity required to cover an acre of land to a depth of 1 foot or 43,560 cubic feet.

acre-feet per year - the flow rate of water equal to 0.00138 cubic feet per second for one year.

adjudication - a formal court proceeding resulting in a determination by the court (a decree) which recognizes the appropriation of waters to a beneficial use.

afterbay - a channel, short stretch of stream, or small reservoir conducting water away from a water turbine or into which a hydropower plant discharges.

alluvium - unconsolidated sediments deposited by running water.

alpine - implies high elevation, particularly above tree line, and cold climate.

amortization - liquidation by installment payments.

amphibolite - crystalline metamorphic rocks consisting mainly of amphibole minerals and feldspar minerals.

annualized - moving all related costs and benefits to an annual payout schedule.

anticline - a geological structure or arch formed by strata from opposite sides dipping from a common line.

appraisal level study - an investigation performed to formulate a preliminary plan for project implementation, as well as make possible selection between alternatives, and to assess the desirability for continued, more detailed analyses. Generally used synonymously with reconnaissance study.

appropriation - the volume of flow of water that is legally allocated to an individual, municipality, corporation or government entity for an identified beneficial use.

appurtenances - something added to another more important thing; an accessory.

arable land - fit for or cultivated by farming. Land which, when properly prepared for agriculture, will have a sufficient yield to justify its development.

arbitrage - the process by which advantage may be taken of differences in the value of money or securities, at different places in the same time.

asymetrical - not symetrical.

augmentation - enlarging or increasing the flow of a stream or river.

average flow - the arithmetic mean of flow rates over a period of time, usually one year.

average load - the hypothetical constant mean load.

B

basalt - a dark, fine-grained extrusive rock composed primarily of feldspar and pyroxene.

base load capacity - a constant load over a period in time.

basement - the rock complex generally consisting of igneous and metamorphic rocks. Where not exposed, overlain unconformably by sedimentary strata. The crystalline crest of the earth.

basin - the drainage or catchment area of a stream or lake.

bedrock - any solid rock exposed at the surface of the earth or overlain by unconsolidated material.

benefits (economic) - the increase in economic value produced by the addition of a project, typically represented as a time stream of value produced by the generation of consumeable resources.

benefit-cost ratio (b/c ratio) - the ratio of the present value of the benefit stream to the present value of the project cost stream computed for comparable price level assumptions.

biotite - a common, block rock-forming mineral. A member of the mica group.

borrow - material excavated from one area to be used as fill material in another area.

breakeven value of power - the value of power that will cover the cost of its production.

brecciated - highly angular and coarse rock components.

British thermal unit (Btu) - the quantity of heat energy required to raise the temperature of 1 pound of water 1 degree Fahrenheit, at sea level.

bulkhead (gate) - a hydraulic gate installed in slots or guides (usually temporary) to hold back water. May be used during construction until permanent works are completed or later to exclude water while repairs are made.

bypass flows - the water allowed to pass a dam or water diversion to meet an instream flow requirement.

C

calc-silicate - a fine-grained metamorphic rock.

capability - the potential to produce resources, supply goods and services, and allow resource uses under a given level of management intensity and assumed set of management practices.

capacity - the power output or load which a turbine-generator, station, or system is capable of producing.

capacity value - that part of the market value of electric power which is assigned to dependable capacity.

carbonaceous - pertaining to, or composed largely of carbon.

cleavage - the splitting, or tendency to split, along rock planes determined by the crystal structure.

conchoidal - a type of rock or mineral fracture yielding smoothly cured surfaces.

conditional decree - a decree of the court awarding a priority date of appropriation to use water even though actual taking and use of the water is delayed until a future time, usually until a project is constructed.

conduit - a channel for conveying water or fluid.

conglomerate - a cemented elastic rock containing gravel- or pebble-sized rounded fragments.

conservation - the storage of water for later consumptive uses.

conservation storage (or capacity) - that water (or capacity) that is stored for use and will be released as needed to supply consumptive uses.

consumptive water use - the volume of water that is used for a process or activity that is not directly returned to the water source and results in a reduction of the water source.

consumptive use - those uses of a resource that reduce the supply.

contact - the place or surface where two different kinds of rock interface.

conveyance - the act of transporting.

costs (economic) - the stream of value required to produce the desired product. In water resources projects this is often the construction cost required to develop the resource, and the administration, operations, maintenance and replacement costs required to continue the project in service.

cost effective - the least cost method of achieving a specified output or objective.

cost efficiency - a comparative measure of economic efficiency determined by maximizing the present net worth of an alternative, subject to meeting the objectives of the alternative.

corridor - a linear strip of land which has similar ecological, technical, economic, social, or other advantages.

Creager's C - a coefficient characteristic as the determined value of an enveloping curve, used in flood study analysis that will give an estimate of the maximum flood from a given drainage basin.

crest - the top line or peak of a dam or hill.

Cretaceous Period - the third and latest of the periods included in the Mesozoic Era. Approximately from 65 to 135 million years ago.

critical drawdown period - the time period between maximum pool drawdown and the previous occurrence of full pool.

crop irrigation requirement - the amount of water required at the farm field level to supplement natural precipitation in satisfying the crops consumptive use.

cross-bedding - the arrangement of laminations of strata transverse or oblique to the main planes of stratification.

cubic feet per second (ft^3/s) - a measure of a moving volume of water at the flow rate of water equal to 724 acre-feet per year or 449 gallons per minute.

cultural resource - any building, site, district, structure, or object significant in history, architecture, archaeology, culture or science.

cutoff trench - an impervious barrier beneath a dam to impede seepage.

crystalline - of or pertaining to the nature of a crystal, having regular molecular structure.

D

dead storage - that water stored (or capacity) in a reservoir that is below the lowest outlet elevation.

debt service - principle and interest payments on the debt used to finance the project.

dependable capacity - the load carrying ability of a hydropower plant under adverse hydrologic conditions for the time interval and period specified for a particular system load.

depletion - the reduction in flow of a stream or the reduction in volume of a lake or reservoir due to withdrawals, evaporation or seepage.

developed recreation site - a land allocation designation for environments that have been substantially modified for campgrounds, ski areas, etc.

diastrophism - the processes by which the earth's crust is deformed, producing oceans, continents and mountains.

dike - a tabular body of igneous rock that cuts across the structure of adjacent rocks - usually an intrusive.

diorite - a dark, plutonic rock composed essentially of feldspar and one, or more, of a number of mafic minerals.

dip - the angle at which a stratum or any planar feature is inclined from the horizontal.

direct diversion - the diversion of water from a natural flowing stream.

discounting - the process of finding the present value of a series of future cash flows, opposite of compounding.

distribution line - low voltage electric power line usually 69 kilovolts or less.

diversion dam - a barrier across a stream built to turn all or some of the water into a diversion channel or conduit.

down-dropped block - the wall of a fault that has moved relatively downward.

drawdown - the decrease in elevation of a lake or reservoir due to a release or discharge from the lake or reservoir.

E

easement - a nonpossessing interest held by one party in land of another party whereby the first person is accorded partial use of such land for a specific purpose. It restricts but does not abridge the rights of the first owner to the use and enjoyment of his land, subject to the enjoyment of the easement holder's rights.

Easterm Slope - that portion of Colorado lying east of the Continental Divide.

ecosystem - an interacting system of organisms considered together with their environment.

effective precipitation - the amount of rainfall that is used by crops to satisfy consumptive use.

EIS - abbreviation for environmental impact statement.

electric system - the physically connected generation, transmission, distribution, and other facilities operated as an integral unit under a control, management or operating supervision.

endangered species - life forms found on the U.S. Department of the Interior's list and published in the Federal Register. Their presence on the list implies their continued existence as a species is questionable.

energy - the capacity for performing work. The electrical energy term generally used is kilowatt-hours and represents power (kilowattts) operating for some time period (hours).

energy value - that part of the market value of electric power which is assigned to energy generated.

environment - all the conditions, circumstances, and influences surrounding and affecting the development of an organism or group of organisms.

environmental analysis - an analysis of alternative actions and their predictable short- and long-term environmental effects.

Eocene - second epoch of the Tertiary Period. Approximately from 37 to 53 million years ago.

epoch - geologic time unit corresponding to a series.

erosion - the group of processes whereby earth or rock material is loosened or dissolved and removed from any part of the earth's surface.

evaporation - the process by which water is transferred from the liquid state in a water body to vapor in the water cycle.

evapotranspiration - the loss of water from land surfaces to the atmosphere by evaporation and by transpiration from plants.

existing reservoir - a reservoir that was created by the construction of an embankment.

F

fault - a fracture or fracture zone along which there has been displacement of the sides relative to one another parallel to the fracture.

feasibility study - an investigation performed to formulate a project and definitively assess its desirability for implementation.

Federal Energy Regulatory Commission (FERC) - an agency in the Department of Energy which licenses non-Federal hydropower projects and regulates interstate transfer of electric energy, formerly the Federal Power Commission (FPC).

felsic - derived from the words; feldspar, lenads and silica. Applies to light-colored rocks containing an abundance of one or all of these constituents. Also applies to the minerals themselves.

fines - the fine fraction of a sediment or the product of rock crushing, particularly that which passes through a grading sieve.

firm water supply - an assured minimum supply of water under the most adverse water year supply conditions.

firm energy - the energy generation ability of a hydropower plant under adverse hydrologic conditions for the time interval and period specified for a particular system load.

flow structure - a structure of igneous rocks, generally but not necessarily restricted to volcanic rocks, in which the stream or flow lines of the magma are revealed by alternating bands or layers of differing composition, crystallinity or texture.

fluvial - of, or pertaining to rivers.

foliation - the laminated structure, resulting from segregation of different minerals into layers parallel to the schistosity.

forebay - the upper water impoundment from which water is discharged to a hydroelectric generating plant.

freeboard - represents the vertical distance between the maximum elevation reached in routing of the spillway design flood and the top of the dam.

G

gallons per capita day - the amount of water one person is estimated to use in an average day.

generator - a machine which converts mechanical energy into electric energy.

geographical - pertaining to the surface of the earth, including its form, development, and the phenomena that take place thereon.

geological - of, or pertaining to the science which deals with the earth, the rocks of which it is composed and the changes which it has undergone.

geomorphic - of, or pertaining to the figure of the earth or the form of its surface.

geomorphology - the branch of both physiography and geology which deals with the form of the earth, the general configuration of its surface and the changes that take place in the evolution of landforms.

geosyncline - large generally linear trough that subsided deeply throughout a long period of time in which a thick succession of stratified sediments and possibly extrusive volcanic rocks commonly accumulated.

gigawatt-hours (GWh) - one million kilowatt-hours.

glacial - pertaining to, characteristic of, produced or deposited by, or derived from a glacier.

glacial striation - fine-cut lines or grooves on the surface of the bedrock which were inscribed by rock fragments carried by the overriding ice of a glacier.

glaciation - alteration of the earth's solid surface through erosion and deposition by glacial ice.

gneiss - a coarse-grained rock in which bands rich in granular minerals alternate with bands in which schistose minerals predominate.

graben - a block, generally long compared to its width, that has been downthrown along faults relative to the rocks on either side.

granodionite - a plutonic rock consisting of quartz, feldspars and various mafic minerals.

graywacke - a type of sandstone characterized by; a dark color, generally tough and well indurated, large quartz and feldspar grains set in a prominent to dominant "clay" matrix.

gross head - the gross difference in elevation between the headwater surface above and the tailwater surface below a hydroelectric power plant, under specified conditions.

H

head losses - reductions to the gross difference in elevation between water surfaces upstream and downstream from a hydroelectric power plant due to friction of the flow of water through a penstock or conduit and changes in direction or velocity of the flow.

headwaters - source of water in a stream.

headworks - structure at the head of a channel or conduit for diverting water into the channel.

hogback - a ridge produced by highly tilted strata.

hornblends - a mineral of the amphibole group; mafic.

horst - a block of the earth's crust, generally long compared to its width, that has been uplifted along faults relative to the rocks on either side.

hydroelectric plant or hydropower plant - an electric power plant in which the turbine-generators are driven by falling water.

hydrology - the science dealing with water on the land, its properties, laws, geographic distribution.

hydrologic study period - a number of years with sufficient records available to use in an analysis to determine the possibility of a set of flows.

I

igneous - rocks formed by solidification from a molten or partially molten state.

inactive storage (or capacity) - that water stored (or capacity) in a reservoir that is above dead storage but not used to store water which will be released from the reservoir for project purposes.

inflow design flood - the size of flood that a dam, spillway and reservoir are designed to accomodate without overtopping the dam.

in situ - in the natural or original position.

insoluble - incapable of being dissolved.

installed capacity - the total of the capacities shown on the nameplates of the generating units in a hydropower plant.

instream flows - a prescribed level(s) of streamflow, usually expressed as a stipulation in a permit authorizing a dam or water diversion which can be met with bypass flows.

intrusion - a body of plastic solid or magmatic igneous rock that is emplaced within older rock.

inundate - to flood or cover with water.

irrigable land or acreage - arable land for which a water supply is available.

irrigation - artificial application of water to arable land for agricultural use.

irrigation efficiencies - the percentage of irrigation water applied that is stored in the soil and available for consumptive use by the crops.

isoclinal folding - a fold, the limbs of which have parallel dips.

J

joint - fracture in rock, generally vertical or transverse to bedding, along which no appreciable movement has occurred.

joint use storage (or capacity) - that storage (or capacity) that is shared by more than one use on a time, or some other priority, basis.

K

kilovolt (kV) - one thousand volts.

kilowatt (kW) - one thousand watts.

kilowatt-hour (kWh) - the amount of electric energy involved with a one kilowatt demand over a period of one hour. It is equivalent to 3,413 Btu of heat energy.

L

Laramide orogeny - in broad sense, the diastrophic movements beginning in the Lower Cretacious and continuing until the Lower Eocene.

leverage - the advantage that arises from employing funds borrowed at a fixed interest rate to earn a rate of return higher than the interest paid.

load - the amount of power needed to be delivered at a given point on an electric system.

load curve - a curve showing power (kilowatts) supplied, plotted against time of occurrence, and illustrating the varying magnitude of the load during the period covered.

load-duration curve - a graphical representation of the manner in which the load varies over time where the load is plotted versus the percentage of time that the load is equalled or exceeded.

load factor - the ratio of the average load during a designated period to the peak or maximum load occurring in that period.

M

mafic - in general, synonymous with "dark minerals" as usually used. Contrasted with felsic.

market value - the value of power at the load center as measured by the cost of producing and delivering equivalent alternative power to the market.

mean annual flow - the average or yearly flow of a stream.

meander - one of a series of somewhat regular and looplike bends in the course of a stream.

megawatt (MW) - one thousand kilowatts.

megawatt-hour (MWh) - one thousand kilowatt-hours.

Mesozoic - one of the grand divisions or eras of geologic time. Approximately from 65 to 225 million years ago.

meta-basalt - metamorphosed basalt.

meta-conglomerate - metamorphosed conglomerate.

metamorphic rock - includes all those rocks which have formed in the solid state in response to pronounced changes of temperature, pressure, and chemical environment.

metamorphism - the process by which consolidated rocks are altered in composition, texture or internal structure, by the introduction of pressure, heat and new chemical substances.

meta-sediments - metamorphosed sedimentary rocks.

migmatite - rock consisting of composite igneous or igneous-looking and/or metamorphic materials.

mills - a measurement of the value of energy where one mill equals 0.001 dollar.

mitigate - to lessen the severity.

monadnock - a residual rock, hill, or mountain standing above the surrounding topography.

monolithic - a single large piece.

moraine - a mass of rocks, gravel, sand, clay, etc., carried and deposited directly by a glacier.

morphology - the external structure of rocks in relation to the development of erosional forms or topographic features.

N

net benefits - the result of subtracting total costs from total benefits.

net head - the adjusted gross head on a power plant, accounting for reductions due to head losses.

O

O&MR - abbreviation for operation, maintenance and replacement.

operation study - the manipulation of data in a simulation process useful to predict a possible outcome.

out-of-priority storage option - the ability to store water before one has the right according to his court decree to do so.

outlet channel - a waterway or drainage channel provided to collect and carry away a discharge of water.

outwash - unconsolidated material deposited by meltwater streams beyond active glacial ice.

overburden - material of any nature, consolidated or unconsolidated, that overlies a rock unit of interest.

P

Paleozoic - one of the eras of geologic time. Approximately from 225 to 570 million years ago.

pasture - land which is currently improved for grazing by irrigation or other means.

peaking capacity - that part of a system's generating capacity which is operating during the hours of highest power demand within the system.

peak load - the maximum load in a stated period of time.

pediments - areas along the face of the uplifted mountain ranges which are generally relatively gently sloping and which have been formed by several factors including sheet erosion and deposition, stream braiding, etc. The general slope of these areas is governed by the slope and erodability of the underlying bedrock formations.

pedologic - pertaining to the study of soils.

pegmatite - coarse-grained igneous rocks found usually as dikes associated with a large mass of plutonic rock of finer grain size. Unless otherwise specified, the name usually means granite pegmatite.

peneplain - an area in which erosion has reduced the landscape to almost a plain.

Pennsylvanian - the sixth of seven periods in the Paleozoic Era. Approximately from 280 to 320 million years ago.

penstock - a tube or conduit used to carry water to a turbine for generating power.

permeability - the measure of the relative ease with which a porous medium can trasmit a liquid under a potential gradient.

permeable material - that which allows water to pass through easily.

Permian - the last of seven periods in the Paleozoic Era. Approximately from 225 to 280 million years ago.

phreatophyte - a long-rooted plant that absorbs its water from the groundwater.

physiography - the study of the genesis and evolution of land forms.

piedmont - lying or formed at the base of mountains.

plant factor - ratio of the average load to the installed capacity of the plant, usually expressed as an annual percentage.

plateau - a relatively elevated area of comparatively flat land which is commonly limited on at least one side by an abrupt descent to lower land.

Pleistocene - the earlier of the two epochs in the Quarternary Period. Approximately from 0.1 to 2 million years ago.

plutonic - rocks, usually igneous, formed at great depth.

pondage - the amount of water stored behind a hydroelectric dam of relatively small storage capacity used for daily or weekly regulation of the flow of a river.

power (electric) - the rate of generation or use of electric energy, usually measured in kilowatts.

power factor - the percentage ratio of the amount of power, measured in kilowatts, used by a consuming electric facility to the apparent power measured in kilovolt-amperes.

power pool - two or more electric systems which are interconnected and coordinated to a greater or lesser degree to supply, in the most economical manner, electric power for their combined loads.

Precambrian - all rocks formed before the Cambrian Period. Approximately from 570 million years ago to the formation of the earth.

precipitation - the discharge of water, in liquid or solid state, out of the atmosphere.

present net value - the difference between net benefits and net costs, each discounted to the present.

present worth - the value today of a future dollar or stream of dollars, discounted at the appropriate rate.

probable maximum flood - the estimated flood that would result if all factors that contribute to a flood were to reach the most critical combination of values that could occur simultaneously.

Q

quartz monzonite - a coarse-grained rock containing feldspars and quartz as the major minerals.

R

rate of return on investment - the interest rate at which the present worth of annual benefits equals the present worth of annual costs.

reconnaissance study - a preliminary study of project feasibility designed to ascertain whether a feasibility study is warranted.

recreation visitor days - twelve visitor hours, which may be aggregated continuously, intermittently or simultaneously by one or more persons.

reliability council - one of nine regions in which power suppliers coordinate reliability council - one of nine regions in which power suppliers coordinate their output to prevent electrical power shortage.

reservoir - a natural or man-made basin used for the storage, regulation and control of water.

revenue bond - project funding, repayment for which is strictly dependent on the income from the project to meet the interest and principal payments.

Richter scale - the range of numerical values of earthquake magnitude.

rolled concrete dam - a dam consisting essentially of an inner or enclosed low cement content concrete mixture which is compacted within a preformed higher cement content concrete shell.

run-of-the-river (plant/hydroelectric generation) - a power plant that uses natural flows or flows released for other purposes to generate power.

S

sandstone - a cemented or otherwise compacted detrital sediment composed predominantly of sand sized quartz grains.

schist - a medium or coarse-grained metamorphic rock with subparallel orientation of the micaceous minerals which dominate its composition.

secondary energy - all hydroelectric energy other than firm energy, sometimes known as intermittent energy.

sediment - solid material, both mineral and organic, that in suspension has been transported from its site of origin by air, water or ice.

sedimentary rocks - rocks formed by the accumulation and compaction of sediment in water or from air.

sedimentation - the process by which solid particles are eroded, transported, and deposited, usually by flowing water.

sediment storage - the volume of a reservoir set aside to store incoming sediments that are deposited in the reservoir over the useful life of the project.

seepage - the process by which surface water flows into and through the ground.

seismic - pertaining to an earthquake or earth vibration.

seismicity - the phenomenon of earth movements or seismic activity.

shale - a laminated sediment in which the constituent particles are predominantly of the clay grade.

shear zone - a zone in which shearing has occurred on a large scale so that the rock is crushed and brecciated.

silliminanite - a fibrous mineral.

slope wash - soil and rock material that has been moved down a slope predominantly by the action of gravity and running water not concentrated in channels.

spillway - overflow channel of a dam.

spinning reserve - generating units operating at no load or at partial load with excess capacity readily available to support additional load.

stereoscopic pair - two photographs of the same area taken from different camera stations in such a manner that a portion of the area appears on both photographs. The mental empression of a three-dimensional model results from viewing the pair through a stereoscope.

stochastic procedure - a procedure involving chance or probability: probabilistic.

storage decree - a decree of the court allowing the storage of water, usually in a reservoir.

strike (geology) - a line formed by the intersection of a horizontal plane and a geologic stratum.

strike slip - the component of the movement parallel with the fault strike.

supplemental irrigation water - additional water applied to irrigate crops over and above that historically or normally used, which could be beneficially used to increase the crop yield.

surcharge - reservoir storage designed to accommodate a sudden increase in the flow of water into a reservoir.

surface acre - the two-dimensional water surface of a lake amounting to 43,560 square feet.

switchyard - an area usually fenced containing equipment for routing the flow of electrical power.

T

tailrace - a channel for conveying discharged water from a hydroelectric power plant.

talus - a collection of fallen disintegrated material which has formed a slope at the foot of a steeper declivity.

terminal storage - the ultimate or last storage facility of the system.

terrace - a relatively flat, horizontal, or gently inclined surface, sometimes long and narrow, which is bounded by a steeper ascending slope on one side and by a steeper descending slope on the opposite side.

Tertiary - the earlier of two geologic periods within the Cenozoic Era. Approximately from 2 to 65 million years ago.

thermal plant - a generating plant which uses heat to produce electricity. Such plants may burn coal, gas, oil, or use nuclear energy to produce thermal energy.

topographic - of, relating to, or concerned with the configuration of the earth's surface including its relief and the position of its natural and man-made features.

topography - the physical features of a district or region, especially the relief and contour of the land.

transmission - the act or process of transporting electric energy in bulk.

transmission line - a facility for transmitting electrical energy at high voltage from one point to another point. Transmission line voltages are normally 115 kV or larger.

transmountain - the crossing or extending over or through a mountain.

tributary - any stream which contributes water to another stream.

tributary groundwater - includes seepage, underflow and percolating water that will eventually become part of a natural stream.

trough - an elongate and wide depression; geosyncline.

tundra - a level or undulating treeless plain characteristic of artic regions.

turbine - the part of a generating unit which is spun by the force of water or stream to drive an electric generator. The turbine usually consists of a series of curved vanes or blades on a central spindle.

V

visit - a significant amount of time spent by one individual at a particular recreation facility during a 24-hour period.

visitor-day - consists of 12 visitor hours which may be aggregated continuously, intermittently, or simultaneously by one or more persons at a recreation facility.

<u>**W**</u>

water right - a grant, permit, decree, appropriation, or claim to the use of water for beneficial purposes, limited by the economical use and subject to other rights of older date of use, called priority, or prior appropriation.

watershed - the whole region or area contributing to the water supply of a river or lake.

water table - the upper limit of the part of the soil or underlying rock material that is wholly saturated with water.

water year - the 12-month period that begins October 1 and ends on September 30 of the following year.

water yield - the amount of water a project would yield for beneficial uses on an average annual basis that is being lost without the existence of the project.

watt - the rate of energy transfer equivalent to one ampere under a pressure of one volt at unity power factor.

weathering - the group of processes, such as the chemical action of air and rain water and of plants and bacteria and the mechanical action of changes of temperature, whereby rocks on exposure to the weather change in character, decay and finally crumble into soil.

weir - an overflow structure built across a channel to measure the rate of flow of water or pass water over its surface.

Western Slope - that portion of Colorado lying west of the Continental Divide.

wheeling - transportation of electricity by a utility over its lines for another utility; also includes the receipt from and delivery to another system of like amount but not necessarily the same energy.

wild rivers - those rivers or sections of rivers free of impoundments with watersheds or shorelines essentially primitive (and waters unpolluted).

wilderness - under the 1964 Wilderness Act, wilderness is undeveloped Federal land retaining its primeval character and influence without permanent improvements or human habitation. It is protected and managed so as to preserve its natural conditions which: 1) generally appear to have been affected primarily by the forces of nature with the imprint of man's activity substantially unnoticeable, 2) has outstanding opportunities for solitude or a primitive and confined type of recreation, 3) has at least 5,000 acres or is of sufficient size to make practical its preservation, enjoyment and use in an unimpaired condition, and 4) may contain features of scientific, educational, scenic or historical value as well as ecologic and geologic interest.

Z

zoned earth dam (zoned embankment) - a rolled-fill dam consisting essentially of an inner or enclosed impervious section supported by two or more outer sections of relatively pervious material.

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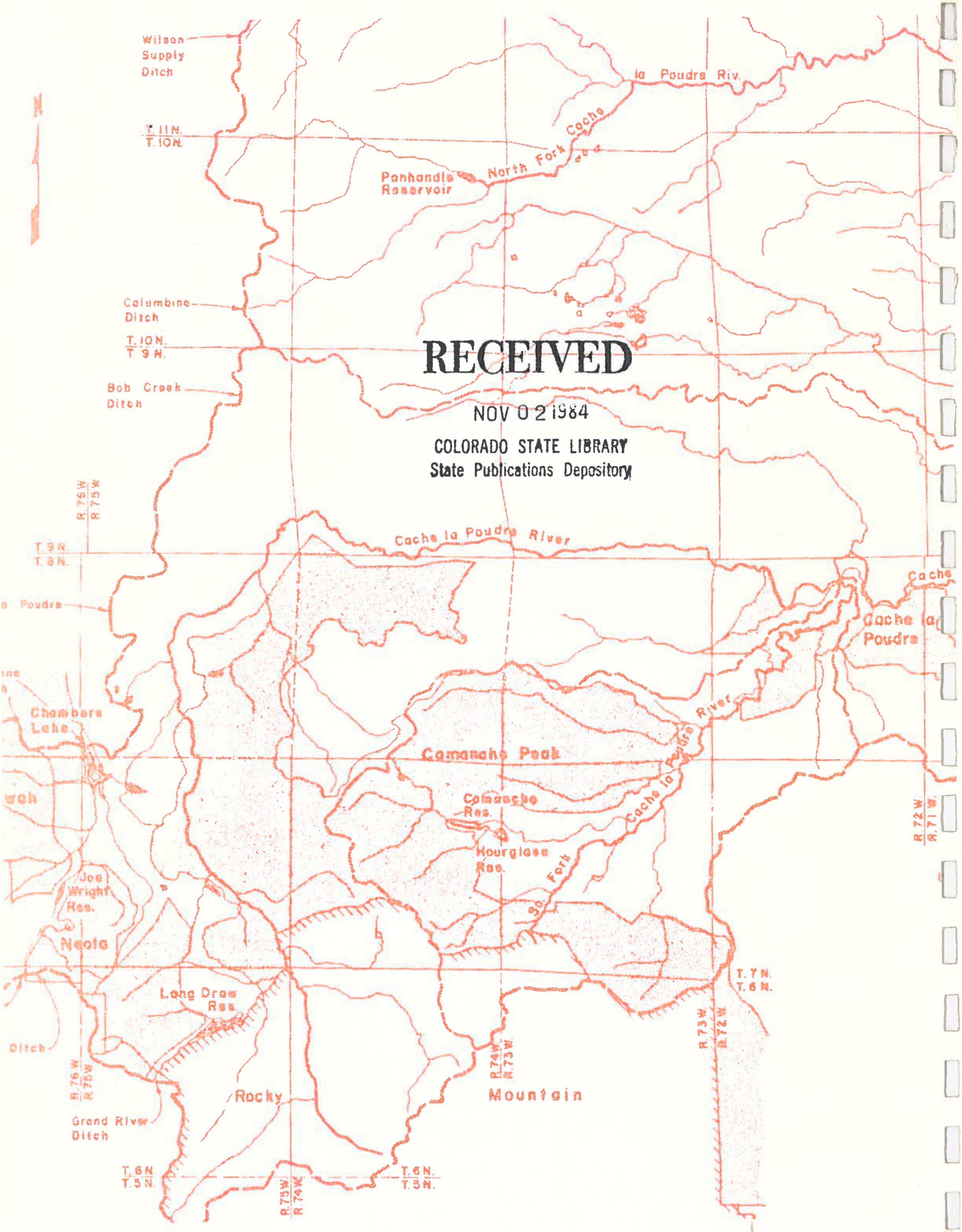
Wilson Supply Ditch
la Poudre Riv.
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North Fork Cache
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T. 10 N.
T. 9 N.
Bob Creek Ditch
R. 76 W.
R. 75 W.
Cache la Poudre River
T. 9 N.
T. 8 N.
Poudre
Cache
Cache la Poudre
Chambers Lake
Comanche Peak
Cache la Poudre River
Comanche Res.
Hourglass Res.
So. Fork
R. 72 W.
R. 71 W.
Joe Wright Res.
Neota
T. 7 N.
T. 6 N.
Long Draw Res.
R. 73 W.
R. 72 W.
Ditch
R. 76 W.
R. 75 W.
R. 74 W.
R. 73 W.
Rocky
Mountain
Grand River Ditch
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