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METHODOLOGY FOR ANALYSIS OF IRRIGATION DEVELOPMENT THAT MIGHT HAVE OCCURRED WITHOUT FEDERAL EXPENDITURE

A CASE STUDY OF
BOISE PROJECT

A THESIS
PRESENTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT
FOR THE DEGREE OF
MASTER OF SCIENCE IN CIVIL ENGINEERING
IN THE
UNIVERSITY OF IDAHO GRADUATE SCHOOL
BY

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AUTHORIZATION TO PROCEED WITH THE FINAL DRAFT:

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ABSTRACT

One of the factors responsible for agricultural high production in the United States is the comprehensive irrigation system that has been developed for which much of the funds have come from federal expenditure. This treatise attempts to analyze, the possible outcomes in the absence of any federal support in this field, by means of a case study of a federally funded (Boise) project and its possible non-federal alternatives.

In this study a useful methodology of simultaneously combining hydrologic and water supply operations analyses with economic analysis of a water development project has been developed in accordance with "The Principles and Standards" specified by U.S. Water Resources Council concerning evaluation of "conditions expected without" the federal expenditure.

On the basis of comparison of engineering, economic and financial efficiencies of the historic irrigation development due to the federal Boise Project and four possible non-federal alternatives (with seven different variations of each), it has been demonstrated that the federal project was as good as any other non-federal alternative could possibly have been under the circumstances existing prior and during the period of study. Yet, there was a possibility of improving the economic efficiency up to 70% by delaying the installation of the Project or by using better expansion criteria.

Thus the study brings out the importance of better planning criteria such as initial size, time of installation and expansion policy for achieving higher economic and financial efficiencies. Of course this still depends upon the economic conditions and the hydrologic occurrences and how they phase together.

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suitable psychological atmosphere to pursue and complete his MS course and this thesis.

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CHAPTER 1

INTRODUCTION

The bicentennial of the United States government marks a milepost in rapid cultural and resource development. This country is the world leader in almost all walks of life. In food production and agriculture development it is unique. Its political rivals and allies depend upon its agricultural products. One of the factors for this advancement is the comprehensive irrigation system which ensures timely and adequate supplies of water, even to the desert lands sometimes hundreds of miles away from the water source. Federal expenditures have provided much of the development of the present system of irrigation.

Questions are now being raised whether or not the present level of irrigation development could have been achieved to the same or higher level without any help or intervention from the federal government, and whether federal support for irrigation development should be continued. The answers to such questions are not only important to the United States of America for its future policy decisions, but even for many developing nations of the world who are very keen to make progress in irrigation development.

So far, a satisfactory methodology has not been developed which could be applied to answer these questions. The purpose of this thesis is an attempt to develop a methodology to analyze whether, in the United

States, the practice of irrigation development by federal agencies and funds has been a prudent one or not, and what might have been the development in this field had there been no federal agency or expenditure to support it.

CHAPTER 2

PLAN OF STUDY

One way of estimating the impact of federal investments in irrigation could be to make a case study of a representative federal project and to compare the irrigation developments 'with' and 'without' this project. This method was used to deal with the subject in hand. Accordingly the following Plan of Study was developed.

I. <u>Project selection criteria</u>

The criteria used to select a suitable project included the following:

a. It is mainly funded and organized by federal agencies.

b. It is one of the five largest projects in dealing with the quantity of water and area to be irrigated, so that it could be considered a representative model for generalization of the methodology and results achieved on a wider basis.

c. It has at least 50 years history of development.

d. It has a good record on the availability and utilization of water data during various months and years, so that it could be evaluated as to success in utilizing the available water for the optimum development of food and other agricultural needs of the area.

e. It is in an area whose economy is primarily dependent upon agriculture, and whose climate and particularly precipitation conditions are such that evolution of a sound irrigation system is essential for advancement of agriculture.

f. It has experienced the advantages or disadvantages of development of agriculture through other types of organizations and financial arrangements before the need was felt for resorting to federal assistance for further progress of the project.

II. A study of relevant literature was made to:

a. Comprehend important stages of progress and setbacks through which this project passed during its pre-federal period.

b. Understand approximately what was the extent and size of the area being served by the project at the time of take-over by the federal organization.

c. Understand and study the social, economic, and other reasons which resulted in various federal actions in the agriculture field.

d. Determine the size and extent of structures which are responsible for the supply and regulation of water to the area covered by the project.

III. Development of Alternative Non-Federal Models.

In view of the information gained from the literature survey, the following considerations were used to develop alternative non-federal models:

a. The size of the non-federal project should be such that it could be a possible alternative to the historic federal project as installed in 1906.

b. It should be in conformity with the actual irrigation developments that had taken place before installation of the federal project.

c. It should be within the financial capacity of non-federal organizations.

d. The size of the project should be in conformity with the stream inflows, maximum feasible reservoir capacity and irrigable area.

IV. Test of Feasibility of Non-Federal Alternatives.

The following procedure was adapted to test the practicability of the non-federal models:

a. Engineering feasibility.

   1. Develop a cropping pattern which is reasonably close to the actual pattern adopted during the study.

   2. Make tabular operation studies with different alternatives and determine the areas which could be irrigated in accordance with the available stream flows,

reservoir size, target area and adopted crop pattern.

3. Evaluate the water shortages on the basis of present day considerations of hydrologic sufficiency such as the criteria adopted by Columbia-North Pacific Region Comprehensive Framework Study (PNWRBC, 1971) that the accumulated shortage during any 10-year period of study should not exceed one year's total demand or other such reasonable considerations for hydrologic acceptance of a project.
4. Reiterate the above steps by making a start with an initial minimum storage, and then increasing it on the experience of 5 or 10 years to make it adequate for the maximum utilization of available water and for serving the maximum area.

b. Economic feasibility.

Having examined the hydrologic limits with different arrangements of storage and area to start with:

1. Develop a reasonable model for the cost of construction of the storage reservoirs, appurtenant distribution system, the cost of initial reclamation of the area proposed to be served and the manner and extent of recovering this cost.
2. Develop a reasonable model for the market value of

crops during various years and on-farm costs such as seed, fertilizers, machinery and labor.

3. Make a periodic assessment of the net profits made according to above adopted formula and expand the capacity of the storage or the area to be covered if the hydrologic considerations and the net profits made during this period warrant such expansion or reduction. Thus the purpose would be to arrive at reasonable alternatives as to what size of storage and area to be irrigated could have passed both the tests of engineering and economic feasibilities.

c. Social feasibility.

Having developed the economical and technically feasible alternative(s), assess whether there would have been enough social support for these alternatives and whether there would have been agencies other than federal government, willing and able to provide the funds required at different stages of development of the same.

IV. After arriving at the size and shape of various alternative non-federal models, compare their contributions to the development of irrigation in the area concerned as against the actual irrigation development achieved by federally funded project.

V. Benefits of the Study.

The above methodology may help in:

a. Estimating the probable irrigation development and its economic impacts had there been no federally-funded planning, construction or subsidization.

b. Developing a technique for combining the hydrological and economic consideration for development of irrigation projects.

c. Understanding the various planning criteria being utilized at present and development of alternative criteria which could be more useful for future planning.

CHAPTER 3

SELECTION OF THE PROJECT FOR CASE STUDY

The largest federal agency, which deals with the construction or operation of irrigation projects, is the Bureau of Reclamation. According to U.S. Bureau of Census (1969), this agency provided irrigation service to 5,865,035 acres in U.S.A. The other federal agency, the U.S. Bureau of Indian Affairs covered only an area of 577,860 acres.

The list of Federal Reclamation projects which have a fairly long history of development (at least 50 years) is as follows:

S.N.	Project	State	Year Authorized	Proposed* Irrigated Area (acres)	Reservoir* Active Capacity (acre ft)
1.	Milk River	Montana	1903	134,000	260,000
2.	New Lands	Nevada	1903	71,566	1,005,600
3.	North Plate	Wyoming	1903	226,000	1,011,000
4.	Salt River	Arizona	1903	240,000	1,382,000
5.	Uncompahgree	Colorado	1903	76,000	106,200
6.	Belle Fourche	S. Dakota	1904	57,000	185,200
7.	Lower Yellowstone	Montana	1904	56,000	-------
8.	Minidoka	Idaho	1904	1,148,739	2,784,600
9.	Shoshone	Wyoming	1904	94,000	381,890
10.	Yuma	Arizona	1904	66,556	-------

*Source: U.S. Department of Interior, Bureau of Reclamation, 1961.

S.N.	Project	State	Year Authorized	Proposed* Irrigated Area (acres)	Reservoir* Active Capacity (acre ft)
11.	Huntley	Montana	1905	32,487	400
12.	Klamath	California	1905	234,000	1,132,400
13.	Okanogan	Washington	1905	5,307	23,500
14.	Rio Grande	New Mexico	1905	178,000	2,547,900
15.	Strawberry	Utah	1905	43,000	270,000
16.	Umatilla	Oregon	1905	31,000	123,800
17.	Yakima	Washington	1905	460,000	1,070,700
18.	Boise	Idaho	1905	357,598	1,693,900
19.	Sun River	Montana	1906	91,584	167,800
20.	Orland	California	1907	19,811	100,600
21.	Grand Valley	Colorado	1912	42,416	-------
22.	Yuma Auxiliary	Arizona	1917	3,406	-------
23.	Riverton	Wyoming	1918	52,945	183,600
24.	Owyhee	Oregon	1926	118,816	715,000
25.	Vale	Oregon	1926	32,000	251,000

*Source: U.S. Department of Interior, Bureau of Reclamation, 1961.

On the basis of proposed irrigated area and reservoir capacity, Minidoka, Rio Grande, Boise, Salt River and Yakima are reasonably large projects which qualify almost equally for final selection for our case study.

The Boise Project is a typically large project. It satisfies the selection criteria proposed in the plan of study. A reasonable record of Boise River water and land use starting from 1895 to date is available in the Water Distribution Report of Boise River District 63 (1975) compiled by Boise River Water Master.

This project has the following interesting characteristics as a representative model:

1. The Boise River which is the source of supply of water of the project has an average annual discharge of over 2 million acre feet. If all this water could be utilized for irrigation purposes, then at an average annual diversion rate of 5.5 acre feet per acre, the river has a potential for irrigating 360,000 acres of land annually, which is roughly 13% of the total irrigated area of the whole state of Idaho, about which it has been said:

   > *"Idaho's most valuable and most precious mineral is not gold nor silver nor any mined or minted ore, Idaho's most valuable mineral is water . . .*
   >
   > *Water is an important commodity in Idaho with much of the population in areas of relatively low rainfall and much of the agriculture depending upon irrigation."*[4]

   This fact is further confirmed when we look at the "Statistics of Irrigated Land in Farms by States 1959 and

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[4] Idaho Department of Commerce, The Idaho Almanac, pp. 80.

1964", Goldfield (1967), and find Idaho as the third largest irrigated state in the U.S.A.

2. Prior to federal irrigation, the area involved in the Boise Project passed through the experiences of irrigation development by different kinds of enterprises, as is evident from the following brief history. Irrigation in Boise Valley is supposed to have started earlier than 1843, because in that year an explorer of the area, Mr. John C. Fremont "suggested that more irrigation at the point (implying that irrigation was already being provided by some means) would produce increased crops for the residents of the fort" (Boise), Caldwell and Wells (1974). The beginning of mining in the Boise Basin in 1862 provided the initiative for diversified farming. "By the end of 1863 there were three cooperative canal companies with 21 miles of canal among them. The largest early pre-federal project in the Boise Valley was the Ridenbaugh Canal System in 1865 and claimed 17,076 acres", Caldwell and Wells (1974). This project was sold or contracted four times before it was completed. Other major land marks in the history of development of irrigation in Boise Valley during the pre-federal period are the New York, Phyllis, the Farmer's Union, and Settler's Ditch, and Sebree Canals.

"Prior to 1902 and the pre-federal period, 96,652 acres were being irrigated and farmed in the Boise Valley, a tribute to the ingenuity and initiative of private enterprise", Murphy (1948).

Thus the Boise Project reasonably satisfies all the five conditions previously laid down for qualifying as a suitable irrigation project to serve as a representative model for the purpose of this study.

But it does not mean that, this project is the ideal one for our study. It even has drawbacks, such as:

a. The project's location near the capitol of the state makes it difficult to assess how far this situation has helped or hindered in the growth of agriculture.

b. Before taking over of the project by Federal reclamation, some irrigation systems had already been developed in the area, having rights of diversion at different points in the river. At this stage it is difficult to assess, whether this situation made the task of further development by Federal agency easier or much more complicated and difficult.

c. The project utilizes water of two rivers, namely Boise and Payette with interconnecting systems of dams and canals. This arrangement was originally

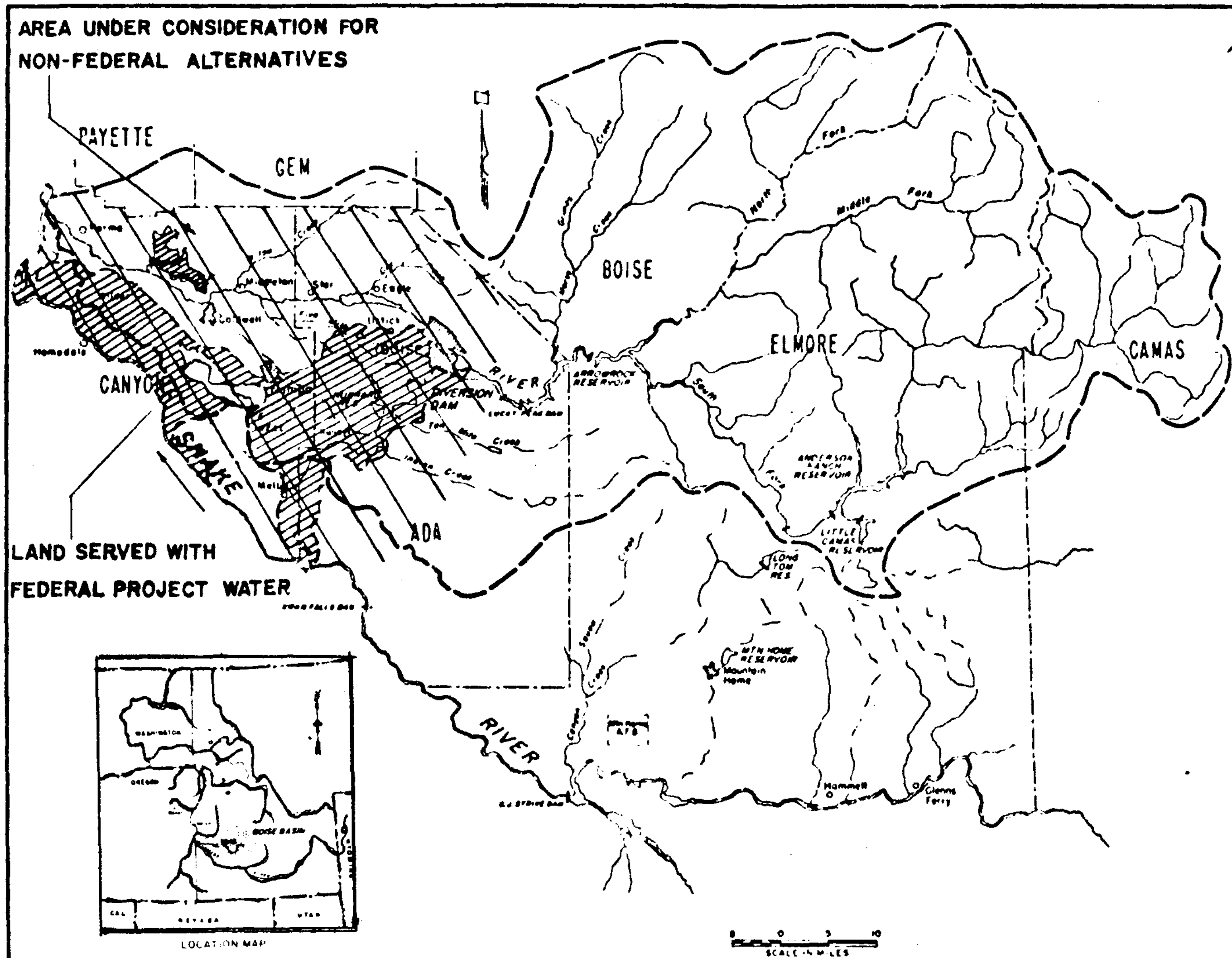

Figure 3.1. Basin map of the Boise River Basin

made more from the point of view of satisfying maximum number of settlers, rather than economic reasons. This makes the estimation of the possible development by a non-federal agency more complex.

d. As shown in the attached map (Figure 3.1) the irrigation operations of the Federal project not only cut across several counties, but even two different states, having diversified needs and plans for economic growth. Hence, the task of assessing the impact of the project and its area of influence becomes all the more complicated and uncertain.

e. During the process of evolution, the project objectives were not confined to irrigation only. At different stages multipurpose features of hydroelectric power, flood control and recreation were incorporated into the system. Estimation of how far these features have enhanced or set back the cause of irrigation in the area adds another negative factor into the selection of the project for the purpose of this study.

But in spite of all the drawbacks and difficulties mentioned above, one has to realize that it is almost impossible to have a suitable existing irrigation project without any complications. Hence, the Boise Project was chosen for this study because (1) it appeared to be a realistic and practicable choice, (2) the project area could be very conveniently visited due to its proximity, (3) already a Boise Post Audit study was going on in the Institute.

In this study it was decided to concentrate the evaluation and development of methodology on the portion of the Boise Project within the Boise River Drainage and a small portion of land south of the Boise River Drainage that receives Boise River water (see Figure 3.1).

CHAPTER 4

PREFEDERAL HISTORY OF THE PROJECT UNDER STUDY (BOISE PROJECT)[1]

The main component of our project of study is the Boise River and the area of its influence herein called Boise Valley. Although there is evidence of some irrigation arrangement, even as early as 1843, the real inspiration for growing of food, and thus the need for irrigation, was provided by the rush of gold seekers to the Boise Valley and southwestern region of Idaho in 1861-62. By the summer of 1863, the population of this region had reached 19,000. High prices of imported foods and other daily provision for such a large mining population in the troubled and lawless days of that period provided opportunity for some intelligent men to make profits by growing hay and food grains locally. The proximity of a reliable flowing Boise River, existence of fertile bottom lands and nearness of the mountainous basin gold fields provided ideal conditions for this venture. The credit for being the first to take up land and begin farming in the Boise Valley goes to Tom Davis, who took water out of the river about a mile and a half above the present town of Boise. This venture brought him such a great success that in the very first year his fruit crops were shipped as far as Montana.

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[1]Most of the information for this chapter has been compiled from "Irrigation in the Boise Valley 1863-1903", Murphy (1948) and Economic and History Support Study - Boise Project", Caldwell and Wells (1976).

this impressive success attracted other settlers to the business of agriculture, both through individual and cooperative measures, thus by the end of 1863 there were three cooperative canal companies which had constructed twenty one miles of canal, and by 1865, all of the early watered riverside farmland was in agricultural production.

The program of irrigation up to this point in time was similar to the development in other western areas where the first important irrigation canals were built by the joint labor of farmers to supply their own needs. This was only feasible where streams could be diverted by simple dams and ditches. The point was soon reached, however, when large amounts of capital were required for constructing costly works to reclaim very large areas. The necessary capital was supplied by eastern speculators who saw a possibility for large profit and so responded with enthusiasm to the opportunity.

One example of this enthusiasm of speculators led to the construction of Ridenbaugh Canal in 1865. In 1877 its founder, William Morris, indicated that there had been 17,076 acres claimed under the Desert Land Act. By 1891, this canal had passed through three owners, but it had, within the system, 100 miles of main ditches and 153 miles of laterals stretching all the way to Deer Flat south of Caldwell. It irrigated 2,000 acres of land also supplied Boise with power for lights.

Another private venture of this kind was the Middleton Mill Ditch which was begun in 1864 to carry 240 cfs of water. By the year 1900, this ditch was 20 miles long. It supplied water to 3,000 acres and ran a flour mill in the Middleton area.

The biggest example of speculative venture in irrigation in Boise Valley was the New York Canal, which was started in 1882 by New York capital. It went under the name of Idaho Mining and Irrigation Company, the plans of which included both mining possibilities as well as irrigation projects. The investors had speculated on the idea that initially the profits made from gold production would meet a part of the cost of an irrigation canal, which would bring them permanent income from farm production during irrigation season and supplemental income from the Snake River placers during the summer.

So, from the very beginning, the New York Canal was planned on an extensive scale with the proposed capacity of 4500 cfs and an eventual irrigation potential of 500,000 acres. For this purpose, the investors even hired the services of a competent engineer named A.D. Foote. After careful investigation and planning, he estimated that for such an ambitious project, about one and a half million dollars will be required for the initial stage of construction. So he designed and located his canal, which was of a modest size in the beginning, such that it could be enlarged later. The excellent prospects of water delivery attracted large numbers of homesteaders who went out into the desert to take up land. But the farmers were kept in the dark about the financial resources or the backing of this venture. To make matters worse, a national financial panic in February, 1884, led to the failure of a Baltimore firm, which was the main subscriber in the New York Canal venture. This meant virtual stoppage of any further construction work of the canal and almost complete economic ruin for the homesteaders.

In 1886 an effort to avert this disaster was made by some Nampa promoters under the name of Phyllis Canal Company by extending the Settler's Ditch into some of the projected New York Canal system. But this effort also collapsed in the fall of 1886. Similar attempts by other different interests brought further misery to the unfortunate homesteaders. The climax of the situation was reached when it came to light that by June 1887 only $500 worth of work had been done and the two men equipped with wheelbarrows seemed to be making little or no headway in the canyon on the mammoth New York Canal. Thus the whole venture proved to be a fraud of the first degree.

In the later years, many attempts were made by different agencies, including farmer's cooperatives, to make this venture a success. In spite of these efforts, the structures completed up to year 1900 consisted only of a rubble diversion dam of hay, straw and loose rock, which had to be torn out each season and a canal with a maximum capacity of 300 second feet. This was far below Foote's ambitious plan for a project for 300,000 to 500,000 acres. At this juncture, Federal help was provided by the Federal Reclamation Act of 1902 for developing irrigation.

During the prefederal period, in addition to the problems faced by the irrigators in the form of complete frauds or vastly exaggerated promises by the private enterprises, another difficulty experienced by them was the practice of these private companies to close the canals completely for repairs suddenly in times of peak demand instead of having a well-planned maintenance program.

The farmers therefore had to pay for the full water charges as originally fixed on some arbitrary acre or annual basis without having any security of adequate water supply due to faulty maintenance arrangements. One such example was provided by the Middleton organization, which was eventually converted into a cooperative to alleviate such problems of the farmers. Under such like circumstances, it is no wonder that in spite of more than 60 years of efforts for irrigation development in the pre-federal period (i.e. before 1902) only "96,652 acres of land were being served with irrigation facilities", Murphy, (1948).

CHAPTER 5

DEVELOPMENT OF THE PROJECT IN FEDERAL ERA

The first step towards ameliorating the conditions of the farming community and evolving a sound agricultural basis for the nation was taken in the year 1900, when Theodore Roosevelt entered the White House and in his first annual message to Congress he said:

> *"The pioneer settlers on the arid public domain chose their homes along streams from which they could themselves divert the water to reclaim their holdings. Such opportunities are practically gone. There remain, however, vast areas of public land which can be made available for homestead settlement, by only reservoirs, and main line canals impracticable for private enterprise. These irrigation works should be built by the national government."* Murphy (1948)

Congress responded with important legislation and under the leadership of Francis G. Newlands of Nevada, the Newlands or Reclamation Act was passed. Roosevelt's signature, June 27, 1902, put the federal government into the business of building dams, tunnels, flumes and ditches necessary for irrigation projects in the arid west. The funds for this purpose came from certain revenues of the General Land Office and were later increased from other sources. The reclaimed lands were made subject to entry, on the condition that the entrymen should assume and pay the cost of construction, to be thereafter ascertained and published by the Secretary of Interior, as well as the annual cost of maintenance and operation.

For handling such a gigantic task with all its ramifications of construction and maintenance of reclamation projects at a national scale and keeping account of expenditure and return, a special agency later known as the Bureau of Reclamation, was set up with an initial investment of $40,000,000. Wide publicity was given to this new field of reclamation work. Each state was active in securing projects and a general invitation was extended to take up farms thereon. The applicants were many, and so naturally the Reclamation Service, with its limited funds, had to make a selection out of these from its own point of view. It wanted to pick up those projects in the beginning which were free from previous complications of any legal, political or technical nature and could ensure early profitable returns and thus enhance the prestige and usefulness of the service as a whole.

Although the Boise Project was a very strong contender for the federal reclamation program funds in Idaho, the Minidoka project was given the first preference due to considerations more useful from the point of view of the Bureau and was allotted $2,600,000 for its start. This meant a delay in the start of the Boise Project for at least 5 or 6 years, which was very disappointing and agonizing for the suffering farmers of the Boise Valley. So, with the cooperation of the state authorities and the political figures, so much pressure was brought on the Federal authorities that not only was the project authorized on March 27, 1905, but also half of the funds earmarked for Minidoka were diverted to this project for a start.

After the initial start, the following important events need to be mentioned:

1. Reclamation Service entered into contract with the water users of New York Canal in 1906.

2. Arrangements were made for provision of active storage of 169,000 acre feet of water in Lake Lowell (formerly known as Deer Flat Reservoir) in 1908.
3. The Boise Diversion Dam, on the Boise River, was also completed by the Bureau in October of 1908, and by 1910 the project was providing irrigation to 37,000 acres of new lands in addition to the 18,000 acres held by the stockholders of the New York Canal.
4. Arrowrock Reservoir was completed in 1915, and it provided additional storage capacity of 276,000 acre feet. This capacity was increased to 286,600 acre feet in 1937.
5. Completion of Anderson Ranch Dam in 1950 added another 423,200 acre feet of storage capacity to the project.
6. The last addition of 279,000 acre feet of storage capacity of Boise River water was made by the completion of Lucky Peak Dam, constructed by the Corps of Engineers mainly for the purpose of flood control. Thus the total active storage capacity of the project was raised to 1,157,800 acre feet as of 1955.

A good amount of information on the detailed history of these developments, along with necessary information on climate, soil conditions and location maps, is given in:

1. "Reclamation Project Data", U.S. Bureau of Reclamation, (1961).

2. "Economic and Ecological History Support Study - on Boise Project", Caldwell and Wells, (1974).
3. "Hydrology Support Study on Boise Project", Warnick and Brockway, (1974).

But the most relevant piece of literature for the purpose of this thesis is the paper entitled "Direct Economic Impact of Irrigation, Boise Project, Idaho", Nelson, Long, and Peterson (1976).

CHAPTER 6

SELECTION OF CROPPING PATTERNS FOR ALTERNATIVE MODELS AND ESTIMATION OF WATER REQUIREMENT

For the purpose of comparing the positive and negative points of the Boise Project with any non-federal alternative, an important requirement is the selection of a suitable cropping pattern(s).

The criteria adopted for this purpose was that alternative cropping patterns should be reasonably comparable to actual historical cropping patterns.

Three-Crop Historical and Alternative Pattern 1906-1950.

According to Table 7 and Figure 3 of the "Direct Economic Impacts of Irrigation, Boise Project, Idaho", Nelson, Long, and Peterson (1976), the cropping pattern as shown in Table 6-1 has been followed by the Boise Project during the 1906 to 1950 period.

The "other" crop percentage included potatoes and sugar beets, which need more advanced technical skill, machinery and adequate storage and market facilities, which might not have been available to an average farmer in a non-federal project area, at least during the first two decades of the twentieth century. It is reasonable to assume that most of the crops in the "other" crops category (about 90%) would have been replaced by forage crops and a minor percentage (about 10%) would have gone to cereal crops. With these assumptions, a non-federal cropping pattern was reduced to 1) forage crops 68% (57 + 13 x 0.9) and 2) cereal or grain crops to 32% (30 + 13 x 0.1).

Table 6.1

Historical cropping pattern of Boise Project, Idaho (1900 to 1950)

Year	Hay & Pasture	Cereal or Grain Crops	Other Crops
	% of Total	% of Total	% of Total
1900	65	30	5
1910	52	41	7
1920	54	31	15
1930	62	25	13
1940	56	26	18
1950	51	22	27
Totals	340	175	85
Average	57	30	13

The economy of the region depends upon agriculture, and to a significant extent on livestock. There is a short growing season, requiring that a good portion of the forage crops be stored during winter months. Therefore, it may be assumed that a greater percentage of forage crops (about 60%) would have been hay and the remaining 40% in the form of irrigated pastures. These assumptions lead to the following alternative cropping pattern for the period 1906 to 1950.

1. Grain crops - 32%
2. Hay crops - 68 x .60 ≃ 40%
3. Pasture crops - 68 x .40 ≃ 28%

Seven-Crop Historical and Alternative Pattern 1950-1974.

According to Figure 3 of the "Direct Economic Impacts of Irrigation, Boise Project, Idaho", Nelson, Long and Peterson (1976) the cropping pattern followed by the Boise Project during the period 1950-1974 is shown in Table 6.2. The difference in cropping patterns in the two periods (1910-49 and 1950-74) is probably due to the great technological and economic boom caused by World War II.

Table 6.2

Historical cropping pattern of Boise Project, Idaho (1950 to 1973)

Year	% of Forage	% of Cereal Crops	% of Field Crops	% of Veg. Crops	% of Seed Crops	% of Fruit Crops	Total Percentage
1950	51	22	11	7	6	3	100
1960	53	22	10	7	5	3	100
1970	47	20	14	8	7	4	100
1973	50	19	12	8	7	4	100
Totals	201	83	47	30	25	14	400
Avg.	50	21	12	8	6	3	100

On the basis of the above table, the cropping pattern for the alternative non-federal model for the period 1950-74 was developed as follows:

1. The project area has a short growing season. It may be assumed that greater percentage of forage crops would have been hay. Thus 50% average for forage crops may be broken down as 30% hay and 20% pasture.
2. A rounded figure of 20% was adopted for cereal crops, in place of 21% computed in the above table.
3. The remaining percentage of 30% has been subdivided in the following ratios:
   a. potatoes 8%
   b. vegetables 6%
   c. fruit 2%
   d. corn 14%

These percentages compare very favorably with the actual average computed above in Table 6.2. So for the period 1951-1974, the adopted cropping pattern was as follows:

Grain	- 20%	Hay	- 30%
Pasture	- 20%	Corn	- 14%
Potatoes	- 8%	Vegetables	- 6%
Fruit	- 2%		

Water Requirements for the Adopted Alternative Cropping Patterns.

The water requirements for the above cropping pattern were computed on the basis of "Consumptive Irrigation Requirements for Crops in Idaho" by Sutter and Corey (1970). For the project area under consideration, the crop water requirement figures for the nearest observation station (Caldwell) were adopted. The monthly consumptive use water requirements and diversion requirements for the two crop patterns for 1910 to 1949 and 1950 to 1974 have been worked out in Tables 6.3 to 6.6.

Table 6.3

Consumptive Use Irrigation Requirements for 3-Crop Pattern (Non-Federal Alternative)
(for period 1910-1949)

	Grain (32%)				Hay (40%)				Pasture (28%)			
Month	Mean Con. Irr. Req. (In.)	Freq. %	Monthly Demand (In.)	Monthly Demand (Ft.)	Mean Con. Irr. Req. (In.)	Freq. %	Monthly Demand (In.)	Monthly Demand (Ft.)	Mean Con. Irr. Req. (In.)	Freq. %	Monthly Demand (In.)	Monthly Demand (Ft.)
March									-0.29	10		
April	1.27	25	0.315	0.027	0.82	25	0.20	0.017	0.59	60	0.35	0.030
May	3.82	95	3.629	0.302	2.62	95	2.49	0.207	2.36	100	2.36	0.197
June	6.91	100	6.91	0.576	5.47	100	5.47	0.456	4.54	100	4.54	0.378
July	7.44	100	7.44	0.620	7.97	100	7.97	0.664	6.79	100	6.79	0.567
August	2.31	68.3	1.58	0.132	6.34	100	6.34	0.528	4.92	100	4.92	0.410
September					3.16	100	3.16	0.263	1.48	100	1.48	0.123
October					0.58	0.73	0.42	0.035	0.17	73.3	0.12	0.001
Total				1.657				2.170				1.706

Annual Irrigation Requirement per acre = (0.32 x 1.657 + 0.40 x 2.170 + 0.28 x 1.706) = 1.88 feet.

Average Annual Diversion in acre feet taken from the average year of 1951 from Boise River Water Master's Report = 5.53.

Therefore Diversion Requirements for one acre for three-crop pattern = 5.53/1.88 = 2.94 acre feet/acre or Diversion Factor = 2.94.

[1]Consumptive Irrigation Requirement - "The amount of water required for consumptive use that is artificially applied to the soil (units of length)".

[2]Freq. (factor) - "This represents the period of record that growth was considered to have taken place in each month." For example, April conditions at Caldwell were suitable for growth of grain only 25 percent of the years examined. So monthly demand was calculated on the basis of a requirement being used only 25 percent of the time. Thus the water demand for grain would be (1.27 x 0.25 = 0.315 in.).

Table 6.4

Total Monthly Diversion Requirements for 3-Crop Pattern (Non-Federal Alternative)
(for period 1910-49)

Month	Div. Fact.	CIR per Acre	Weighted Diversion Req./Ac	Div. Fact.	CIR per Acre	Weighted Diversion Req./Ac	Div. Fact.	CIR per Acre	Weighted Diversion Req./Ac	Weighted Total Diver. Reqmt.
		Ac.Ft.	Ac.Ft.		Ac.Ft.	Ac.Ft.		Ac.Ft.	Ac.Ft.	Ac.Ft./Ac.
April	2.94	0.027	0.025	2.94	0.017	0.020	2.94	0.030	0.025	0.07
May	2.94	0.302	0.284	2.94	0.207	0.244	2.94	0.197	0.162	0.69
June	2.94	0.576	0.542	2.94	0.456	0.536	2.94	0.378	0.311	1.37
July	2.94	0.620	0.583	2.94	0.664	0.781	2.94	0.567	0.467	1.83
August	2.94	0.132	0.124	2.94	0.528	0.621	2.94	0.410	0.338	1.08
September	----	-----	-----	2.94	0.263	0.309	2.94	0.123	0.101	0.41

Explanation of terms

Div. Fact. - Diversion Factor from Table 6.3.

CIR per Ac - Monthly Crop Irrigation Requirements from Table 8 of "Consumptive Irrigation Requirements of Crops" (U of I, 1970).

Weighted Diversion Req./Ac - Weighted Diversion Requirement = Diversion Factor x CIR per Acre x Percentage of crop in the cropping pattern.

Weighted Total Diver. Requirement - Weighted Total Diversion Requirement = Sum of weighted diversion requirements of hay, pasture, corn, potatoes, vegetables and orchards.

Table 6.5

Consumptive Use Irrigation Requirements for 7-Crop Pattern (Non-Federal Alternative)
(for period 1951 - 1974)

	Grain (20%)			Hay (30%)			Pasture (20%)			Corn (14%)			Potatoes (8%)			Vegetables (6%)			Orchards (2%)		
Month	Mean CIR	Frq.	Mon. Dem.	Mean CIR	Frq.	Mon. Dem.	Mean CIR	Frq.	Mon. Dem.	Mean CIR	Frq.	Mon. Dem.	Mean CIR	Frq.	Mon. Dem.	Mean CIR	Frq.	Mon. Dem.	Mean CIR	Frq.	Mon. Dem.
	In.	%	Ft.	In.	%	Ft.	In.	%	Ft.	In.	%	Ft.	In.	%	Ft.	In.	%	Ft.	In.	%	Ft.
March	----	--	-----	----	--	-----	-0.29	10	-----	----	---	-----	----	---	-----	----	---	-----	----	--	-----
April	1.27	25	0.027	0.82	25	0.017	0.59	60	0.030	----	---	-----	0.04	100	0.003	0.03	100	0.003	0.67	25	0.014
May	3.82	95	0.302	2.62	95	0.207	2.36	100	0.197	0.98	100	0.082	0.84	100	0.070	1.00	100	0.083	2.05	95	0.162
June	6.91	100	0.576	5.47	100	0.456	4.54	100	0.378	3.26	100	0.272	4.61	100	0.384	3.60	100	0.300	4.31	100	0.359
July	7.44	100	0.620	7.97	100	0.664	6.80	100	0.567	7.53	100	0.628	9.67	100	0.806	5.32	100	0.433	6.90	100	0.575
Aug.	2.31	68.3	0.132	6.34	100	0.528	4.92	100	0.410	6.09	100	0.508	8.05	100	0.671	0.72	100	0.060	5.41	100	0.451
Sept.	----	---		3.16	100	0.263	1.48	100	0.123	2.00	98.3	0.167	0.17	98.3	0.014	----	---	-----	2.72	100	0.227
Oct.	----	---		0.58	73.3	0.035	-0.17	73.3	-----	----		-----	----	---	-----			-----	0.44	73.3	0.027
TOTAL			1.657			2.170			1.705			1.657			1.948			0.879			1.815

Annual Irrigation Requirement per Acre = (0.20 x 1.657 + 0.30 x 2.17 + 0.20 x 1.705 + 0.14 x 1.657 + 0.08 x 1.948 + 0.06 x 0.879 + 0.02 x 1.815) = 1.80 feet.

Average Annual Diversion in Ac. Ft. taken from the average runoff year of 1951 from Boise River Water Master Report = 5.53.

Therefore Diversion Requirement for One Acre in 7-Crop System = $\frac{5.53}{1.80}$ = 3.07 Ac. Ft./Ac. or Div. Factor = 3.07.

Table 6.6

Total Monthly Diversion Requirements for 7-Crop Pattern (Non-Federal Alternative)

(for period 1950 - 1974)

Month	Div. Fact.	CIR per Ac.	Wtd. Div. Reqmt.	Div. Fact.	CIR per Ac.	Wtd. Div. Reqmt.	Div. Fact.	CIR per Ac.	Wtd. Div. Reqmt.	Div. Fact.	CIR per Ac.	Wtd. Div. Reqmt.	Div. Fact.	CIR per Ac.	Wtd. Div. Reqmt.	Div. Fact.	CIR per Ac.	Wtd. Div. Reqmt.	Div. Fact.	CIR per Ac.	Wtd. Div. Req't.	Weighted Tot. Div. Reqmt.
		AcFt	AcFt		AcFt	AcFt		AcFt	AcFt		AcFt	AcFt		AcFt	AcFt		AcFt	AcFt		AcFt	AcFt	AcFt/Ac
April	3.07	0.027	0.017	3.07	0.017	0.016	3.07	0.030	0.018	3.07	-----	-----	3.07	0.003	0.001	3.07	0.003	0.001	3.07	0.014	0.001	0.05
May	3.07	0.302	0.185	3.07	0.207	0.191	3.07	0.197	0.121	3.07	0.082	0.035	3.07	0.070	0.017	3.07	0.083	0.015	3.07	0.162	0.009	0.58
June	3.07	0.576	0.354	3.07	0.456	0.420	3.07	0.378	0.232	3.07	0.272	0.117	3.07	0.384	0.094	3.07	0.300	0.055	3.07	0.359	0.022	1.29
July	3.07	0.620	0.381	3.07	0.664	0.612	3.07	0.567	0.348	3.07	0.628	0.270	3.07	0.806	0.198	3.07	0.433	0.080	3.07	0.575	0.035	1.92
Aug.	3.07	0.132	0.081	3.07	0.528	0.486	3.07	0.410	0.252	3.07	0.508	0.218	3.07	0.671	0.164	3.07	0.060	0.011	3.07	0.451	0.028	1.24
Sept.	----	-----	-----	3.07	0.263	0.242	3.07	0.123	0.076	3.07	0.167	0.072	3.07	-----	-----	3.07	-----	-----	3.07	0.227	0.014	0.41
Oct.	----	-----	-----	3.07	0.035	0.032	----	-----	-----	----	-----	-----	----	-----	-----	----	-----	-----	3.07	0.027	0.002	0.03

Explanation of terms

Div. Fact. = Diversion Factor from Table 6.5

CIR per Ac. - Monthly Crop Irrigation Requirements from Table 8 of "Consumptive Irrigation Requirements of Crops" (U of I, 1970).

Wtd. Div. Reqmt. - Weighted Diversion Requirement = Diversion Factor x CIR per Acre x Percentage of crop in the cropping pattern.

Weighted Total Div. Reqmt. - Weighted Total Diversion Requirement = Sum of weighted diversion requirements of hay, pasture, corn, potatoes, vegetables and orchards.

The cropping pattern adopted for alternative non-federal models and their water requirements are summarized as follows:

I. <u>3-Crop Pattern (for the period 1906 to 1950)</u>

1. Grain - 32%
2. Hay - 40%
3. Pasture - 28%

with total monthly diversion requirements as:

April - 0.07 AcFt/Acre

May - 0.69 AcFt/Acre

June - 1.37 AcFt/Acre

July - 1.83 AcFt/Acre

Aug - 1.08 AcFt/Acre

Sept - 0.41 AcFt/Acre

Oct-Mar - Nil

II. <u>7-Crop Pattern (for the period 1951-1974)</u>

1. Grain - 20%
2. Hay - 30%
3. Pasture - 20%
4. Corn - 14%
5. Potatoes - 8%
6. Vegetables - 6%
7. Orchards - 2%

with total monthly diversion requirements as:

April	- 0.05 AcFt/Acre
May	- 0.58 AcFt/Acre
June	- 1.29 AcFt/Acre
July	- 1.92 AcFt/Acre
Aug	- 1.24 AcFt/Acre
Sept	- 0.41 AcFt/Acre
Oct	- 0.03 AcFt/Acre
Nov-Mar	- Nil.

CHAPTER 7

SELECTION OF ALTERNATIVE NONFEDERAL MODELS

Chapter 6 dealt with selection of cropping patterns for alternative models and estimation of water requirements. The next step, according to the plan of study, required selection of alternative irrigation development models with which any non-federal development agency might have made a start or continued operation had there been no authorization of the Boise Project in 1905.

Out of many possible non-federal alternative irrigation development models that could have been considered, four were selected. Each of the alternatives considered and reasons for their selection were as follows:

Alternative I.

1. Area proposed to be irrigated - 96,652 acres,
2. No initial storage facilities,
3. No environmental or other restraints for maintenance of a minimum instream flow for the protection of fishery and water quality control.

Rationale for Selection:

Prior to 1902 and the federal aid period, "96,652 acres were being irrigated and farmed in the Boise Valley", Murphy (1948) and Caldwell (1974).

There was no provision in Alternative I for storage. This would have required large amounts of money and in view of pre-federal project history outlined in Chapter 5, it is questionable whether financing could have been obtained.

The reason for not putting any environmental or minimum release conditions was that the environmental constraints and the laws about minimum release requirements are only recent developments.

Alternative II-A.

1. Proposed irrigated area 174,000 acres,
2. Initial storage 0 acre feet,
3. No minimum release restrictions.

Rationale for Selection:

Under the Stewart decree of 1906, the start of the Boise Project, people had decreed water rights that totalled 3,472 cfs on 174,000 acres (See Table 7.1).

Alternative II-B.

This model is the same as Alternative II-A with the exception of the following modifications:

1. Initial storage 200,000 acre feet,
2. Minimum release requirements 3,000 acre feet per month (50 cfs).

Rationale for Selection:

To decrease dependence on less reliable natural river flows, farmers would have tried to finance some minimum amount of storage.

TABLE 7.1

Area Having Water Rights As Of 1906

Reach No.	Reach of River	Canal Name	Area as per Boise Project (acres)	Authorized Discharge as per Decrees (cfs)
1	Lucky Peak Dam to Boise	Ridenbaugh	26,877	553
		Bubb	1,057	21
		Meeves #18, #2	99	2
		Rossi Mill	500	10
		Boise City	1,828	40
		New York	13,231	219
2	Boise to Star	Settlers	12,282	186
		Davis Ditch	634	14
		Thurman Mill	1,799	36
		Farmers Union & Boise Valley	11,624	248
		New Dry Creek & Union	3,747	76
		Ballentyne	763	18
		9 Eagle Islands Canal	2,628	54
		Middleton	9,580	194
		Phyllis & Eureka #1	26,162	672
		Little Pioneer	1,286	27
		Canyon County	4,007	83
		Caldwell High Line	13,960	81
3	Star to Notus	Riverside & Pioneer Dixie	13,645	306
		Sebree	15,500	319
		Campbell	802	28
		Siebenberg	646	15
		Memanus & Teater	168	0
		Eureka #2	2,625	61
		Upper Center Point	641	19
		Bowman & Swisher	424	11
		Lower Center Point	880	38
4	Notus to Parma	Baxter	200	4
		Boone	517	13
		Andrews	1,068	24
		Mammon	468	27
		Maas	867	17
		Parma	602	13
		Island Highline	945	23
		McConnel Island	1,600	25
		Miscellaneous	763	13
GRAND TOTAL			174,424	3,472

Approximate total area prior to 1906 = 174,000 acres

Source: Water Master Boise River - 1973.

This assumption is based on the fact that accounts of the development history of the project in pre-federal period indicate interest in a Carey Act development and a storage amount equal to the storage of Lake Lowell capacity (169,000 acre feet) prior to installation of Federal Project. A rounded figure of 200,000 acre feet has been chosen here as a possible storage capacity for use in this alternative. In addition, a more liberal or accomodating attitude toward maintaining minimum flow in the river has been introduced.

Alternative III.

1. Proposed irrigated area 330,000 acres,
2. Initial storage 1,157,000 acre feet,
3. Minimum release requirement 3,000 acre feet per month.

Rationale for Selection:

The assumptions represent approximately the size of development which the project has achieved to date. The purpose of selection of this model is to study the impacts if the present size of the project would have been launched in the very beginning instead of development by stages.

CHAPTER 8

COMPARISON OF ACTUAL PROJECT AND ALTERNATIVE MODELS WITH REGARD TO IRRIGATED ACREAGES

Irrigated Acreages

In order to assess the performance of the historic federal Boise Project, it is necessary to look at the progress in irrigated acreage itself which occurred in the area 'with' the project and then compare it with the possible irrigated acreage which would have occurred 'without' it by alternative projects.

The areas actually irrigated during the period of study were compared with the areas which could have been irrigated by non-federal alternatives.

The irrigated area figures with the project were taken from Table 1 of "Direct Economic Impact of Irrigation, Boise Project, Idaho" by Nelson, Long, and Petterson (1976).

The procedure for estimating the alternative irrigation areas for the non-federal models was based on the "Tabular Operation Study" made in Example 12.1 of "Economics of Water Resources Planning" by James and Lee (1971) with necessary modifications. A sample output for Alternative II-B for year 1951 to 1953 is given in Table 8.1.

The essentials of this procedure along with sample output are as follow:

1. Calculate the water requirement for each month starting from October, 1951 for a given acreage. For example: Acreage - 174,000, Consumptive Irrigation Requirement/ Acre - 0.03 acre feet, Water Requirement for the Month = 5,220 acre feet.
2. To start with the reservoir was assumed empty as there was 0 storage from the previous month of September.
3. Assume that the capacity of the reservoir was 200,000 acre feet.
4. From the past records of Boise River it is known that the inflow of the river was 61,600 acre feet during that month.
5. So water available for utilization during October, 1951 was 0 + 61,600 = 61,600 acre feet.
6. Assuming a minimum release requirement of 3,000 acre feet, water available for irrigation = 61,600 - 3,000 = 58,600 acre feet.
7. Irrigation demand for this month was 5,220 acre feet, so after meeting this demand 53,380 acre feet were left for storage.
8. Since irrigation demand was met in full, the figures under column "Def. Stor" (Deficiency in stored water) and "Def. Acr" (area which could not be irrigated) were 0 acre feet.
9. Hence actual irrigated area - 174,000 - 0 = 174,000 acres. An examination of the figures for actually irrigated areas reveals that up to July, 1951, the diversion demands were

TABLE 8.1

TABULAR OPERATION STUDY FOR ALT-II- A (TARGET AREA 174,000 ACRES RES. CAP. 200,000 ACFT MINRELL 3000 ACFT/MONTH)

MONTH	INFLOW (ACFT)	MIN REL	DEMAND (ACFT)	STORAGE (ACFT)	SPILL (ACFT)	DEFSTOR (ACFT)	DEFACR (ACFT)	ACTIRR (ACRE)
10-1951	61600.	3000.	5220.	53380.	0.	0.	0.	174000.
11-1951	84400.	3000.	0.	134780.	0.	0.	0.	174000.
12-1951	85000.	3000.	0.	200000.	20780.	0.	0.	174000.
1-1951	69900.	3000.	0.	200000.	66900.	0.	0.	174000.
2-1951	125900.	3000.	0.	200000.	122900.	0.	0.	174000.
3-1951	125100.	3000.	0.	200000.	122100.	0.	0.	174000.
4-1951	557000.	3000.	8700.	200000.	545300.	0.	0.	174000.
5-1951	684900.	3000.	100920.	200000.	580980.	0.	0.	174000.
6-1951	440600.	3000.	224460.	200000.	213140.	0.	0.	174000.
7-1951	195100.	3000.	334080.	58020.	0.	0.	0.	174000.
8-1951	71000.	3000.	217500.	0.	0.	-91480.	-73184.	100816.
9-1951	42600.	3000.	71340.	0.	0.	-31740.	-77415.	96585.
10-1952	79300.	3000.	5220.	71080.	0.	0.	0.	174000.
11-1952	63400.	3000.	0.	131480.	0.	0.	0.	174000.
12-1952	86800.	3000.	0.	200000.	15280.	0.	0.	174000.
1-1952	68600.	3000.	0.	200000.	65600.	0.	0.	174000.
2-1952	77100.	3000.	0.	200000.	74100.	0.	0.	174000.
3-1952	103000.	3000.	0.	200000.	100000.	0.	0.	174000.
4-1952	677900.	3000.	8700.	200000.	666200.	0.	0.	174000.
5-1952	901600.	3000.	100920.	200000.	797680.	0.	0.	174000.
6-1952	518300.	3000.	224460.	200000.	290840.	0.	0.	174000.
7-1952	171500.	3000.	334080.	34420.	0.	0.	0.	174000.
8-1952	68800.	3000.	217500.	0.	0.	-117280.	-93824.	80176.
9-1952	45900.	3000.	71340.	0.	0.	-24440.	-59610.	114390.
10-1953	52100.	3000.	5220.	43880.	0.	0.	0.	174000.

fully met, but during August, 1951 actual irrigated area dropped to 100,816 acres versus the proposed 174,000 acres. The reasons for this drop were that:

a. By the end of July, 1951 only 58,020 acre feet of water were left in the reservoir and the inflow in the river was 71,000 acre feet during August, 1951 so the total available water during that month was 71,000 + 58,020 = 129,020 acre feet.

b. After meeting the minimum release requirement of 3,000 acre feet, the water available for irrigation was 126,020 acre feet.

c. The irrigation diversion requirement for August, 1951 was 174,000 x 1.25 = 217,500 acre feet. There was not sufficient water to meet the demand even after depleting all the reservoir storage and using all the inflow of the river, so there was 0 storage and 0 spill during that month and there was a shortage of 217,500 - 126,020 = 91,480 acre feet which resulted in deficiency in irrigated area of 91,480/1.25 = 73,184 acres.

d. Hence actual irrigation during August, 1951 was 174,000 - 73,184 = 100,816 acres, which further went down to 96,585 acres in the next month due to insufficient river inflow and unavailability of any stored water.

The irrigated acreages in August for three models and the historical federal project have been plotted in Figure 8.1 This figure emphasizes the following points:

1. Irrigated acreages for non-federal models have been generally less than the historical federal project.
2. There have been more abrupt variations in irrigated areas that could have served the non-federal alternatives. These fluctuations could have hampered the development of irrigation and could lead to serious economic repercussions both for the farmers and the financiers of the project.
3. The performance of historic federal project with regard to irrigated acreage served has been better even than the large size Alternative III. In this alternative, the irrigated area has been targeted for 330,000 acres with a storage capacity of 1.157 million acre feet right from the start. The irrigated areas have been served equal to the target development level quite often, but in some years the acreages have fallen so low (for example: 11% in 1915, 6% in 1924 and 8% in 1926) that these could have meant total ruin to the farmers (See Table 8.2). They would have spent lots of money on seeds, machinery and fertilizers for the farms, but would have faced total crop failures due to nonavailability of irrigation water. The difficulty of supplying water even with a large storage

FIG 8.1

IRRIGATED ACREAGES IN AUGUST WITH DIFFERENT FEDERAL & NON-FEDERAL ALTERNATIVES

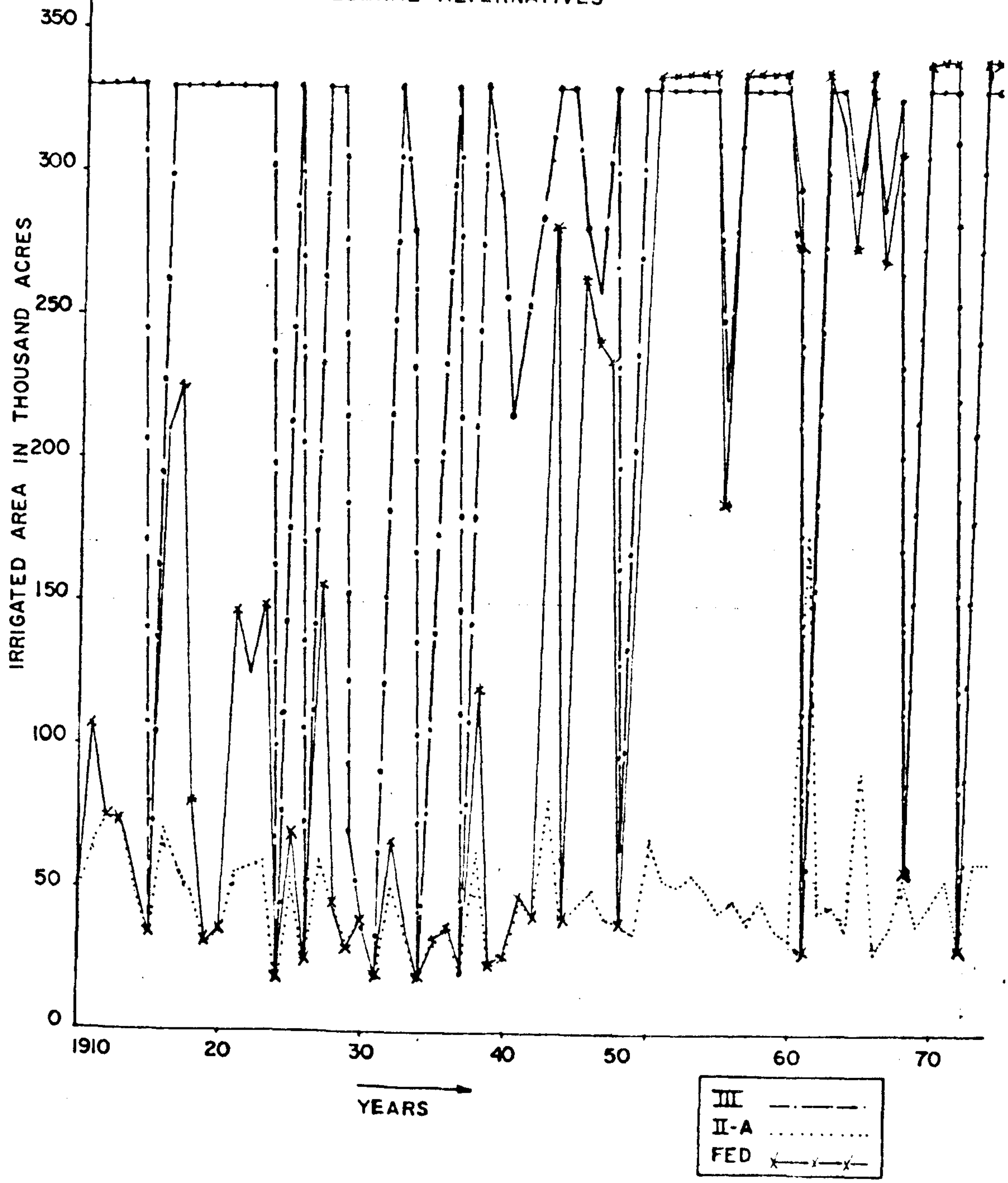


TABLE 8.2

TABULAR OPERATION STUDY FOR ALT-III-A (TARGET AREA 330,000 ACRES RES. CAP. 1157,000 AC FT MIN. REL. 3,000 AC FT/MONTH)

MONTH	INFLOW (Ac Ft)	MIN REL	DEMAND (Ac Ft)	STORAGE (Ac Ft)	SPILL (Ac Ft)	DEFSTOR (Ac Ft)	DEFACR (Ac Ft)	ACTIRI (Acri)
9-1914	52600.	3000.	135300.	140400.	0.	0.	0.	330000.
10-1915	69700.	3000.	0.	207100.	0.	0.	0.	330000.
11-1915	58400.	3000.	0.	262500.	0.	0.	0.	330000.
12-1915	44800.	3000.	0.	304300.	0.	0.	0.	330000.
1-1915	59600.	3000.	0.	360900.	0.	0.	0.	330000.
2-1915	59700.	3000.	0.	417600.	0.	0.	0.	330000.
3-1915	94800.	3000.	0.	509400.	0.	0.	0.	330000.
4-1915	196600.	3000.	23100.	679900.	0.	0.	0.	330000.
5-1915	27400.	3000.	227700.	476600.	0.	0.	0.	330000.
6-1915	191900.	3000.	452100.	213400.	0.	0.	0.	330000.
7-1915	83900.	3000.	603900.	0.	0.	-309600.	-169180.	160320.
8-1915	40900.	3000.	356400	0.	0.	-318500.	-294907.	35093.
9-1915	39700.	3000.	135300.	0.	0.	- 98600.	-240488.	89512.
10-1916	42400.	3000.	0.	39400.	0.	0.	0.	330000.
11-1916	45600.	3000.	0.	82000.	0.	0.	0.	330000.
12-1916	53300.	3000.	0.	132300.	0.	0.	0.	330000.
1-1916	49900.	3000.	0.	179200.	0.	0.	0.	330000.
2-1916	63300.	3000.	0.	239500.	0.	0.	0.	330000.
3-1916	197500.	3000.	0.	434000.	0.	0.	0.	330000.
4-1916	555100.	3000.	23100.	963000.	0.	0.	0.	330000.
5-1916	563800.	3000.	227700.	1157000.	139100.	0.	0.	330000.
6-1916	594800.	3000.	452100.	1157000.	139700.	0.	0.	330000.
7-1916	293800.	3000.	603900.	843900.	0.	0.	0.	330000.
8-1916	80100.	3000.	356400.	564600.	0.	0.	0.	330000.

capacity is illustrated in Table 8.2 where the 1915 operation shows even with storage carryover from the previous 1914 year there were shortages three months in a row and only enough water to irrigate 35,093 acres in August of 1915. Obviously similar situations developed in the 'with' case of the Federal development, but the number and severity of the fluctuations is not so large.

CHAPTER 9

ENGINEERING FEASIBILITY COMPARISON OF ALTERNATIVE NON-FEDERAL MODELS

According to "Economics of Water Resources Planning" by James and Lee (1971):

> *"Project planners must select from a myriad of proposed projects. Each proposal must pass five feasibility tests. The test of engineering feasibility is passed if the proposed project is physically capable of performing its intended function . . . "*

The other four tests mentioned are for economic, financial, political and social feasibilities.

This chapter treats only the engineering feasibility.

The intended functions for the three alternative non-federal models (as selected in Chapter 7) are to irrigate (1) 96,652 acres, (2) 174,000 acres, and (3) 330,000 acres with different sizes of storage systems. Systems should be capable of providing sufficient water for meeting the corresponding agricultural demands as specified for the crop requirements defined in Chapter 5. The procedure for evaluating the performance of the alternatives becomes complex due to: (1) a wide range of changes in annual and monthly river flows over a period of 64 years; (2) monthly variations in irrigation requirements of crops, and (3) changes in cropping patterns.

Due to the above difficulties, the performance of the alternatives was tested on the basis of the following criteria:

1. General Performance Criteria.

(a) Meeting the full irrigation diversion requirements at all times.

On the basis of monthly operational studies for this full service to the target area, it was found that with Alternative I, 100% of the target area was irrigated during only 284 months out of a total of 415 crop season months during the period of study (from 1910 to 1949, crop season months from April to September = 6 x 40 = 240, from 1950 to 1974, crop season months = April to October = 7 x 25 = 175, total = 415). Therefore, this alternative met the conditions of the criterion 68% of the time. The corresponding results for Alternatives II-A, II-B and III were 50, 64 and 84% respectively.

(b) Meeting at least 90% of the irrigation diversion requirement.

With this relaxation, Alternatives I, II-A, II-B and III succeeded 72, 61, 69 and 85% of the time.

(c) Meeting at least 80% of the irrigation diversion requirement.

In this case the situation changed to 81, 52, 70 and 88% of the time for Alternatives I, II-A, II-B and III respectively.

It was not considered necessary to see the results with greater relaxations. However, on examining the general performance of all alternatives, it was found that the average irrigated area for Alternative I was 68% (65,723/96,652) with the lowest figure of 20% in

July, 1924. The corresponding results for other alternatives were an average of 71% and the lowest figure of 10% for Alternative II-A, 82% and 11% for II-B and 89% and 6% for Alternative III.

2. Pacific Northwest River Basins Commission Criteria. (Henceforth to be called PNWRBC criteria)

At page 17 of "Comprehensive Framework Study of Water and Related Lands, Appendix IX - Irrigation", Pacific Northwest River Basins Commission (1971) states "for the purposes of this study, lands are considered to have an adequate supply if the sum of the shortages in any 10-year period does not exceed 1 year's diversion requirement".

It has not been possible to: (a) find out the original source or rationale of this criterion, (b) whether this criteria is applicable for only the North Pacific Study, or (c) could it be applied to other irrigation projects as well. However, it is understood that the Bureau of Reclamation has been adopting this criterion for many of their proposals. Use of this criterion gave the following results:

Alternative I

(a) There was not a single 10-year period in which the sum of the shortages did not exceed 1 year's diversion requirements.

(b) Average sum of the shortages in 10-year periods was 248% of one year's diversion requirement.

(c) The maximum shortage, 365%, occurred in the period 1931-40.

Alternative II-B

(a) Same as for Alternative I.

(b) Average shortage was 215%.

(c) Maximum shortage was 316% in the 10-year period 1931-40.

Alternative III

(a) Sum of the shortages exceeded 18 times out of 56 ten-year periods.

(b) Average shortage 94%.

(c) Maximum shortage 211% during 1928-37.

So even according to this criterion, all the alternatives seemed to be infeasible from an engineering point of view and need was felt for some remedial measures.

Remedial Measures

In order to improve the engineering feasibility of the alternatives, the possible ways could be:

i. increase the storage capacities for each alternative,

ii. decrease the target area to be irrigated,

iii. decrease the crop irrigation water requirement and thus the water diversion requirement by changing the cropping patterns.

iv. relax the criteria for passing these tests. For example, in the PNWRBC criterion assume that the accumulated shortage should not exceed 100% in five years instead of 10 years.

A summary of the findings with above measures is as follows:

1. Increase of Storage. With this approach it was found that for meeting the full diversion requirements of Alternatives I, II and III at all times, reservoir capacities of 200,000, 650,000 and 2,000,000 acre feet respectively were required. Similarly for fulfilling the conditions of PNWRBC criterion, the required storages would have been 300,000, 657,000 and 5,400,000 respectively for Alternatives I, II and III. It is very doubtful as to whether these large capacity reservoirs would have been found financially possible or desirable. It should be pointed out that required storage capacities in the case of PNWRBC criterion are higher than the full service criterion, because in the latter case the required storage capacity is chosen in the start of the operation study, whereas in the former case, the storage goes on increasing every year, on the basis of shortage in the previous ten years and ultimately it grows to very large proportions.

2. Decreasing the Target Area. This alternative would have seemed a simple solution. Applying this strategy, it was found that in the case of Alternative I, even if the target area was reduced to 40,000 acres, there were still 30 occasions of inadequate supply. Similar results might have been true for other alternatives. But this approach was omitted from further consideration as a regressive measure

which was not socially acceptable during this period of land development.

3. Changing the Crop Pattern. Perhaps this could have been a practical solution, because if the existing water supply system could not supply adequate water to irrigate all the target lands according to practical cropping patterns, then they would have changed to some other crops with lesser crop irrigation water requirements. But how far this would have been desirable from the point of view of soil characteristics or the economic outcomes could be anybody's guess. Moreover, while selecting cropping patterns, it was stipulated in Chapter 6 that "the alternative cropping patterns should be reasonably comparable to the actual historical ones". Changing to cropping patterns incomparable to historical cropping patterns would have envisaged a different industrial and social structure. This was considered beyond the scope of this study.

4. Relaxing the Criteria for Passing the Engineering Feasibility Test. It has already been brought out that if instead of always irrigating the 100% of the target areas, 90% (and above) was considered good enough, then Alternative I would have passed this test 72% of the time and Alternative II and III, 69 and 85% respectively.

Similarly in the case of the PNWRBC criterion, if instead of 10 years the limit is lowered to five years for accumulated shortages, then in the Case of Alternative III, the sum of five yearly shortages would have exceeded 100% of the average yearly diversion requirement instead of only six times. The reason for this difference is that during a ten-year period the number of accumulated shortages is double that of the number in a five-year period. Similarly, in the cases of Alternatives I and II-B, there were only 44 and 32 months respectively in which shortage exceeded 100%, whereas with the 10-year criteria, the shortages always exceeded the 100% mark.

Following this relaxed procedure, it was found that a reservoir capacity of 221,000 acre feet was needed for Alternative I and the corresponding figures for Alternatives II and III were 402,000 and 3,630,000 acre feet respectively. These proposed capacities are much less than their counterparts of 300,000, 657,000 and 5,400,000 acre feet respectively for the 10-year period criteria.

Tabular operation studies with these desired capacities showed that in the case of Alternative I it was possible to irrigate 100% of the target area for 406 months out of a total 415 considered. In the case of Alternatives II and III, the corresponding figures were 380 and 405 months respectively.

These results seem encouraging, but still it is doubtful that any non-federal agencies would have found building large capacity reservoirs feasible. The most likely courses for the agency would have been to build a feasible project on the basis of past records and available finances.

With these starting points, the agency would have run the system for the next five or ten years, and watched its performance. If the performance had showed a lack of water supply, then subject to economic and financial considerations, reservoir capacity would have been raised, and in case of abundance of supply, more area would have been brought under irrigation. This way the project would have continued its growth on the basis of previous performance. However, there would have been certain practical limitations. For example, the inquiries to the Bureau of Reclamation and the Water Resource Board in Boise, Idaho, reveal that the maximum feasible reservoir capacity on the Boise River is about 1,500,000 acre feet. This limit has been adopted as the maximum upper storage capacity limit for further consideration. Similarly, a rounded figure of 570,000 [based on sum of presently irrigated and Class I lands plus 50% of Class II lands for Canyon and Ada Counties as given in a state of Idaho report "Potentially Irrigable Lands in Idaho", Idaho Water Resource Board (1970)] acres has been adopted as maximum desirable limit for the irrigation target area.

With the above assumptions, the following plans were considered for the growth of different alternatives.

Plan A (10)

This plan is based on PNWRBC criterion and comprises the following steps:

1. Run the system with some initial target area and reservoir capacity.
2. Add the shortages in diversion requirements every year and find the average shortage during the period.

3. If the sum of shortages in ten years exceeds 100% of one year total diversion requirement, increase the reservoir capacity by the average shortage.
4. If the sum of shortages is less than 50% of one year total diversion requirement, increase the target area by 10%.
5. Run the system for another year and note the deficiency for 10 years immediately preceding this year.
6. Repeat Steps 3 and 4 and run for next year.

Plan A (5)

This plan is the same as Plan A (10) with the exception that here the period considered is five years instead of ten.

Plan B (5)

This is based on general performance criterion (c) mentioned earlier. This plan comprises the following steps:

1. Run the system for five years with some initial reservoir capacity and target area.
2. Note the actual irrigated areas in different months for each year.
3. Calculate the equivalent irrigated area for each year with the equation: Equivalent Area = 1.0 (Area Irrigated in August)

    + 0.65 (Area irrigated in July minus area irrigated in August)

    + 0.30 (Area irrigated in June minus area irrigated in July)

+ 0.082 (Area irrigated in September minus area irrigated in August).

The coefficients of 1, 0.65, 0.30, 0.082 have been adopted from "Economics Scenario Boise Valley Without a Federal Irrigation Project", Nelson (1976). Justification is based on the contention that the farmers would have received full sale value for production from all land irrigated in August, the critical month. In addition, they could have been able to produce two crops of hay on area irrigated in July over and above the area irrigated in August. This would have a value of 65% of full year's production. Similarly, the farmers could have produced some pasture and a partial crop of hay on area irrigated in June over and above that irrigated in July and it was considered this would have had 30% of a full year's production value. The farmers could have also received some benefit from pasture area irrigated in September in excess of acreage served in August. The value of this production was considered to be 20% of a full year's production, but because the lands irrigated above the August area would have needed more water than normal September requirements, an amount of 1.0 acre feet diversion in place of 0.41 acre foot would have been needed to bring about the production in September. Thus only 41% as much land could have been served. So the coefficient adopted for September equivalency of area was reduced to 0.41 x 0.20 = 0.082.

Operation studies were made with different alternatives by adopting the above plans. The results of these studies have been summarized in Table 9.1. Some of the points of interest in this table are:

Table 9.1. Engineering Feasibility Comparison of Non Federal Alternatives with Various Plans

	ALTERNATIVE-I Plan				ALTERNATIVE-II-A Plan			
	A(10)	A(5)	B(5)	C(5)	A(10)	A(5)	B(5)	C(5)
1. Maximum Average Equivalent Irrigated Area in Acres	401,847	355,240	405,939	135,970	358,988	405,834	422,944	192,031
1) Period	1971-74	1971-74	1971-74	1971-74	1971-74	1971-74	1971-74	1971-74
2) Target Area (acres)	488,526	403,741	496,652	157,015	410,284	496,444	570,000	250,560
3) Reservoir Cap. (acre feet)	1,500,000	1,500,000	1,500,000	152,196	1,500,000	1,500,000	1,500,000	347,772
2. Minimum Average Equivalent Irrigated Area in Acres	81,288	80,907	96,652	33,226	107,570	107,570	145,386	111,607
1) Period	1911-15	1916-20	1911-15	1911-15	1911-15	1911-15	1911-15	1911-15
2) Target area (acres)	96,652	116,949	96,652	96,652	174,000	174,000	174,000	174,000
3) Reservoir Capacity (acre feet)	0	0	200,000	9,677	0	0	200,000	26,384
3. Maximum Target Area in Acres	488,526	403,741	496,652	157,015	410,284	496,444	579,000	250,560
1) Period	1953-74	1955-74	1956-74	1955-74	1951-74	1955-74	1966-74	1966-74
4. Minimum Target Area in Acres	96,652	96,652	96,652	96,652	174,000	174,000	174,000	174,000
1) Period	1910-25	1910-15	1910-15	1910-15	1910-25	1910-20	1910-14	1910-45
5. Maximum Reservoir Capacity (acre feet)	1,500,000	1,500,000	1,500,000	152,196	1,500,000	1,500,000	1,500,000	347,772
1) Period	1957-74	1960-74	1966-74	1971-74	1924-74	1938-74	1966-74	1971-74
6. Minimum Reservoir Capacity (acre feet)	0	0	0	0	0	0	0	0
1) Period	1910	1910-20	1910	1910	1910-16	1910-16	1910	1910
7. Overall Average								
1) Equvt. Irrig. Area (acres)	215,100	216,570	365,426	98,337	266,032	379,840	265,317	135,276
2) Reservoir Capacity (acre feet)	762,193	679,770	800,000	70,213	120,750	1,075,159	671,429	172,856
8. Average Equivalent Area in 1931-40 (acres)	150,748	201,253	233,651	78,017	287,794	281,371	233,578	106,863
Average Reservoir Capacity in 1931-40 (acre feet)	539,281	629,981	700,000	64,309	1,500,000	1,420,170	700,000	154,282

Table 9.1 continued

	ALTERNATIVE II-B Plan				ALTERNATIVE III Plan			
	A(10)	A(5)	B(5)	C(5)	A(10)	A(5)	B(5)	C(5)
1. Maximum Average Equivalent Irrigated Area in Acres	376,228	403,293	418,196	231,219	384,942	396,610	406,412	418,197
1) Period	1951-55	1971-74	1971-74	1971-74	1941-44	1971-74	1971-74	1971-74
2) Target Area (acres)	410,284	496,444	570,000	300,672	439,230	483,153	530,000	570,000
3) Reservoir Cap. (acre feet)	1,500,000	1,500,000	518,744	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000
2. Minimum Average Equivalent Irrigated Area in Acres	145,386	145,386	166,030	148,708	289,824	214,920	208,783	215,962
1) Period	1911-15	1911-15	1911-75	1911-15	1926-30	1931-35	1931-35	1931-35
2) Target area (acres)	174,000	174,000	174,000	174,000	363,000	483,153	530,000	475,200
3) Reservoir Capacity (acre feet)	200,000	200,000	400,000	226,984	1,500,000	1,500,000	1,500,000	1,407,916
3. Maximum Target Area in Acres	410,284	496,444	570,000	300,672	439,230	483,153	530,000	570,000
1) Period	1946-74	1955-74	1956-74	1956-74	1951-74	1921-74	1921-74	1956-74
4. Minimum Target Area in Acres	174,000	174,000	174,000	174,000	330,000	330,000	330,000	330,000
1) Period	1910-25	1910-16	1910-15	1910-15	1910-16	1910-16	1910-15	1910-15
5. Maximum Reservoir Capacity (acre feet)	1,500,000	1,500,000	1,500,000	518,744	1,500,000	1,500,000	1,500,000	1,500,000
1) Period	1951-74	1933-74	1961-74	1971-74	1922-74	1924-74	1926-74	1941-74
6. Minimum Reservoir Capacity (acre feet)	200,000	200,000	200,000	200,000	1,157,000	1,157,000	1,157,000	1,157,000
1) Period	1910-16	1018-21	1910	1910	1910-20	1910-23	1910	1910-25
7. Overall Average								
1) Equvt. Irrig. Area (acres)	246,544	274,190	276,327	1[illegible]9,552	318,612	316,632	319,893	219,411
2) Reservoir Capacity (acre feet)	830,090	1,096,935	992,857	354,220	1,435,041	1,411,800	1,444,857	1,469,017
8. Average Equivalent Area in 1931-40 (acres)	190,023	273,713	251,050	149,579	256,108	250,522	245,793	250,593
Average Reservoir Capacity in 1931-40 (acre feet)	666,772	1,412,005	900,000	343,322	1,500,000	1,500,000	1,500,000	1,360,104

1. The maximum average equivalent irrigated area was equal to 422,944 acres with Alternative II-A under Plan B (5) in the period 1971-74. The corresponding figure for this alternative under Plan A (5) was 405,834 acres.
2. The minimum average equivalent irrigated area was equal to 80,907 acres with Alternative I under Plan A (5) in the period 1916-20.
3. The maximum target area was achieved with Plan B (5).
4. The period for maximum equiv. area with all alternatives and plans [except A (10)] was 1971-74. In case of Plan A (10) the period for maximum equivalent area was generally 1951-55.
5. The maximum reservoir capacity of 150,000 acre feet was attained by all the alternatives under all the plans except Plan C (5). The earliest time of attaining the maximum capacity was 1922, with Plan A (10) for Alternative III.
6. The best overall average for equivalent irrigated area achieved was 379,840 acres under Plan A(5) for Alternative II-A, with an overall average reservoir capacity of 1,075,159 acre feet.
7. During the low flow period of 1931-40, the maximum average equivalent area was 287,794 acres with Plan A (10)

for Alternative II-A. The corresponding figure for this alternative under Plan A (5) was 281,371 acres.

On the basis of the above observations, Alternative II-A with Plan A (5) appeared to be the most desirable course of action from the irrigation point of view, but this consideration alone is not sufficient. The economic and financial consequences of achieving better average irrigation figures with larger storage capacities have to be estimated before final selection of the best alternative, ie. in addition to engineering feasibility, the economic and financial feasibilities of a project also have to be studied.

CHAPTER 10

ECONOMIC AND FINANCIAL FEASIBILITY COMPARISON OF DIFFERENT NON-FEDERAL ALTERNATIVES AND HISTORIC FEDERAL PROJECT

The terms economic and financial feasibilities have not been consistently used in official or critical use. According to Hirshlefer, Dehaven and Milliman (1969) in an economically feasible project valuation of the benefits to whom ever they accrue, exceeds the economic valuation of the costs to whomever they accrue. By 'financial feasibility', they imply "the self-liquidating character of a project -- a financially feasible project generates revenues that suffice to cover all costs including interest on funds borrowed to finance the project". James and Lee (1971) postulate that "test of economic feasibility is passed if the total benefits that result from the project exceed those which would accrue without the project by an amount in excess of the project cost". "The test of financial feasibility is passed if sufficient funds can be raised to pay for project installation and operation."

In this study the 'economic feasibility' has been used to imply the long term net positive returns and 'financial feasibility' to imply the net cash flows on short term basis. In other words, for any project to be economically feasible, the accumulated benefits must exceed the accumulated costs at the end of study period. For the alternative to be 'financially feasible', it should meet two conditions. (1) The organizers of the project should be able to mobilize sufficient funds for installation of the project, and (2) during operation either the net cash flows (benefits minus costs) should be positive or the organizers should be able to arrange additional finances to continue in business during the periods of net negative cash flows.

For the purpose of counting benefits and costs, the following assumptions were made.

1. The benefits and costs were all counted in constant dollars for 1910.
2. Only the primary benefits and costs of irrigation were considered.
3. Benefits were restricted to sale value of crops.
4. Costs were split up into two subgroups.
    a. On-farm costs - including cost of seeds, fertilizers, machinery and labor.
    b. Off-farm costs - cost of construction of canals and reservoirs, and their operation and maintenance.
5. The study period was assumed to be 64 years starting with 1910 and ending in 1974.
6. It was assumed that the initial target area for each non-federal alternative was already developed and that fifty percent of the cost of canals had already been paid off before 1910 and the remaining 50% was to be paid.
7. It was assumed that there was no permanent reservoir

built before 1910 and so the cost of any storage had to be paid in full after 1910.

8. The life of all new canals or reservoirs was assumed to be 100 years.
9. It was assumed that after 100 years the salvage value of the project was 25% of the original cost.
10. During the intervening period, it was assumed that salvage value varied linearly between 100% and 25%.
11. The cost of reservoirs and canals was taken on the basis of average costs of the features on the historic Federal Boise project, as determined in "Direct Economic Impacts of Irrigation, Boise Project, Idaho", by Nelson, Long and Peterson (1976).
12. It was assumed that all costs would be paid off in 100 years at the rate of interest prevailing in the year in which the canals and reservoirs were built or purchased.
13. For economic analysis the rate of interest assumed was the prime rate of interest for both federal and non-federal alternatives.
14. For financial analysis the rate of interest used for non-federal alternatives was prime rate of interest, but the long term bond rate for federal project. The reason for this has been explained later.

15. All the obligations of the project were assumed to be paid off in 1974, thus the net present worth of the project could be calculated at the end of study period.

The following procedure was adopted for examination of economic and financial feasibilities of the non-federal alternatives.

1. Operation studies and year by year economic analyses were made with different plans for each alternative mentioned in Chapter 9 on Engineering Feasibility.
2. For expansion of project size during any year an additional condition was used which indicated that during the period under consideration, average benefits must exceed average costs by at least the interest on costs for that year.
3. In addition, to Plans A (10), A (5), B (5) and C (5) discussed in earlier chapters, the following additional plans were considered in this section:

   N (5) - This plan envisions no change in the initial target area or reservoir capacity of any alternative throughout the study period.

   O (5) - According to this plan, initial project size is increased by an arbitrary percentage when average benefits for a 5-year period are greater than average costs. Trials with different rates of increase are made until the gross profit at the end of study period is maximum.

G (5) - According to this plan the project size was kept very small or even nil during the period of 1910 to 1939 in view of relatively unprofitable prices of agricultural products and generally low instream flows. The project size was increased to maximum feasible extent in the years 1940-70 to take maximum economic advantage of relatively high food prices after World War II and generally high instream flows during the period 1940 to 1974. A summary of various non-federal alternatives is given in Table 10.1 which is also accompanied by a concise summary of all the alternatives and plans which were evaluated in this study.

4. Computations for various values of benefits, costs and present worth of the alternatives were made as summarized in Tables 10.3 to 10.6. Sample printouts of computer programs are reproduced in Appendix B.

5. A brief explanation of the various terms used in the above computations follows:

   a. Initial investment and the equivalent annual capital recovery cost of any project were computed in accordance with assumptions 5, 6, 7 and 11 at beginning of Chapter 10.

   b. The salvage values and the obligations due on this initial project size in 1974 were computed according to assumptions 8 to 10.

TABLE 10.1

SUMMARY OF NON-FEDERAL ALTERNATIVES

Altern-ative	Project Area (acres)	Storage Capacity (Ac Ft)	Minimum Instream Flow (Ac Ft/Month)	Remarks
I	96,652	0	0	Based on Paul L. Murphy's Thesis.
II(A)	174,000	0	0	Based on issued water rights.
II(B)	174,000	200,000	3,000	Based on issued water rights & Carey Act proposal.
III	300,000	1,157,000	3,000	Based on present federal development.

SUMMARY OF PLANS

FOR ANALYSIS OF NON-FEDERAL ALTERNATIVES

Plan	Period Basis (yrs)	Operation	Remarks
A(10)	10	No change for first 10 years. a. After that increase the storage capacity by average shortage if 1) the shortage experienced is more than 100% of yearly demand, 2) the average benefits exceed average cost plus interest at current rate. b. Increase the project area by 10% if 1) 10-year shortage is less than 50% and 2) on the average, benefits exceed costs. c. Repeat the above every year on the basis of previous 10 years results.	Based on Pacific Northwest River Basin Commission 10-year shortage criteria.
A(5)	5	Same as A(10), except that after first 10 years changes are made on the basis of previous 5 year results instead of 10 years.	A modification of Pacific Northwest 10-year criteria.
B(5)	5	a. Note the average irrigated area for every five years. Increase the storage capacity by 200,000 ac. ft. if 1) the average irrigated area is less than 80% of project area, 2) average benefits exceed average cost plus interest at current rate. b. Increase the project area by 100,000 acres if 1) average irrigated area is equal to the Project area, 2) benefits exceed average cost plus interest at current rate.	Based on the assumption that any non-federal agency will not make changes every year, but base its strategy on the results of every 5-year period.
C(5)	5	Same as B(5) except that instead of arbitrary figures, storage capacity is increased by the average amount of shortage during the 5-year period and project area is increased by 20%.	
O(5)	5	Note the average benefits and costs for a 5-year period. a. Increase the project area and capacity by a certain percentage if on the average, benefits exceed costs. b. Note the net total profit in the entire period of study. c. Reiterate the above operations with different rates of increase until the net total profit is maximum.	Based on the assumption that in the period of losses, any non-federal agency will not increase its operations at all, but in the event of profits, it will like to increase the project scope as much as possible to maximize its total profits.
N(5)	-	No change in the initial condition of the project throughout the study period.	

Plan	Period Basis (yrs)	Operation	Remarks
G(5)	-	The study period is split into two sub-periods during which the project sizes are adjusted as follows:	Based on the assumption that up to year 1940 when economic conditions were not good, there would have been very small or no federal irrigation projects. After 1940, due to economic upturn, there would have been sudden large growth and expansion of irrigation ventures to the maximum feasible project size.

	Period 1910-39	Period 1940-74
Alternative I		
Target Area (ac)	96,652	330,000
Stor. Cap. (ac ft)	0	1,157,000
Min. Release (ac ft)	0	3,000
Alternative II-A		
Target Area (ac)	40,000	174,000
Stor. Cap. (ac ft)	0	0
Min. Release (ac ft)	0	0
Alternative II-B		
Target Area (ac)	40,000	174,000
Stor. Cap. (ac ft)	0	200,000
Min. Release (ac ft)	0	3,000
Alternative III		
Target Area (ac)	0	330,000
Stor. Cap. (ac ft)	0	1,157,000
Min. Release (ac ft)	n.a.	3,000

c. Irrigated area for each month was computed on the basis of monthly operation study with the initial project size and release conditions.

d. On the basis of monthly irrigated areas, equivalent irrigated area for the whole year was calculated as explained in Chapter 9.

e. Annual net benefits were computed by multiplying the equivalent irrigated area with a net value added per acre as indicated in Table A-3 of Appendix A.

f. Annual costs were computed by adding the cost of labor for equivalent irrigated area to the annual capital recovery cost computed in step (a) above.

g. Profit was computed by subtracting the benefit value obtained in (f) from the cost value obtained in (e). Any profit made in the previous year was added to this to compute gross profit for the year.

h. If the gross profit was negative for any year, the project was kept going by borrowing money at the current prime rate of interest. The additional interest paid on this account was added to the cost for next year, for computation of gross profits for that year. If, on the contrary, the gross profit was positive, then additional profit was made by investing this amount at the current prime rate of interest and this was added to the benefit for the next year. This may be explained by the following equation:

Profit in first year = Benefit-cost (in 1st year)

Gross profit in 1st yr. = Profit in 1st year.

Additional profit = Rate of interest x gross profit.

Profit for next yr. = Benefit - cost (for the next year) + additional profit from the previous year.

i. No corrections were made for income tax, because up to 1940 generally there were losses and after 1940, the profit would have been divided between one thousand farmers at least (assuming an average size farm as 100 acres) and for most part of the study period, the individual profits would have been below the exemption limit for income tax.

j. The project size was enlarged if it satisfied the engineering and economic conditions laid down in Step (2) above, and the process was repeated for the next year until the end of study period in 1974, subject to constraints on available storage capacity, and maximum feasible target area as explained in Chapter 9.

k. At the end of study period, the net present worth of the project was computed by adding the salvage value and subtracting the obligation on irrigation works investment from the gross profit in accordance with step 6 (b), i.e. Net present worth = Gross profit

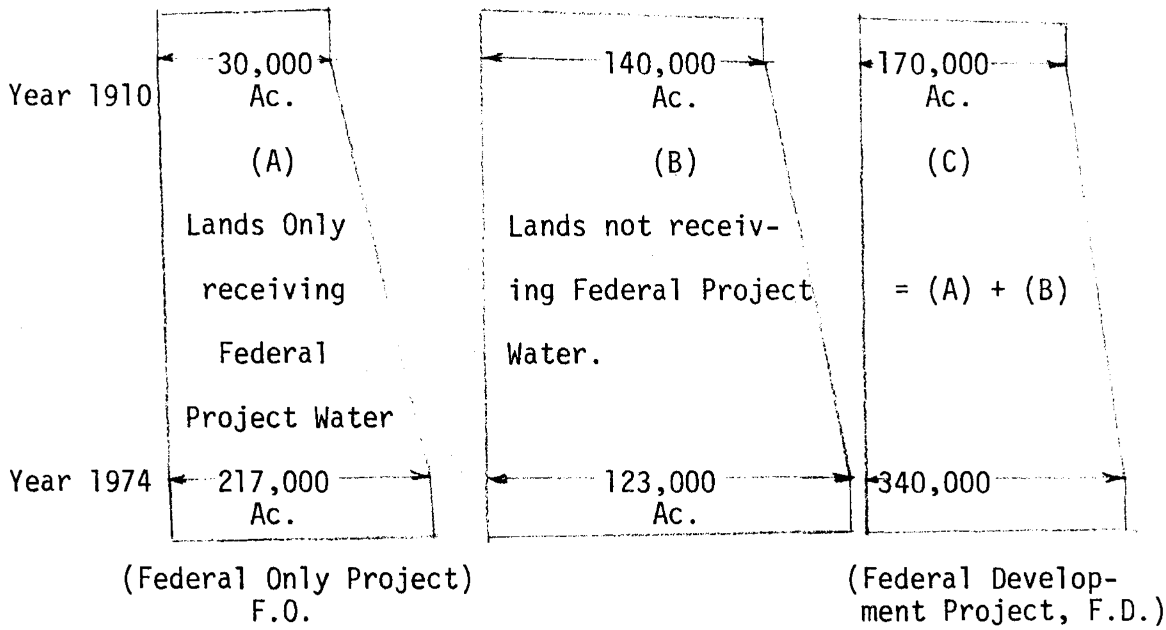
+ salvage value - obligation.

6. Values obtained for net present worth of the project were used for the purpose of comparing economic feasibility of federal and non-federal alternatives with different plans as shown in Table 10.7.
7. Values obtained for gross profit at five year intervals were used for comparing the financial feasibility of the federal and non-federal alternatives as shown in Figures 10.1 to 10.6.
8. Values obtained for average equivalent irrigated areas at five year intervals were plotted to compare the magnitude of possible irrigation development of various federal and non-federal alternatives as shown in Figures 10.7 to 10.12.

Economic and Financial Feasibility of Federal Project

The economic and financial impacts with the historic federal project were approached from two different points of view. In the first approach, only lands irrigated by the federal project waters were considered. This approach has been referred to as Federal Only Project (F.O.). In the second approach, lands irrigated both by the Federal project waters and lands irrigated under individual private arrangement, on the basis of prior water rights, were added to constitute a historical "with development situation". This has been referred to as Federal Development Project (F.D.).

The schematic representation of the irrigation development according to these two approaches may be made as follows:



(NOT TO SCALE)

The computation of present worth of the Federal Boise project was done as follows:

1. In this case the investment costs included the features as shown in Table 10.2, and their allocation to the Federal Irrigation Project was done on the following basis:.
   a. The total investment cost of various irrigation and power feasures up to year 1953 was estimated to be $44,909,862, as per 'Revised Allocation of Cost', U.S. Bureau of Reclamation (1953).
   b. Out of the above total costs $23,652,459 (ie. 52.67%) were allocated to irrigation.

c. So the costs of individual features was also allocated to irrigation in the same ratio.

d. As the individual features were installed in different years, their allocated costs were multiplied with wholesale price relatives to bring them to a common base year: 1910.

2. In addition to above costs, $22,066,000 were invested for the construction of Lucky Peak Dam in 1955 as per "Definite Project Report on Lucky Peak Dam", Corps of Engineers (1949). This dam was built mainly for the purpose of flood control, hence only $249,763 were changed to irrigation.

3. The figures for irrigated areas during various years were adopted from the "Revised Allocation and Repayment Report", Bureau of Reclamation (1953) and the reports of the Boise River Watermaster (1975). No breakdown of these figures on a monthly basis was available. Operation studies were made assuming these figures as target areas and the storage capacities as follows.

1910 to 1915	---	169,000 acre feet	(Lake Lowell)
1916 to 1950	---	169,000 + 286,600 = 455,600	(Arrowrock)
1951 to 1955	---	455,600 + 423,200 = 878,800	(Anderson Ranch)
1956 to 1974	---	878,800 + 279,000 = 1,157,800 ≃ 1,157,000 acre feet.	(Lucky Peak)

4. The monthly irrigated areas computed on the basis of operation study were utilized to compute the equivalent irrigated areas on the same basis as utilized for non-federal alternatives. The economic feasibility was determined on the basis of the same methodology as adopted for non-federal alternatives. For determination of financial feasibility, Federal Long Term Bond rate was used for computing the annual capital recovery factors and interest charges on investment, instead of prime rates of interest used for non-federal alternatives. The reasons for this difference are (a) Investments in federal projects is considered relatively more risk free than non-federal ones hence people are willing to invest in federal bonds at relatively lower interest rates, (b) The interest rate used by federal agencies for economic analysis of various projects is based on Federal Long Term Bond rates.

Federal Development Project

In this case, additional costs were added to those already computed for Federal Only project. These additional costs consisted of the cost of extra canal and diversion facilities which had to be provided to meet the irrigation demands of the lands receiving water in addition to Federal Project water. It was assumed that seventy-five percent of the costs remained to be paid off beyond the year 1910 for the initial investment. This is based on an assumption that these facilities might have been developed to some extent before 1910 and would have been partially paid for by 1910. Thus the 75 percent is a reduction in the investment amount that had to be repaid. The investments during various periods were computed as below:

Period	Target Area for Federal Only Project (acres)	Target Area for Federal Development Project. (acres)	Additional Area for Federal Development Project (acres)	Additional Cost Charged to Federal Development Project* (dollars)
1910	30,000	170,000	170,000 - 30,000 = 140,000	2,364,600 (140,000 x 22.52 x 0.75)
1920	130,000	290,000	290,000 - 130,000 = 160,000 - 140,000 = 20,000	450,400 (20,000 x 22.52)

*A uniform rate of $22.52 per acre was utilized as worked out in "Economic Scenario of Boise Valley Without a Federal Irrigation Project", Nelson, Long & Peterson (1976).

For economic analysis, the remaining procedure for calculating the benefits and costs was the same as for Federal Only Project, but for financial analysis, costs incurred on account of purely Federal features were charged at the long-term bond rate of interest and any other additional costs were charged at the prime rate of interest, as illustrated in Table 10.3. The gross accumulated profit at the end of study period in 1974 was computed on the basis of methodology shown in Tables 10.3 and 10.4. The salvage values and the obligation to be liquidated in 1974 were calculated as shown in Table 10.5 and 10.6 respectively. These figures were utilized to calculate the net present worth of the Federal Development Project. The procedure may be briefly explained with the help of the following equations:

1. Let P = Investment Cost in a Project Feature in any Year.

   i = Applicable rate of interest for that year.

   N = The number of years in which the cost is to be repaid.

   A = Capital recovery factor for liquidating the investment cost in N years.

   I = The annual installments to be paid for N years on amount of investment.

   $= \frac{i(1 + i)^N}{(1 + i)^N - 1} \times P +$ (The annual installment to be paid on account of expenditure incurred previous to the current year.)

2. L = Cost of labor on irrigated area

   = Equivalent irrigated area x labor cost per acre.

3. C = Total annual cost = I + L.

4. B = Annual benefit derived from the irrigated area

   = Equivalent irrigated area x net sale value of crops per acre.

5. P = Annual profit = B - C.

6. G = Gross profit

   = Accumulated profit up to the current year + interest on the accumulated profit up to the current year + profit in the current year.

7. L = Total no. of years assumed for the life of project = 100.

8. E = Assumed salvage value of the project at the end of 100 years = 25 percent of the original investment cost.

9. n = No. of years remaining for the life of project at the end of study period.

10. S = Salvage value of the project feature at the end of study period.

$$= [0.25 + \frac{0.75}{100} \times n] \times I$$

11. O = obligation of the project feature on account of annual investments remaining to be paid at the end of study period

$$= I \times \text{Series present worth factor} = \frac{(1 + i)^n - 1}{i(1 + i)^n} \times I$$

12. NPW = Net present worth = G + S - O

In an earlier chapter engineering feasibility of various alternatives was considered, but no conclusive inferences could be drawn in the absence of comparisons from other feasibilities point of view, particularly economic and financial. It was therefore thought desirable to again compare engineering efficiency of various alternatives along with economic and financial feasibilities comparison as shown in Table 10.8. The points chosen for engineering feasibility comparison were:

1. Maximum target area and maximum storage capacity achieved to assess how much various alternatives

could grow in size of the project in view of various engineering, and economic constraints and yearly stream flows.

2. Overall average of equivalent irrigated area and storage capacity during the period of study to compare how much area was served per unit of storage capacity. In order to bring this comparison on a common basis, the following procedure was adopted:

   A = overall average of equivalent irrigated area during 1910 to 74 for Alternative I with no storage (i.e. Plan N(5).

   = 73,000 acres.

   B = overall average of equivalent irrigated area for other alternative and plan under consideration.

   C = overall average of storage capacity for other alternative and plan under consideration.

   Additional Equivalent Irrigated Area per Unit Storage Capacity = (C - A)/B.

The values for additional equivalent irrigated area per unit of storage capacity calculated in the above manner has been adopted as a measure of engineering efficiency of various alternatives and has been referred to in subsequent discussion.

An additional comparison from point of view of irrigation service provided by various alternatives was made by plotting the five yearly average of equivalent irrigated areas for various federal and non-federal alternatives in Figures 10.7 to 10.12.

A comprehensive and simultaneous comparison of all the federal and non-federal alternatives is given in Tables 10.3 to 10.8 and Figures 10.1 to 10.10.

Some of the inferences which can be drawn from the above tables and figures are listed below:

Federal versus Non-Federal Alternatives

1. From irrigation point of view, federal projects have been more economically efficient than the non-federal alternatives. There were possibilities of achieving better economic efficiency either by not installing any project up to 1940 or by installing a very small size project in 1910 and expanding it to the maximum size after 1940, as demonstrated by Alternative I [Plan G(5), Alternative II-A (Plan A(5), O(5)) and Alternative III (Plan G(5)].

2. Similarly, from the financial point of view, during the period of economic recovery (from 1940 to 1974) the federal projects generally accumulated more profits than the non-federal alternatives. But there were still possibilities of increasing these profits appreciably (50% in case of F.D. x 100% in case of F.O) by delaying the installation until 1940 or adopting better expansion policies. During the period of economic depression, the maximum extent of

loss suffered by the Federal Project was generally of the same order as that suffered by most of the non-federal models. Keeping these losses to lower figures required adopting and maintaining smaller sized projects during the depression period as demonstrated by Plans C(5), G(5) and N(5) for Alternative I.

3. From the point of view of irrigation service (or engineering efficiency), Federal Projects have been generally comparable to the non-federal alternatives (See Column 12, Table 10.8). However, much better results could be achieved with some of the non-federal alternatives, particularly with Plans C(5) of Alternative I & II-A, which have a figure of 0.56 and 0.60 acres of additional equivalent irrigated area per acre ft. of storage capacity against the corresponding figures of 0.27 and 0.15 for Federal development and Federal Only projects.

4. On the whole, if it were possible to go back to year 1910 and install the project all over again, Alternative I under Plan G(5) (96,652 acres area and zero storage between 1910 to 1939, then 330,000 acres area and 1,157,000 acre feet capacity from 1940-1974) would have been the best choice. With this alternative, the net present worth of the project in 1974 would have been 43% more than the Federal Development Project ($205.7 million against $143.9 million); maximum accumulated loss up to 1941 would have been 65% less

($11 million against $31 million). The maximum area served by canals in this case would have been almost equal [330,000 (federal) against 340,000 (non-federal)] and the additional equivalent area irrigated per unit of storage capacity would have been the same as with the Federal Development Project (0.27 acre per acre feet).

This plan would have been more realistic than the Plan G(5) for Alternative III with a Net Present Worth of $225 million, because the latter plan would have meant not having any canals and irrigation facilities until 1940, which is quite contrary to the actual situation. It is known that prior to installation of the Federal Project, people had acquired water rights for up to 174,000 acres and irrigation of some of these areas had been operating for several years. It is difficult to imagine that farmers would have agreed to abandon even the existing irrigation facilities.

In short, the study indicates that the Federal Project has been better than some of the non-federal alternatives, from engineering, economic and financial efficiency point of view, yet better results could be achieved by adopting a small size project up to 1940 and utilizing better expansion criteria. But since it is very difficult to forecast the economic situations 40 or 50 years in advance and adopt suitable sized projects on that basis, it can be said that the Federal Project has been a prudent choice for a water development project.

Regarding private capital, it is said that:

> *"The wealthy eastern speculator, seeing visions of rich returns, undertook the expensive construction. But often failing to realize his estimate of return, he disposed of the undeveloped project to the settlers."* Murphy (1948).

Similar ideas were expressed during a meeting of civil engineers held at Salt Lake City, Utah on July 8, 1925.

> *"The modern period began on July 27, 1847 when a company of mormon pioneers led by Brigham Young, entered the Great Salt Lake Valley . . . The prosperity that attended these pioneer enterprises was so marked that capital soon became interested . . . It was discovered, however, that many difficulties and dangers attend an irrigation enterprise . . . It seemed to be demonstrated that ordinarily capitalistic irrigation enterprises was not profitable. Finally it became clear that the development of the irrigated section was lagging because the precarious financial returns of irrigation investments made capital reluctant to engage in irrigation enterprise."* Widstoe (1925).

In a way this reluctancy on the part of the private capital entities was perhaps a good thing for them, because as brought out in the previous chapter, if they had continued financing and running the irrigation work they would have been suffering losses up to 1940, which could have accumulated up to about 25 million dollars for an enterprise like the Boise Project.

So, if the private capitalists had become disinterested in irrigation enterprise, the possible non-federal agency was the state itself.

The most feasible way for the state to develop irrigation was to take advantage of the Carey Act. Although Idaho is considered to be the most successful state in utilizing the Carey Act provisions,

TABLE 10.2

INVESTMENT COSTS OF VARIOUS FEATURES OF

BOISE FEDERAL PROJECT

Item No.	Year (1)	Feature (2)	Total Cost $ (3)	Wholesale Price Relative for the Year[2] (4)	Costs Charged to Irrigation. Col 3 x Col 4 x 0.5267[3] (5)
1	1908	Boise River Dam	369,977	1.000	
2	1908	Boise River Power Plant	200,373	1.000	
			570,350	1.000	300,383
3	1911	Deer Flat Dam	978,224	1.0862	559,643
4	1915	Arrow Rock Dam	5,250,744	1.0168	2,812,030
5	1918	Canals and Drains	7,384,258	0.5258	2,044,988
6	1932	Common cost between the period 1908 to 1953.[4]	396,193	1.0833	226,058
7	1937	Costs of alteration to Arrowrock Dam incurred between 1915 to 1950 but shown in the middle of this period - i.e. 1932.	232,000	0.8180	99,955
8	1950	Cost of Anderson Ranch Dam between the period 1930 to 1944, but shown in the middle of the period - i.e. 1937.	30,494,286	0.4450	7,147,296
TOTAL (Excluding Item 6)			44,909,862		

[2]See Table A-2, Appendix A.

[3]Allocation of costs as of 1953 as per "Revised Allocation of Cost", U.S. Bureau of Reclamation (1953).

	Chargable Amount	% of Total
Irrigation	$23,652,459	52.67
Flood Control	15,152,000	
Power	6,105,403	
TOTAL	$44,909,862	

[4]As estimated in "Economic Subproject Report of a Dynamic Regional Impact Analysis of Federal Expenditure - The Boise Project Idaho", Nelson and Long (1976).

TABLE 10.3

COMPUTATION OF ANNUAL CAPITAL RECOVERY PAYMENT FOR FEDERAL DEVELOPMENT PROJECT

Year	Capital Investment for Purely Federal Project	Long Term Bond Rate of Interest	Annual Capital Recovery Factor for 100 Year Payment	Annual Capital Payment for Purely Federal Pjt.	Capital Investment for Private Lands not Receiving Federal Pjt. Water	Prime rate of interest	Annual Capital Recovery Factor for Private Lands	Annual Capital Payment for Private Lands	Total Accumulated Annual Recovery Payment. Prev. col. 10 + col. 5 + col. 9.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1910	300,383	0.0473	0.0478	14,358	2,364,600	0.0481	0.0485	114,683	129,041
1911	559,643	0.0473	0.0478	26,750	-	0.0481	0.0485	-	155,791
1912	-	-	-	-	-	-	-	-	155,791
1915	2,812,030	0.0473	0.0478	134,420	-	0.0481	0.0485	-	290,211
1916	-	-	-	-	-	-	-	-	290,211
1918	2,044,988	0.0473	0.0478	97,750	-	0.0481	0.0485	-	387,961
1919	-	-	-	-	-	-	-	-	387,961
1932	226,058	0.0368	0.0378	8,545	-	0.0470	0.0475	-	419,927
1933	-	-	-	-	-	-	-	-	419,927
1950	7,147,296	0.0232	0.0258	184,400	-	0.0248	0.0271	-	607,266
1951	-	-	-	-	-	-	-	-	607,266
1955	103,552	0.0284	0.0393	4,069	-	0.0295	0.0312	-	611,335
1956	-	-	-	-	-	-	-	-	611,335
1973	-	-	-	-	-	-	-	-	611,335
1974	-	-	-	-	-	-	-	-	611,335

TABLE 10.4

ECONOMIC OPERATIONAL STUDY OF THE HISTORIC DEVELOPMENT OF THE BOISE RIVER VALLEY LANDS

(Federal Development Project)

Year	Accumulated An. Recovery Payment $	Equivalent Irrigated Acreage	Labor & Mgt. Cost/Acre 1910 $	Total Annual Variable Cost $	Total Annual Cost $	Value Added Per Acre $	Total An. Benefit	An. Profit or Loss	Prime Rate of Interest $	An. Int. on Indebt. or P. $	Accum. Debt or Gain $
1910	129,041	129,478	9.10	1,178,250	1,307,291	0.966	125,076	-1,182,215	0.0481	-	-1,182,215
1911	155,791	168,262	9.00	1,514,358	1,607,149	2.475	416,448	-1,190,701	0.0481	- 56,865	-2,429,731
1912	155,791	179,967	8.92	1,605,306	1,761,097	1.652	297,320	-1,463,777	0.0481	-116,872	-4,010,430
1915	290,211	135,891	8.70	1,182,252	1,472,463	6.180	839,806	- 632,657	0.0481	-303,504	-7,246,016
1916	290,211	285,361	8.60	2,454,105	2,744,316	13,997	3,994,198	1,249,882	0.0481	-348,534	-6,344,667
1918	387,961	221,977	8.45	1,875,706	2,263,667	14,087	3,126,990	863,323	0.0481	-247,428	-4,528,156
1919	387,961	173,440	8.38	1,453,427	1,841,388	14.782	1,054,607	- 786,781	0.0481	-217,804	-5,532,741
1932	419,927	237,190	7.40	1,755,206	2,175,133	-2.002	- 474,854	-2,649,987	0.0470	-631,509	-16,757,862
1933	419,927	223,860	7.30	1,634,178	2,054,105	6.578	1,472,551	581,554	0.0410	-685,432	-17,984,848
1950	607,266	334,750	4.75	1,590,063	2,197,329	9.000	3,012,750	815,421	0.0248	-640,239	-25,540,918
1951	607,266	334,870	4.60	1,540,402	2,147,668	17.035	5,704,510	3,556,892	0.0259	-664,099	-22,748,177
1955	611,335	295,579	4.00	1,182,316	1,793,651	13.484	3,985,587	2,191,936	0.0295	-416,043	-12,327,277
1956	611,335	335,400	3.80	1,274,520	1,885,855	23.243	7,795,702	5,909,847	0.0299	-368,585	6,786,015
1973	611,335	340,000	2.45	833,000	1,444,335	32.283	10,976,220	9,531,885	0.0720	8,271,758	132,689,183
1974	611,335	340,000	2.44	829,600	1,440,935	24.625	8,372,500	6,931,565	0.0720	9,553,621	149,174,369

"Accumulated gain at the end of 1974 if prime rate of interest is charged on all project features = $147,319,210"

TABLE 10.5

CALCULATION OF SALVAGE VALUES FOR FEDERAL PROJECT

ASSUMING 100 YEAR LIFE

(All monetary values in 1910 dollars)

Year	Investment	No. of Years of Life after 74.	Salvage Factor (0.25 + 0.0075 x N)	Salvage Value
(P)		(N)	(F)	(P) x (F)
1910	2,364,600	36	0.5200	1,229,592
1910	300,383	36	0.5200	156,199
1911	559,643	37	0.5275	295,212
1915	2,812,030	41	0.5575	1,567,710
1918	2,044,988	44	0.5800	1,186,093
1920	450,400	46	0.5950	267,988
1932	226,058	58	0.6850	154,849
1937	99,955	63	0.7225	72,217
1950	7,147,296	76	0.8200	5,860,783
1955	103,552	81	0.8575	88,796
TOTAL				10,879,439

TABLE 10.6

CALCULATION OF OBLIGATION VALUES FOR FEDERAL DEVELOPMENT PROJECT

(Assuming 100 years payment period)
(All monetary values in 1910 dollars)

Year	Nature of invest-ment.	Annual Value of Invest-ment. (A)	No. of Years still to be paid after 74. (N)	Appli-cable In. Rate[1]	Series Present Worth Factor	Obligation at the end of study period. (F x A)
1910	Federal	14,358	36	0.0473	17.136	246,038
1910	Non-Fed.	114,683	36	0.0481	16.958	1,947,890
1911	Federal	26,750	37	0.0473	17.317	463,249
1915	Federal	134,420	41	0.0473	17.963	2,414,586
1918	Federal	97,750	44	0.0473	18.374	1,796,120
1920	Non-Fed.	23,421	46	0.0517	19.960	467,489
1932	Federal	8,545	58	0.0368	23.833	203,654
1937	Federal	2,939	63	0.0274	29.849	87,726
1950	Federal	184,400	76	0.0232	35.561	6,557,452
1955	Federal	4,069	81	0.0284	31.567	128,448
Total Obligation						$14,312,652

Accumulated Profit =	147,319,210[2]
Salvage Value =	10,879,439[3]
Gross Present Worth	158,198,649
Obligation =	14,312,652
Net Present Worth	$143,885,997

[1]See Table A2, Appendix A.
[2]See Table 10.4.
[3]See Table 10.5

TABLE 10.7

ECONOMIC FEASIBILITY COMPARISON OF DIFFERENT NON-FEDERAL ALTERNATIVES AND HISTORIC FEDERAL PROJECT

Alternative I: Initial Target Area = 96,652 acres. Storage = 0 acre feet. Min. Rel. = 0 acre feet.

Alternative II-A: Initial Target Area = 174,000 acres. Storage = 0 acre feet. Min. Rel. = 0 acre feet.

Alternative II-B: Initial Target Area = 174,000 acres. Storage = 200,000 acre feet. Min. Rel. = 3,000 Ac ft/M

Alternative III: Initial Target Area = 330,000 acres. Storage = 1,157,000 acre feet. Min. Rel.= 3,000 Ac ft/M

Plan	Conditions for Expansion	Alternative	Amount in Million Dollars (Base Year - 1910)				
			Initial Investment	Accumulated Profit up to 1974	Obligation Beyond 1974	Salvage Value - 1974	Net Present Worth - 1974
A(10)	Run the system for 10 years. Increase target area by 10% if the total shortage during 10 years is less than 50%. Increase storage if shortage is greater than 100 %. Repeat every year.	I	1.1	121.9	28.4	25.0	118.5
		II-A	1.9	109.5	26.5	21.2	104.2
		II-B	4.6	102.1	22.2	18.7	98.6
		III	18.9	- 47.9	23.2	18.4	- 52.7
A(5)	Same as A(10) except that period under consideration is 5 years instead of 10. Run for 5 years.	I	1.1	111.2	17.0	14.1	108.3
		II-A	1.9	154.6	25.8	22.5	151.3
		II-B	4.6	93.7	19.8	18.1	92.0
		III	18.9	- 42.1	23.8	18.9	- 47.0
B(5)	Increase storage by 20,000 Acre ft. if equiv. irrigated area is less than 80%, otherwise increase target area by 10,000 acres. Repeat every 5 years.	I	1.1	59.6	5.4	1.8	56.0
		II-A	1.9	92.3	7.6	6.9	91.6
		II-B	4.6	55.8	7.4	6.3	54.7
		III	18.9	- 48.8	16.9	13.0	- 52.7
C(5)	Same as B(5) except that increase in storage is equal to average shortage during last 5 years and increase in Target Area is by 10%.	I	1.1	51.5	2.9	2.4	51.0
		II-A	1.9	60.1	6.2	5.8	59.7
		II-B	4.6	49.6	7.4	6.8	49.0
		III	18.9	- 42.8	20.9	16.7	- 47.0

N(5)	No increase	I	1.1	37.4	0.9	1.1	37.6
		II-A	1.9	47.0	1.6	2.0	47.4
		II-B	4.6	31.1	3.8	3.4	30.7
		III	18.9	- 54.4	15.6	11.8	- 58.2
O(5)	Run for 5 years. If benefits exceed costs, increase the area and storage by suitable ratio until the gross profit is maximum.	I	1.1	188.9	28.8	24.8	184.9
		II-A	1.9	169.8	27.9	23.9	165.8
		II-B	4.6	134.8	27.6	23.5	130.7
		III	18.9	- 40.4	25.0	20.4	- 45.0
G(5)	For Alternative I - In 1910 Target Area = 96,652 acres. Storage = 0 acre feet. In 1940, Target Area = 330,000 acres. Storage = 1,157,000 acre feet.	I	1.1	208.2	19.0	16.5	205.7
G(5)	For Alternative II-A: In 1910, Target Area = 40,000 acres. Storage = 0 In 1940, Target Area = 174,000 acres. Storage = 0 acre feet.	II-A	0.5	83.0	2.7	2.5	82.8
G(5)	For Alternative II-B: In 1910, Target Area = 40,000 acres. Storage = 0 acre feet. In 1940, Target Area = 174,000 acres. Storage = 200,000 acre feet.	II-B	0.5	101.1	5.4	4.7	100.4
G(5)	For Alternative II: In 1910, Target Area = 0, Storage = 0 In 1940, Target Area = 330,000 acres. Storage = 1,157,000 acre feet.	III	18.9	226.3	16.6	13.9	223.6
F.0	Lands receiving only Federal Project water.		0.3	109.9	11.9	9.4	107.4
F.D.	Lands receiving both Federal Project water and water from other private arrangements.		23.9	147.3	14.3	10.9	143.9

TABLE 10.8

ECONOMIC, FINANCIAL AND ENGINEERING FEASIBILITIES COMPARISON OF FEDERAL AND NON-FEDERAL ALTERNATIVES

Altern-ative	Initial Invest-ment	Plan	Million Dollars (base year 1910) Net Present Worth	Maximum Gross Profit	Minimum Gross Profit	Maximum Target Area Achieved		Maximum Storage Capacity Achieved		Overall Average From 1910 - 1974		
(1)	(2)		(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)[1]
	(million dollars)					Thousand Acres	Year	Thousand Ac. Ft.	Year	Equiv. Ir. Area-Th.Ft.	Stor. Cap. Th.Ac.Ft.	Add'l Equiv. Irr. Area Per Unit Stor.-Ac/AcFt.
I	1.1	A(10)	118.5	118.5	-15.4	488	74	1,500	64	154	531	0.15
		A(5)	108.3	111.2	-12.6	367	69	1,500	72	136	271	0.23
		B(5)	56.0	59.6	-12.5	157	71	200	26	102	151	0.19
		C(5)	51.0	51.5	- 9.2	139	56	68	71	83	18	0.56
		G(5)	205.7	208.2	-11.0	330	40	1,157	40	244	632	0.27
		N(5)	37.6	37.4	- 9.1	97	10	0	10	73	0	-
		O(5)	184.9	188.9	-17.2	570	46	1,500	51	214	704	0.20
		F.O.	107.4	109.9	-18.0	217	69	1,157	56	176	667	0.15
		F.D.	143.9	147.3	-31.5	340	70	1,157	56	251	667	0.27
II-A	1.9	A(10)	104.2	109.5	-31.1	496	58	1,500	61	210	685	0.20
		A(5)	151.3	154.6	-19.7	451	53	1,500	61	207	634	0.21
		B(5)	91.6	92.3	-16.6	224	71	400	56	207	225	0.32
		C(5)	59.7	60.1	-13.3	174	10	171	71	108	58	0.60
		G(5)	82.8	83.0	-45.2	174	40	0	10	73	0	-
		N(5)	47.4	47.0	-12.8	174	10	0	10	97	0	-
		O(5)	165.8	169.8	-23.0	570	46	1,500	51	226	678	0.23
		F.O.	107.4	109.9	-18.0	217	69	1,157	56	176	667	0.15
		F.D.	143.9	147.3	-31.5	340	70	1,157	56	251	667	0.27

Table 10.8 (cont.)

Altern-ative	Initial Invest-ment	Plan	Million Dollars (base year 1910): Net Present Worth	Maximum Gross Profit	Minimum Gross Profit	Maximum Target Area Achieved		Maximum Storage Capacity Achieved		Overall Average From 1910 - 1974		
(1)	(2)		(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)[1]
	(million dollars)					Thousand Acres	Year	Thousand Ac. Ft.	Year	Equiv. Ir. Area-Th.Ft.	Stor. Cap. Th.Ac.Ft.	Add'l Equiv. Irr. Area Per Unit Stor.-Ac/AcFt.
II-B	4.6	A(10)	98.6	102.1	-31.6	373	55	1,500	60	216	761	0.19
		A(5)	92.0	93.7	-23.8	339	67	1,184	72	175	373	0.27
		B(5)	54.7	55.8	-27.5	234	71	400	26	167	350	0.27
		C(5)	49.0	49.6	-24.2	250	66	363	71	148	196	0.38
		G(5)	100.4	101.1	-49.6	174	40	200	40	93	107	0.19
		N(5)	30.7	31.1	-23.8	174	10	200	10	136	192	0.33
		O(5)	130.7	134.7	-31.5	570	46	1,500	51	242	788	0.21
		F.O.	107.4	109.9	-18.0	217	69	1,157	56	176	667	0.15
		F.D.	143.9	147.3	-31.5	340	70	1,157	56	251	667	0.27
III	18.9	A(10)	-52.7	-47.9	-88.3	483	54	1,500	59	310	1,250	0.19
		A(5)	-47.0	-42.1	-89.3	531	54	1,500	44	312	1,299	0.18
		B(5)	-52.7	-48.8	-88.3	390	71	1,157	71	286	1,157	0.18
		C(5)	-47.0	-42.8	-88.5	475	56	1,332	71	310	1,184	0.20
		G(5)	223.6	226.3	- 2.9	330	40	1,157	40	98	623	0.04
		N(5)	-58.2	-54.4	-88.3	330	10	1,157	10	294	1,157	0.19
		O(5)	-45.0	-40.4	-88.4	510	71	1,500	56	309	1,284	0.18
		F.O.	107.4	109.9	-18.0	217	69	1,157	56	176	667	0.15
		F.D.	143.9	147.3	-31.5	340	70	1,157	56	251	667	0.27

[1] Col. 12 = $\frac{\text{Col. (10)} - 73}{\text{Col. (11)}}$

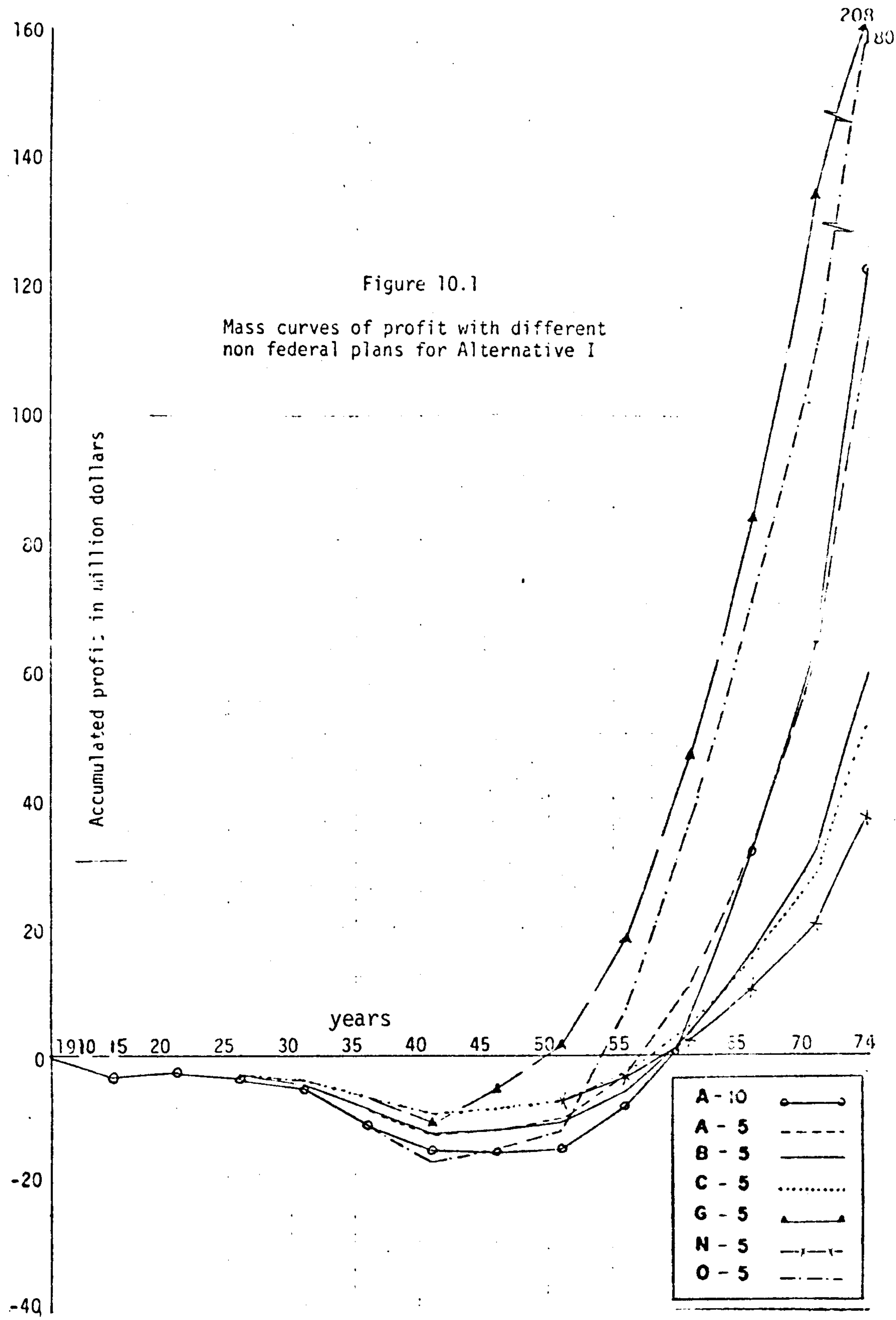


Figure 10.1
Mass curves of profit with different non federal plans for Alternative I
Accumulated profit in million dollars
years
160
140
120
100
80
60
40
20
0
-20
-40
1910
15
20
25
30
35
40
45
50
55
65
70
74
208
180
A - 10
A - 5
B - 5
C - 5
G - 5
N - 5
O - 5

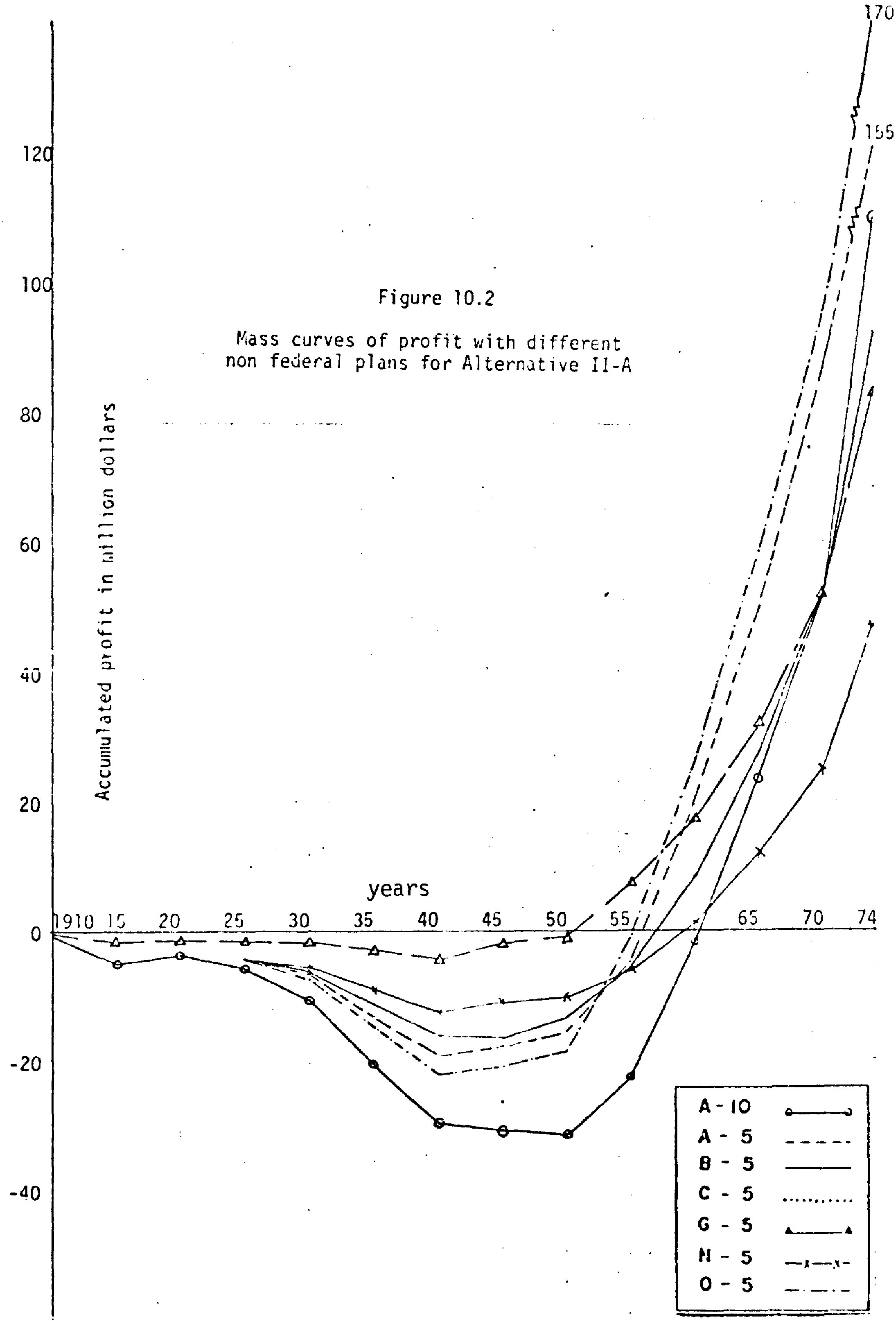


Figure 10.2
Mass curves of profit with different non federal plans for Alternative II-A
Accumulated profit in million dollars
years
170
155
120
100
80
60
40
20
0
-20
-40
1910 15 20 25 30 35 40 45 50 55 65 70 74
A - 10
A - 5
B - 5
C - 5
G - 5
N - 5
O - 5

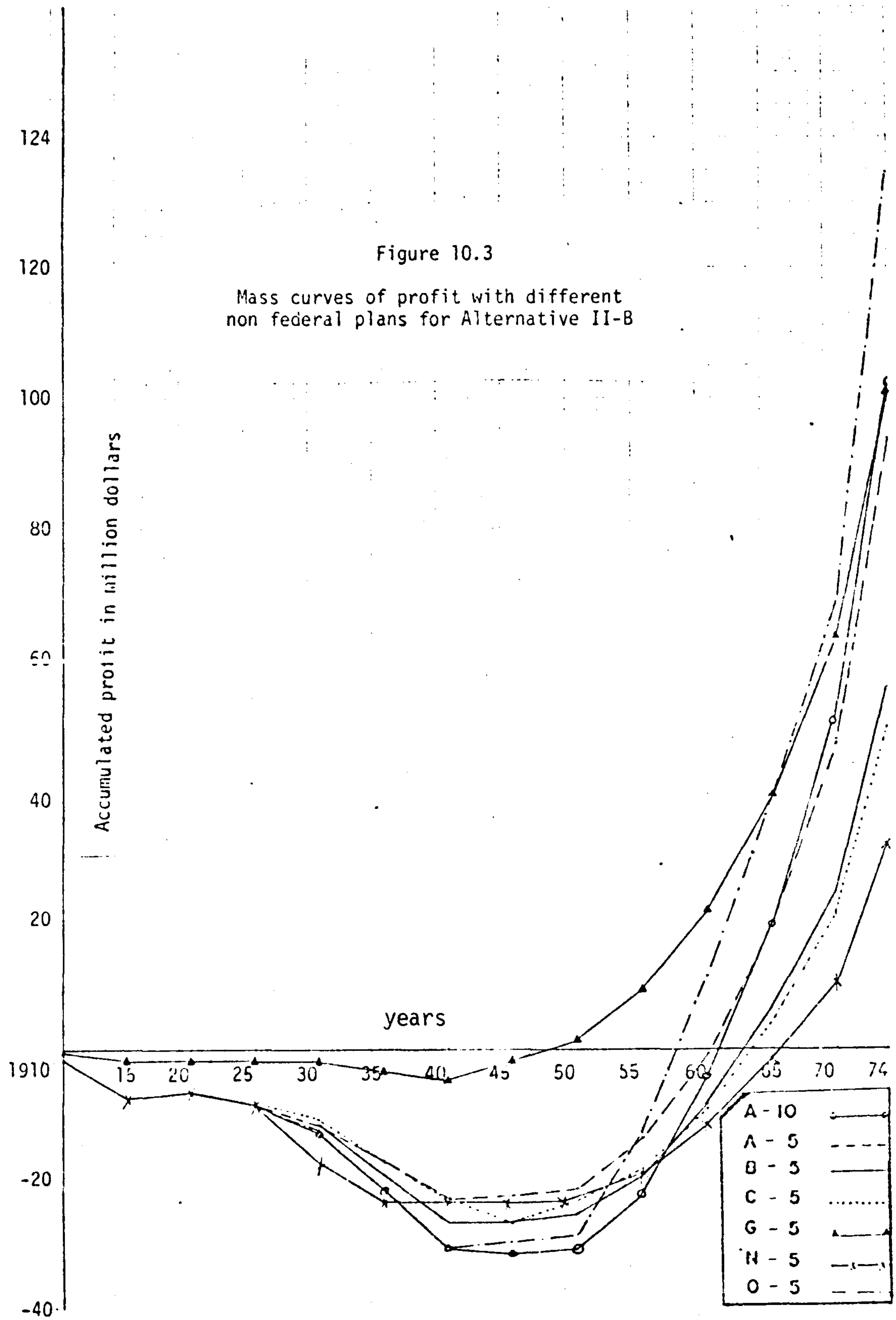
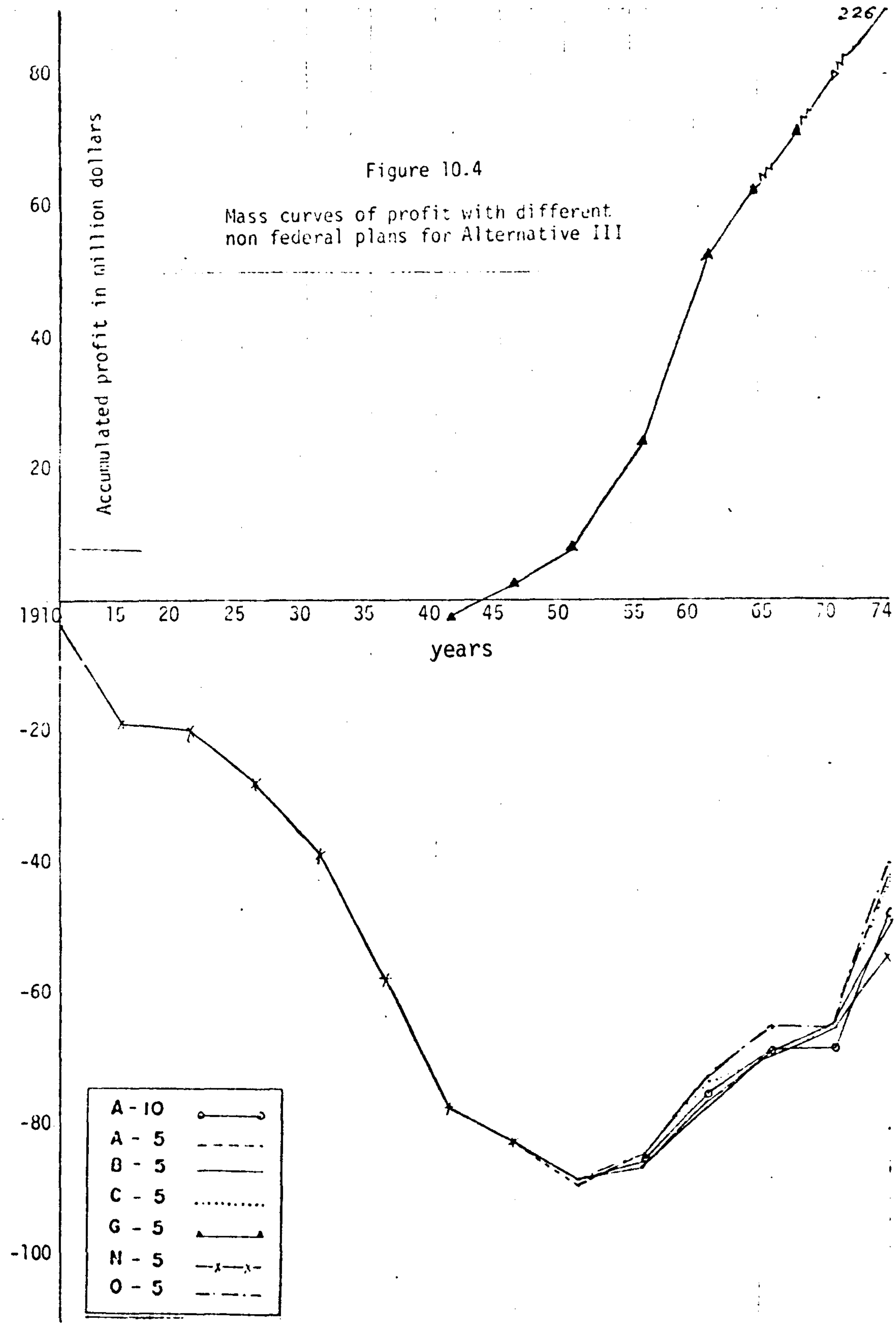


Figure 10.3

Mass curves of profit with different non federal plans for Alternative II-B

Figure 10.4

Mass curves of profit with different non federal plans for Alternative III



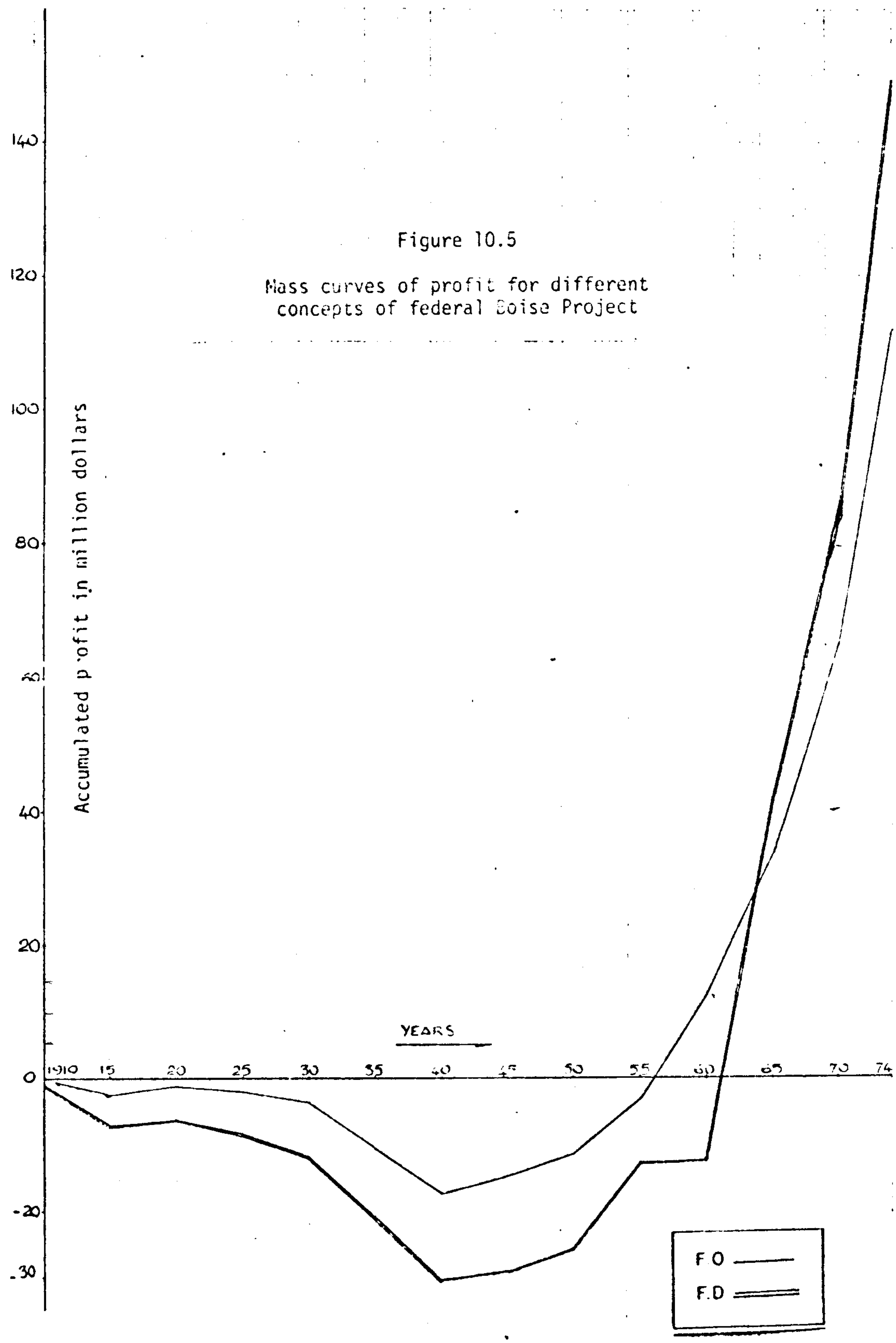


Figure 10.5

Mass curves of profit for different concepts of federal Boise Project

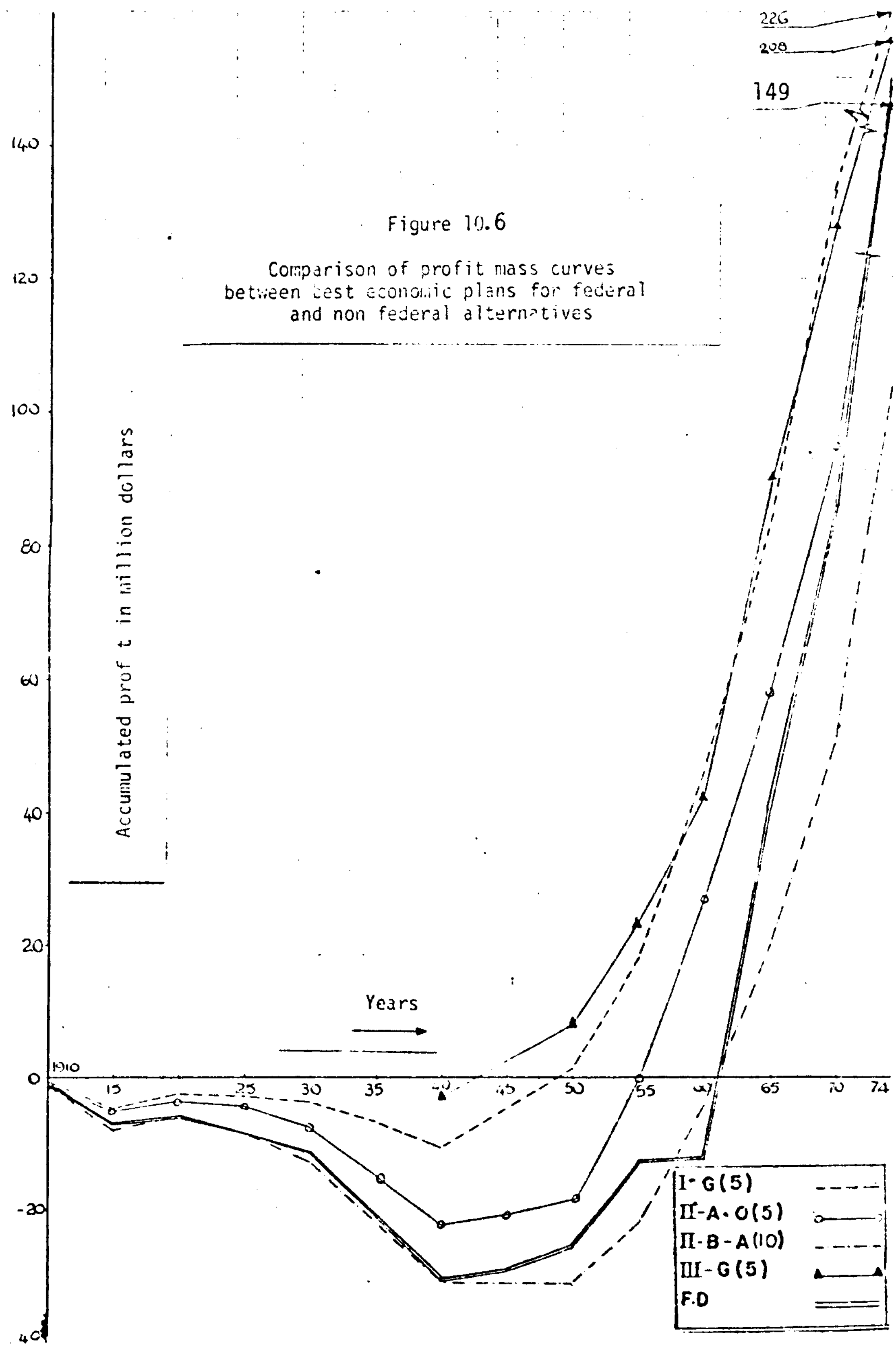


Figure 10.6

Comparison of profit mass curves between best economic plans for federal and non federal alternatives

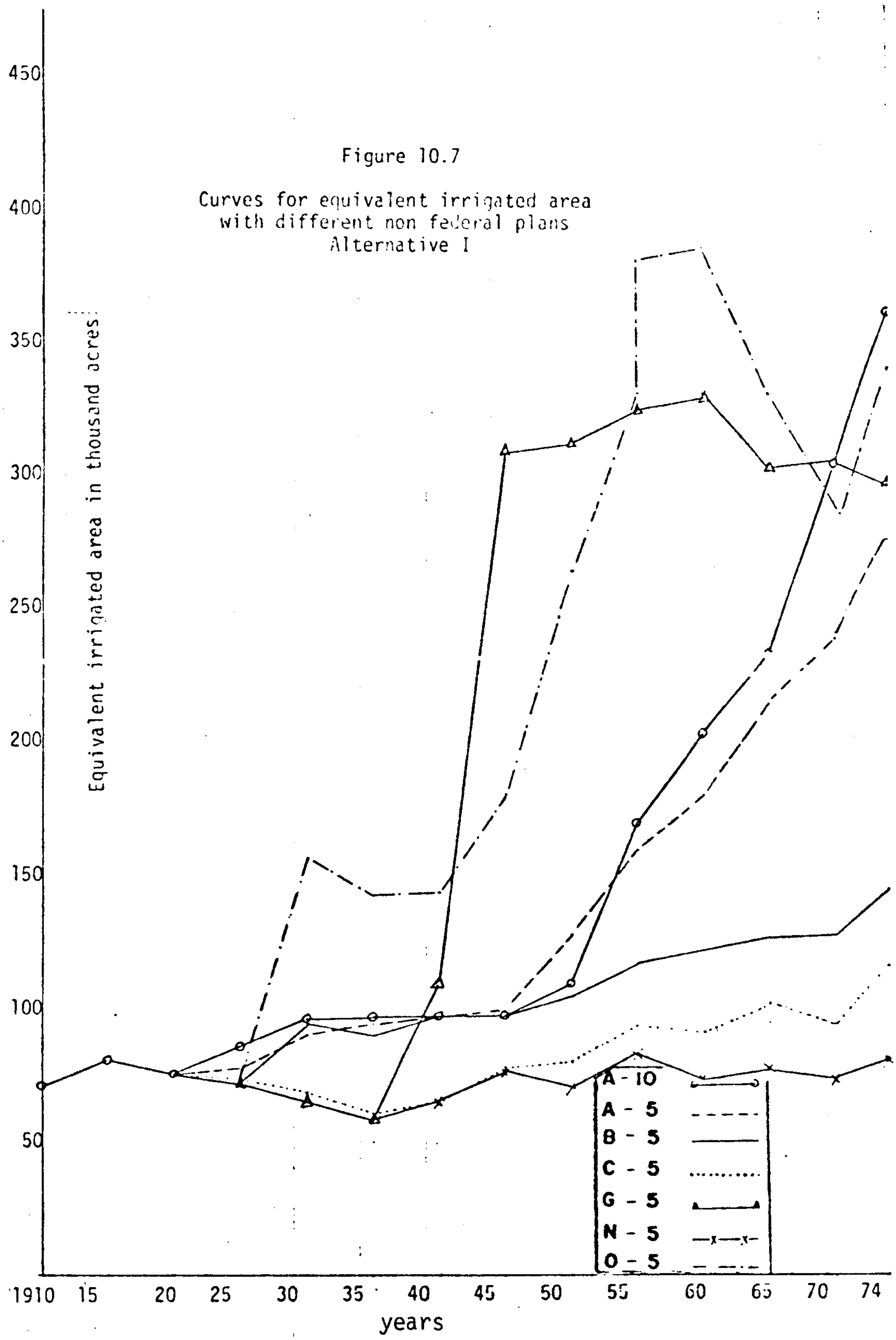


Figure 10.7
Curves for equivalent irrigated area
with different non federal plans
Alternative I
Equivalent irrigated area in thousand acres
450
400
350
300
250
200
150
100
50
1910
15
20
25
30
35
40
45
50
55
60
65
70
74
years
A - 10
A - 5
B - 5
C - 5
G - 5
N - 5
O - 5

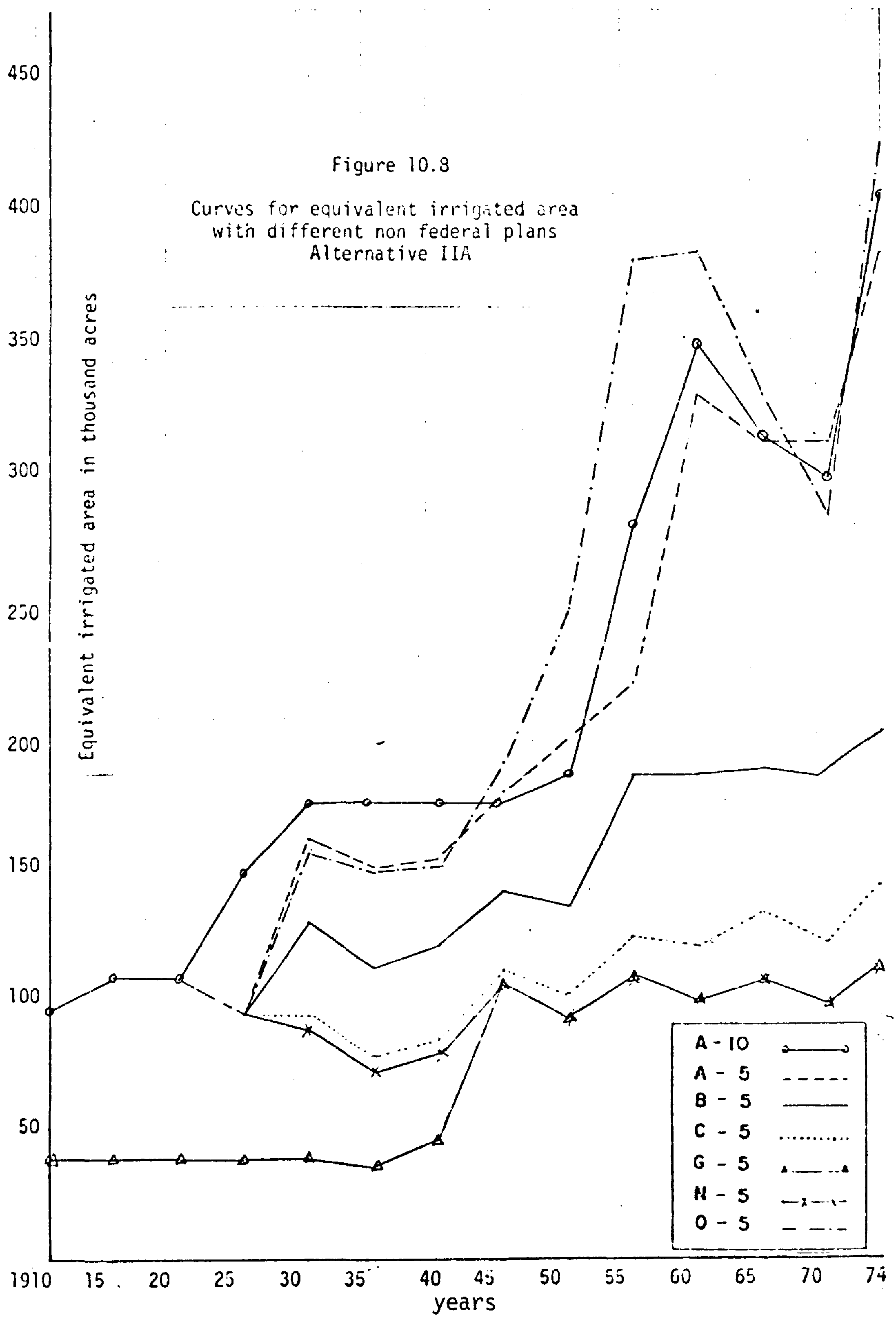


Figure 10.8
Curves for equivalent irrigated area
with different non federal plans
Alternative IIA
Equivalent irrigated area in thousand acres
450
400
350
300
250
200
150
100
50
1910
15
20
25
30
35
40
45
50
55
60
65
70
74
years
A - 10
A - 5
B - 5
C - 5
G - 5
N - 5
O - 5

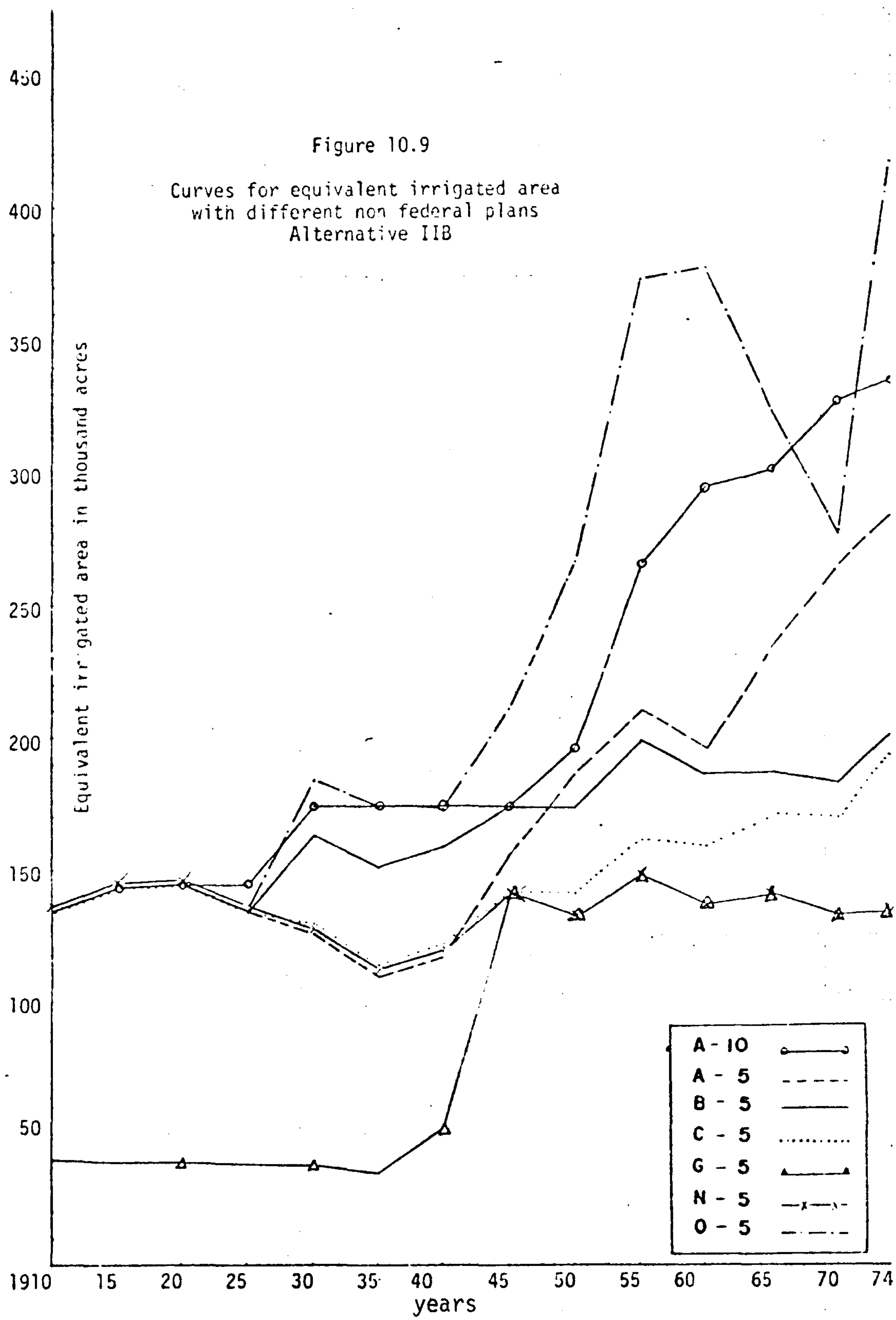


Figure 10.9

Curves for equivalent irrigated area with different non federal plans Alternative IIB

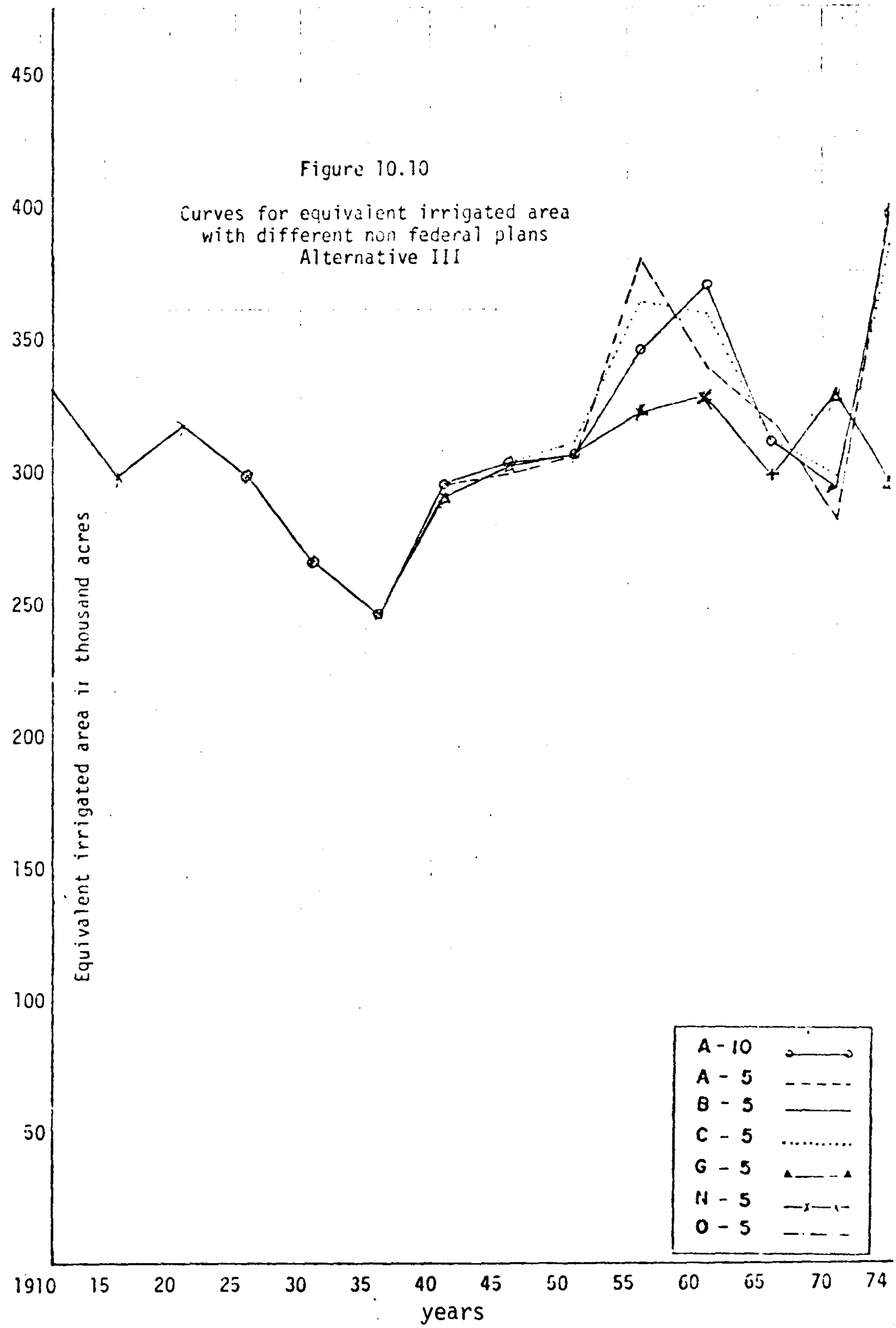


Figure 10.10

Curves for equivalent irrigated area with different non federal plans Alternative III

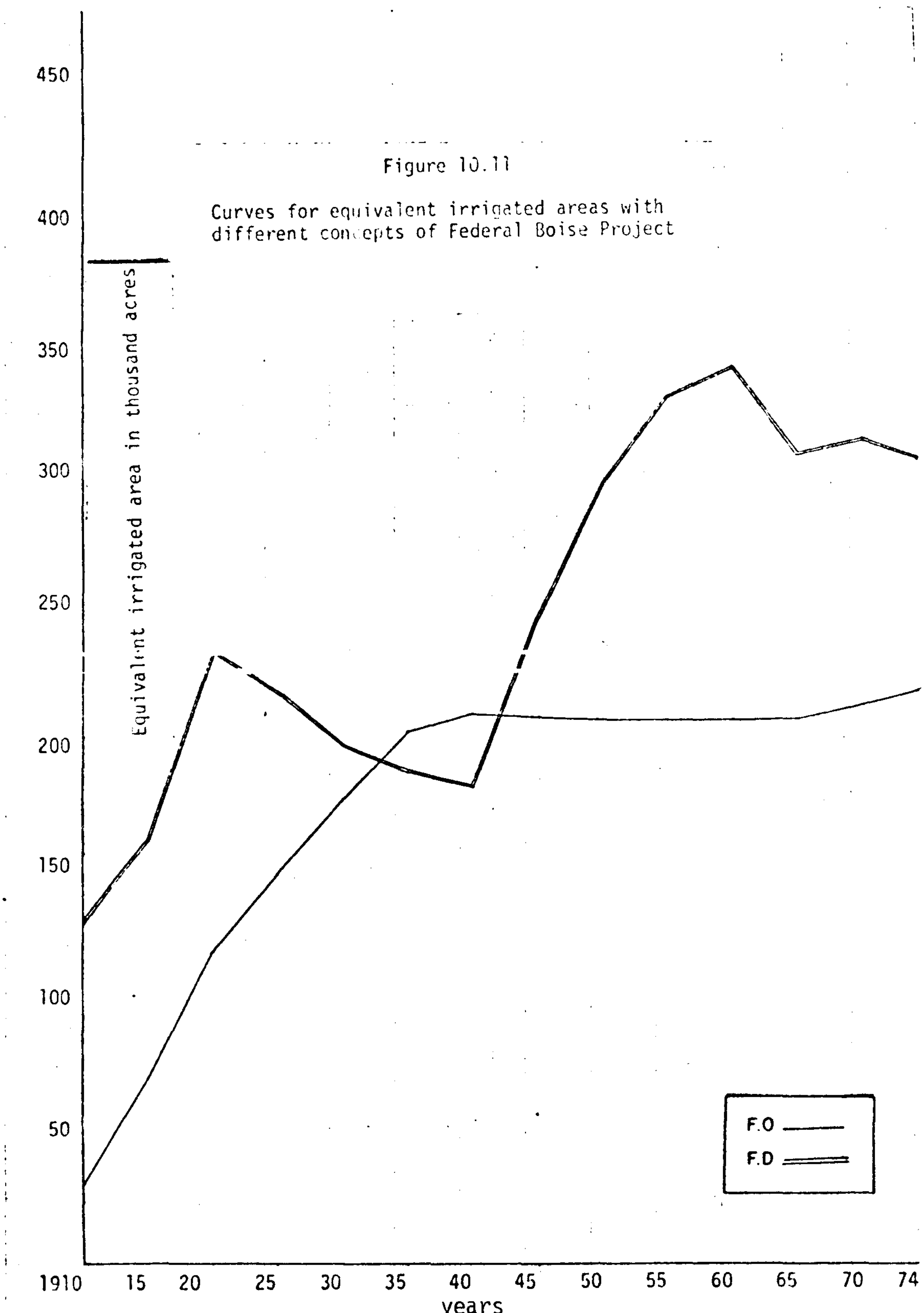


Figure 10.11
Curves for equivalent irrigated areas with different concepts of Federal Boise Project
Equivalent irrigated area in thousand acres
450
400
350
300
250
200
150
100
50
1910
15
20
25
30
35
40
45
50
55
60
65
70
74
years
F.O
F.D

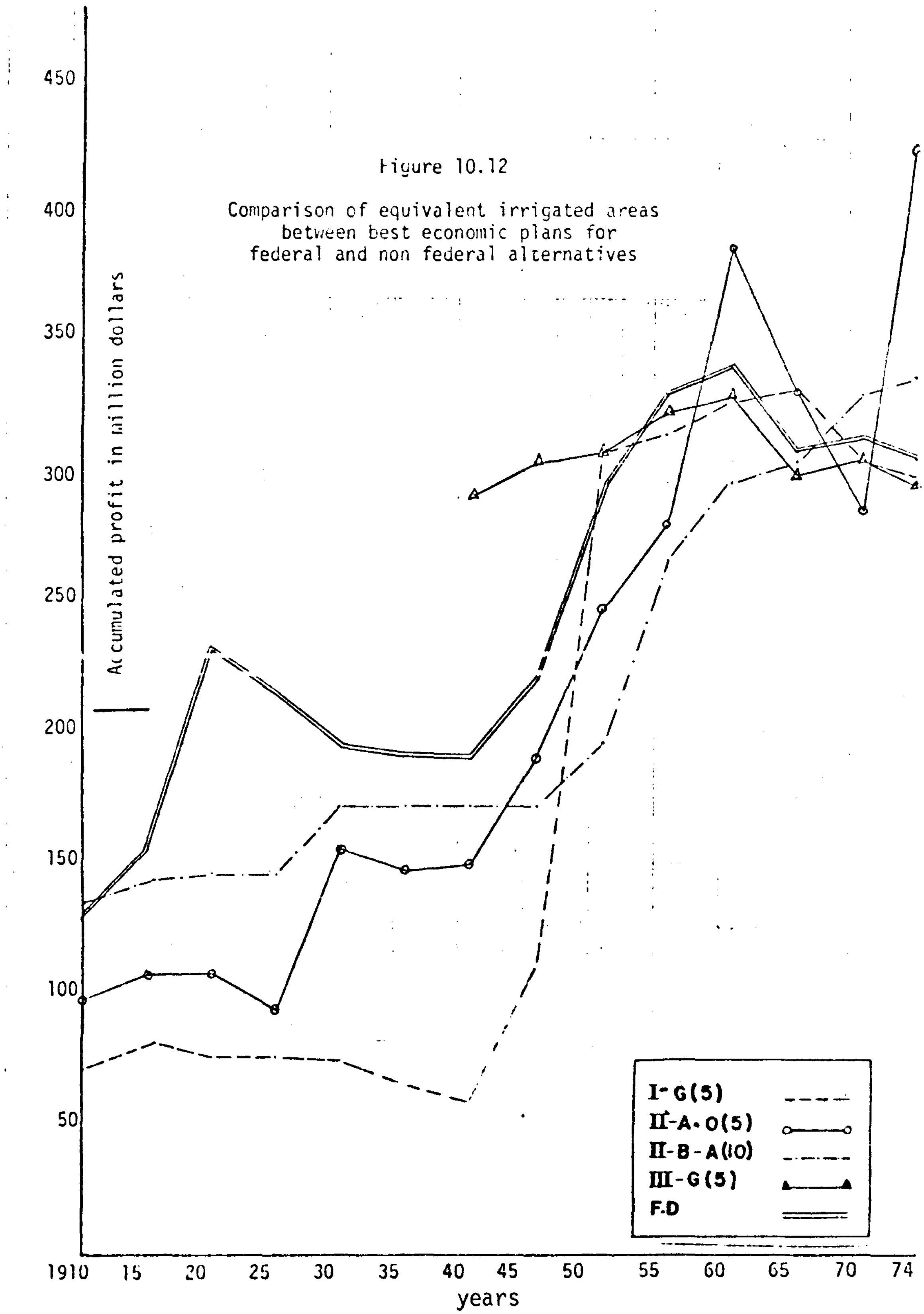


Figure 10.12
Comparison of equivalent irrigated areas
between best economic plans for
federal and non federal alternatives
Accumulated profit in million dollars
450
400
350
300
250
200
150
100
50
1910
15
20
25
30
35
40
45
50
55
60
65
70
74
years
I-G(5)
II-A.O(5)
II-B-A(10)
III-G(5)
F.D

CHAPTER 11

DISCUSSION OF FINANCIAL AND SOCIAL FEASIBILITIES OF NON-FEDERAL ALTERNATIVES

In the earlier chapters, engineering, economic and financial feasibilities of the various possible non-federal alternatives were studied. These studies were done on the assumption that sufficient funds and social support could be arranged in the early part of the twentieth century for initial installation of non-federal projects. In this chapter it is proposed to discuss the actual and historical reality of the situation with regard to financial and social feasibilities.

Apart from the federal government, alternative agencies for building any irrigation project, either independently or in cooperation with each other could be (i) farmers or settlers of the land, (ii) private capitalists, (iii) state agencies.

Taking these groups one by one, the farmers by their individual and cooperative efforts were able to develop lands, generally adjacent to the rivers, which did not require lengthy canal diversions or storage reservoirs. But soon such lands were exhausted, and substantial amounts of money were required to bring more lands under irrigation and to assure consistent supplies of water even for the land already developed.

the limitations of the Carey Act were recognized very early as is evident from the following remarks contained in "Irrigation Under the Provisions of the Carey Act", United States Department of Agriculture Circular No. 121 (1919):

> *"The development reached its crest about 1910 or 1911 and ceased almost entirely in 1913, following the failure of a large banking house which was financing several of the principal projects under construction.*
>
> *A number of projects proposed were found to have an insufficient water supply and others were unable to secure sufficient capital for their construction, and the lands were consequently restored to entry before the construction stage was reached. A few others were begun, but abandoned after considerable work had been done. Some of the completed projects were found to contain a larger acreage than could be irrigated with existing water supply, and others had land under the canals which was found to be unacceptable for agriculture for one cause or another. As a result of all this, the area included in existing projects has been greatly reduced . . ."*

With the above facts, it is no wonder that out of sixty five projects proposed in Idaho from 1895 to 1930, only four projects were completed and are continuing in operation, as revealed in "The History of Development and Current Status of the Carey Act in Idaho", Idaho Department of Reclamation (1970). While detailing the circumstances leading to the virtual cessation of any development under the Carey Act, this report points out that:

> *"After a substantial number of failures of construction companies, it became increasingly difficult to finance a Carey Act project or to complete those already under construction. In the early 1900's, the problem became so acute that it was almost impossible to sell bonds to general public, or to find people willing to invest as stockholders in a construction company."*

The above facts are sufficient to say that barring direct federal action, the construction of irrigation projects had become financially infeasible, and in a way socially infeasible too, because no doubt people were anxious to have these projects built, but their faith in purely private or state ventures had been so badly shaken that they preferred to stay away from them.

CHAPTER 12

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The methodology adapted in this study consisted mainly of comparing the primary economic benefits of areas which could be actually irrigated with different federal and possible non-federal alternatives of the Boise Project. This was done by making hydrologic operation studies with the historic instream flows and the irrigation diversion demands according to a cropping pattern comparable with the actual pattern adopted in the project area during the period of study (1910-1974).

Thus, the present thesis has been mainly a post audit of irrigation aspects of the Federal Boise water development project for the period from 1910 to 1974. For the purpose of irrigation development, this period may be broadly divided into two portions. The first portion may be considered from 1910 to 1939, which was generally marked with depressed economic conditions and a decade of low instream flows. The second portion was from 1940 to 1974, with prosperous economic conditions and generally good instream flows. The conclusions arrived at in this study are valid for this sequence of events and may or may not be valid for a different order or magnitude of the good or bad economic conditions and streamflows.

Secondly, it may be emphasized that the conclusions are based on the case study of irrigation aspects only of a federal multipurpose project. Different results may come out from the overall study of other multipurpose federal projects. Within the framework of the above assumptions the following conclusions can be made:

1. A useful methodology of simultaneously combining hydrologic and water supply operations analysis with financial and economic analysis of a water development project has been developed. This methodology is in accord with "The Principles and Standards" specified by the U.S, Water Resource Council concerning evaluation of "conditions expected without" the federal expenditure.
2. The performance of the federal project from engineering, economic and financial points of view has been better than most of the non-federal alternatives considered in this study.
3. The economic and financial efficiency of the federal project could be improved appreciably (up to 43% for F.D. and 100% for F.O.) by either delaying the installation of the project until 1940 or by continuing a small sized project from 1910 to 1939 and then expanding it to the present size in 1940 and years shortly thereafter. In short, with the sequence of events which occurred from 1910-74, installation and continuation of smaller sized projects in the first half and expansion of the same to the maximum size in the latter half would have been a

better economic and financial policy than the Federal project. However, it has been pointed out that the social and financial reality of such expansion through non-federal development did not exist at the time the Federal project was installed.

4. The engineering, economic and financial efficiency of any irrigation project is very sensitive to the following three factors:
   a. the initial size of the project,
   b. the time of installation of the project,
   c. the criteria adapted for increase of the project size.
5. For selection of projects from among different available alternatives, it is essential to examine the economic, engineering and financial efficiencies simultaneously. Selection of any alternative by considering only one or two efficiencies may lead to wrong choices.
6. Above all, the methodology presented here supports the idea that "with and without" aspect of analysis of any irrigation project is essential to have a true picture of its merits and demerits. Thus, high net present worth of the Federal project in 1974 ($149 million in 1910 dollars for federal development project), may appear to be a very sound investment; yet in economic terms this would not have been the best choice, because there were other available alternatives with a net present worth

of 226 million dollars. Similarly, the accumulated loss of 25 million dollars by 1941 for the Federal development project makes it look very unproductive, yet this was not the worst situation, because with other non-federal alternatives, losses suffered could have been more severe [$88 million by 1941 in the case of Alternative III, Plan A (10)].

Recommendations

Some useful conclusions and findings have come out of the present thesis which is a case study of only one federal project. In order to confirm these conclusions and to use them profitably for future planning, the following recommendations are made:

1. More case studies of both federal and non-federal projects be made to conclude which type of arrangement has proved more efficient in the irrigation field.
2. This study was restricted to consideration of only irrigation aspects of the federal and non-federal alternatives. It would be much more informative if similar studies could be including all the multipurpose aspects such as irrigation, flood control, power, fisheries and recreation, and considering the oeverall engineering, economic and financial efficiencies of different federal and non-federal alternatives. It is

pointed out that this broader approach is already underway by other groups here at the University of Idaho.

3. During these studies it was observed that the generally recommended rule of thumb for shortage criteria for planning irrigation projects by the Pacific Northwest River Basins Commission did not always yield the best economic and financial results. Other criteria as adopted in this study proved better. The soundness of the PNWRBC rule thus has been put in doubt. Therefore, studies are recommended for either confirming the soundness of criteria presented in this thesis or devising better criteria for future planning.

4. The periods of relatively depressed economic situation from 1910 to 1940 and a rapid economic recovery from 1940 to 1974 have led to the conclusion that it would have been advisable to install very small size projects during the first period. This finding could have been very different if the sequence of events had been in the reverse order or if the economic depression had lasted for a different length of time. It is therefore useful for planning purposes to know the expected sequence of future events for as long a period as possible. Therefore, it would be a welcome step if the economists could devise new ways and means to make economic projections or at least indications for a decade or so instead of for one or two coming years.

APPENDIX A

DATA USED IN BENEFIT COST ANALYSIS

TABLE A1

CROP BUDGETS

Net Value Per Acre (1970 Dollars)

Crop	Gross Sale Value Per Acre ($)	Operation Cost: Seeds, Fertilizers & Chemicals	Operation Cost: Farm Machinery & Implements	Misc. Insurance, Taxes, etc.	Net Value Per Acre
(1)	(2)	(3)	(4)	(5)	(6)
Wheat	78.88	17.25	6.26	16.66	38.71
Hay	98.66	11.06	5.92	15.64	66.04
Pasture	32.69	5.00	1.75	2.58	23.36
Potatoes	416.88	83.02	22.35	32.08	279.43
Corn	109.88	21.10	11.24	8.73	68.81
Vegetables	257.31	45.94	10.21	10.25	190.91
Fruit	328.94	101.40	68.37	61.10	98.07

Example calculations for net value added per acre in 1970

Value added per acre = 0.20 x wheat + 0.130 x hay + 0.20 x pasture + 0.14 x corn + 0.08 x potatoes + 0.06 x vegetables + 0.02 x fruit

= 0.20 x 38.71 + 0.30 x 66.04 + 0.02 x 23.36 + 0.14 x 68.81 + 0.08 x 279.47 + 0.06 x 190.91 + 0.02 x 98.07

= $77.63 per acre

Depreciation = $20.07

Net value added per acre in 1970 $ = 77.63 - 20.02

= 57.56

Net value added per acre in 1910 $ = 57.56 x 0.3661

= $21.16

Sources: Column 1: Reclamation Bureau, "Crop Reports" 1910-1974. Columns 3, 4 and 5 based on Famure, O. "The Income Contribution of Agricultural Commodities for Idaho's Economy and the Economic Interrelationship in Agriculture: An Input-Output Model". Master's thesis, Department of Agricultural Economics, University of Idaho, March 1974.

TABLE A2

INDICES AND FACTORS USED IN BENEFIT-COST ANALYSIS

Year	Prices Received by Farmers Price Relative in 1910 Dollars	Prime Rate of Interest %	Long Term Government Bond Rate %	Labor Cost per Acre in 1910 $'s	Wholesale Price Relative in 1910 $'s
(1)	(2)	(3)	(4)	(5)	(6)
1910	1.0000	4.81	4.73	9.10	1.0000
1911	1.1081	4.81	4.73	9.00	1.0862
1912	1.0513	4.81	4.73	8.92	1.0225
1913	1.0250	4.81	4.73	8.85	1.0111
1914	1.0250	4.81	4.73	8.78	1.0341
1915	1.0513	4.81	4.73	8.70	1.0168
1916	0.8723	4.81	4.73	8.60	0.8254
1917	0.5857	4.81	4.73	8.52	0.6007
1918	0.5062	4.81	4.73	8.45	0.5258
1919	0.4824	4.81	4.73	8.38	0.5098
1920	0.4940	5.17	5.32	8.30	0.4573
1921	0.8367	5.31	5.09	8.22	0.7237
1922	0.7885	4.85	4.30	8.15	0.7295
1923	0.8039	4.68	4.06	8.00	0.7013
1924	0.7321	4.69	4.06	8.00	0.7208
1925	0.6721	4.50	3.86	7.90	0.6829
1926	0.7193	4.40	3.34	7.82	0.7096
1927	0.7455	4.30	3.34	7.73	0.7383
1928	0.7069	4.05	3.33	7.67	0.7280
1929	0.7069	4.45	3.60	7.60	0.7413
1930	0.8367	4.40	3.29	7.52	0.8161
1931	1.2059	4.10	3.34	7.46	0.9681
1932	1.5769	4.70	3.68	7.40	1.0833
1933	1.4643	4.10	3.31	7.30	1.0706
1934	1.1714	3.91	3.12	7.25	0.9430
1935	0.9535	3.37	2.79	7.18	0.8814
1936	0.9111	3.04	2.69	7.10	0.8729
1937	0.8542	2.90	2.74	7.05	0.8180
1938	1.0789	2.91	2.61	6.85	0.8988
1939	1.1081	2.65	2.41	6.67	0.9146
1940	1.0513	2.55	2.26	6.50	0.8988
1941	0.8367	2.61	2.05	6.30	0.8071
1942	0.6508	2.61	2.46	6.10	0.7151
1943	0.5395	2.60	2.47	5.90	0.6829
1944	0.5256	2.55	2.48	5.70	0.6791
1945	0.5062	2.35	2.37	5.55	0.6667
1946	0.4409	2.35	2.19	5.40	0.5843
1947	0.3761	2.40	2.25	5.20	0.4758

(contd.)

Table A2 continued

Year	Prices Received by Farmers Price Relative in 1910 Dollars	Prime Rate of Interest %	Long Term Government Bond Rate %	Labor Cost per Acre in 1910 $'s	Wholesale Price Relative in 1910 $'s
(1)	(2)	(3)	(4)	(5)	(6)
1948	0.3628	2.73	2.44	5.05	0.4396
1949	0.4184	2.62	2.31	4.90	0.4625
1950	0.4020	2.48	2.32	4.75	0.4450
1951	0.3445	2.59	2.57	4.60	0.3996
1952	0.3628	2.88	2.68	4.40	0.4108
1953	0.4100	3.05	2.94	4.30	0.4165
1954	0.4227	3.88	2.55	4.15	0.4155
1955	0.4505	2.95	2.84	4.00	0.4146
1956	0.4505	2.99	3.03	3.80	0.4013
1957	0.4457	3.50	3.47	3.68	0.3881
1958	0.4184	3.47	3.43	3.60	0.3848
1959	0.4316	4.10	4.07	3.48	0.3840
1960	0.4362	4.55	4.01	3.40	0.3836
1961	0.4362	4.12	3.90	3.28	0.3852
1962	0.4271	4.40	3.95	3.18	0.3850
1963	0.4271	4.20	4.00	3.08	0.3852
1964	0.4409	4.33	4.15	2.98	0.3844
1965	0.4184	4.35	4.21	2.88	0.3768
1966	0.3905	5.00	4.66	2.77	0.3647
1967	0.4100	6.00	4.85	2.65	0.3640
1968	0.3981	6.00	5.25	2.55	0.3551
1969	0.3727	6.77	6.10	2.50	0.3418
1970	0.3661	7.60	6.59	2.50	0.3297
1971	0.3831	7.12	5.74	2.48	0.3196
1972	0.3565	7.05	5.63	2.46	0.3056
1973	0.2500	7.20	6.30	2.45	0.2702
1974	0.1925	7.20	6.30	2.44	0.2274

Sources: Columns 1 and 5 - Agricultural Statistics, United States Department of Agriculture.
Columns 2 and 3 - Historical Statistics of the United States
Column 4 - Based on Labor Price Index, Labor hours per acre for different crops. Tables 648,666, "Agricultural Statistics", United States Department of Agriculture, 1972.

TABLE A3

NET VALUES ADDED PER ACRE OF EQUIVALENT IRRIGATED AREA FOR NON FEDERAL ALTERNATIVES

Year	Total Value Added in Current Dollars	Effective Irrigated Area in Acres	Value Added Per Acre In Current Dollars	Value Added Per Acre in 1910 Dollars	Operation and Maintenance Cost Per Acre In Current Dollars	Operation and Maintenance Cost Per Acre in 1910 Dollars	Net Value Added Per Acre in 1910 Dollars
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1910	98,299	51,824	1.897	1.897	0.93	0.93	0.967
1911	181,051	58,059	3.118	3.455	0.90	0.98	2.475
1912	146,598	61,103	2.399	2.523	0.85	0.87	1.653
1913	261,926	64,072	4.088	4.190	1.40	1.42	2.770
1914	336,260	54,390	6.182	6.336	0.97	1.00	5.336
1915	253,404	37,894	6.687	7.030	0.84	0.85	6.180
1916	1,125,618	65,778	17.112	14.927	1.13	0.93	13.997
1917	1,641,698	60,393	27.184	15.922	1.24	0.74	15.182
1918	1,520,522	52,122	29.172	14.767	1.27	0.68	14.087
1919	1,067,783	33,707	31.678	15.281	0.98	0.50	14.781
1920	694,084	37,579	18.470	9.124	1.17	0.54	8.584
1921	520,514	53,790	9.677	8.097	1.16	0.84	7.257
1922	923,565	53,792	17.169	13.537	0.84	0.61	12.928
1923	741,422	53,745	13.795	11.089	0.77	0.54	10.550
1924	193,466	22,616	8.554	6.262	0.80	0.58	5.682
1925	740,286	46,994	15.753	10.588	0.71	0.48	10.108
1926	230,255	28,572	8.059	5.797	0.45	0.32	5.476
1927	560,418	40,854	13.718	10,226	0.40	0.30	9.926
1928	556,461	40,849	13.622	9.629	0.67	0.48	9.149
1929	482,464	33,070	14.589	10.313	0.86	0.64	9.672
1930	294,452	41,594	7.079	5.923	0.68	0.55	5.373
1931	46,964	22,179	2.117	2.553	0.52	0.50	2.053
1932	-32,254	35,507	-0.908	-1.432	0.53	0.57	-2.002
1933	172,857	35,509	4.868	7.128	0.51	0.55	6.578
1934	132,026	21,824	6.050	7.087	0.58	0.55	6.537
1935	197,312	35,237	5.600	5.339	0.58	0.51	4.829
1936	232,320	37,459	6.202	5.651	0.66	0.58	5.071
1937	162,117	24,026	6.748	5.764	0.75	0.61	5.703
1938	94,623	33,722	2.806	3.027	0.64	0.58	2.448
1939	51,926	26,343	1.971	2.184	0.71	0.65	1.534
1940	84,334	28,526	2.956	3.108	0.66	0.59	2.518
1941	306,893	33,599	9.134	7.642	0.64	0.52	7.122
1942	648,697	33,605	19.304	12.563	0.63	0.45	12.113
1943	914,953	33,597	27.233	14.692	0.62	0.42	14.272
1944	976,895	38,069	25.661	13.488	0.83	0.56	12.928
1945	1,012,289	39,492	25.633	12.975	0.82	0.55	12.425
1946	1,026,949	39,489	26.006	11,466	1.07	0.63	10.836
1947	1,438,623	42,748	33.654	12.657	1.16	0.55	12.107
1948	1,533,050	41,307	37.114	13.465	1.36	0.60	12.865
1949	1,161,484	38,074	30.506	12.764	1.90	0.88	11.884
1950	1,077,394	44,105	24.428	9.821	1.84	0.82	9.000
1951	2,272,111	44,135	51,481	17.735	1.74	0.70	17.035
1952	3,825,518	45,721	83,671	30.356	1.65	0.68	29.676
1953	596,476	45,726	13,045	5.348	1.63	0.68	4.668
1954	1,597,174	48,404	32,997	13,948	1.54	0.64	13.308
1955	1,451,184	45,769	31.707	14,284	1.92	0.80	13.484
1956	2,710,179	50,592	53.570	24.133	2.22	0.89	18.631
1957	1,830,934	41,890	43.708	19.481	2.20	0.85	18.631
1958	1,446,618	49,811	29.042	12.151	1.91	0.73	11.421
1959	2,020,225	39,058	51.724	22.324	1.99	0.76	21.564
1960	2,360,581	36,902	63.969	27.903	3.63	1.39	26.513
1961	1,671,681	32,306	54.531	23.786	1.98	0.76	23.026
1962	2,357,461	46,332	50,882	21.732	2.98	1.15	20.582
1963	2,196,441	42,992	51.090	21.821	3.02	1.16	20.660
1964	2,245,383	40,397	55.583	24.506	3.41	1.31	23.196
1965	2,632,353	46,652	56.425	23.608	3.58	1.35	22.258
1966	2,171,778	31,494	68.958	26.928	3.63	1.32	25.608
1967	1,838,168	39,597	46.422	19.033	4.04	1.47	17.563
1968	2,137,640	43,797	48.808	19.430	3.90	1.33	18.050
1969	2,679,165	41,354	64.786	24.146	3.87	1.32	22.826
1970	2,626,910	45,638	57.560	21.072	4.12	1.36	19.713
1971	4,368,142	48,447	90.163	34.541	4.62	1.48	33.061
1972	5,292,930	48,973	108.078	38.530	4.77	1.46	37.070
1973	4,550,760	33,766	134.773	33.693	5.23	1.41	32.283
1974	6,561,535	48,758	134.574	25.905	5.64	1.28	24.625

Sources: Columns 2 and 3: Based on Boise River System Model of "An Economic Scenario of the Boise and Payette Valleys "Without" a Federal Irrigation Project" by T. Nelson and C.C. Warnick, Department of Agricultural Economics, University of Idaho, Moscow, 1976.

Column 4: Column 2 ÷ Column 3.

Column 5: Column 4 x Farmer's Price Relative from Table A-2.

Column 6: Based on Table 16 "Economics of Subproject Report of A Dynamic Regional Impact Analysis of Federal Expenditure on a Water and Related Land Resource Project: The Boise Project, Idaho and Oregon" by Department of Agricultural Economics, University of Idaho, 1976.

Column 7: Column 6 x Wholesale Price Relative from Table A-2.

Column 8: Column 5 - Column 7.

APPENDIX B

SOME COMPUTER PROGRAMS AND SAMPLE PRINTOUTS USED IN THE STUDY

COMPUTER PROGRAM

PLAN A (10)

This program makes the following computations:

1. Calculates the monthly irrigated areas according to the instream flows, storage capacity and target area of the alternative under study.
2. Calculates the annual equivalent irrigated area from the monthly irrigated areas.
3. Calculates the benefits, costs, profit, interest on profit and accumulated profit on the basis of equivalent irrigated area, and initial project cost based on its size.
4. Repeats the process for ten years.
5. Increases the project size on the basis of average equivalent irrigated area and accumulated profits for 10 years as per conditions specified for Plan A (10).
6. Repeats the process for next year and increases the project size on the basis of ten years immediately preceding the current year if warranted by conditions of Plan A (10).

```
$JOB DALJIT (XXXXXXX,241-19-8997)
   C       PROGRAM FOR OPERATION STUDY AND COMPUTATION OF BENIFITS ACCORDING TO PACI
   C      FIC NORTH WEST COMMISSION CRITERIA I.E PLAN A (10)
   C      RESERVE  STORAGE  FOR DIFFERENT  PARAMETERS
1  10     DIMENSION Q(12),F(12),WUF(12),AIRR(72),USAGE(12),C1(12),C2(12)
         *,DSTOR(12),ENT(73)
2         DIMENSION ERRAC(70),VA(70),TVA(70),ECC(70),PLI(73),OMC(70)
         *,YCEF(70),AR(12),VAA(70)
         *,COST(70),GVA(70),PROF(70)
         *,YDEM(70)
3  20     WRITE(6,30)
4  30     FORMAT ('1',T9,'TABLE B-1 POSSIBLE NONFED IRRIGATION DEVELOPMENT'//
         */T9,'WITH3000ACFT.MINREL174000  ACRE INITIALIRRIGATION AND 200000
         *ACFT STORAGE'///T8,'WATER'
         *,8X,'INFLOW',11X,'PRAREA', 6X,'EQAREA',4X,'RES-CAP', 6X,
         *'BENFIT',6X,' COST ',11X,'INT ON PROFT',6X,'ACPROF '
         *//T9,'YEAR',8X,'(ACFT)',10X,'(ACRE)', 7X,'(ACRE)', 3X,'(ACFT)'
         *,8X,'DOLLARS',8X,'DOLLARS',10X,'DOLLARS',6X,'DOLLARS')
   C      IRS=NO OF YEARS OF OPERATION
5         IRS=0
   C      STOR=RESERVOIR CONTENTS
6         STOR=0
   C      J=NUMBER RELATING VARIABLE TO THE YEAR
7         J=0
   C      ADPROF=INTEREST ON PROFIT
8         ADPROF=0
   C      GPROF=GROSS PROFIT
9         GPROF=0
   C      CPA =COST PER ACRE
   C      CPAF=COST PER ACREFT OF RESERVOIR CAPACITY
10        READ,CPA,CPAF
   C      AREA=TARGET AREA
11 50     READ,AREA
   C      CAP= STORAGE CAPICITY OF RESERVOIR
   C      REL=MINIMUM  INSTREAM FLOW PER MONTH
12 40     READ,REL,CAP
   C      ERRAC(K)=AREA IRRIGATED AS PER TERRY NELSON,S UNPUBLISHED SCENERIO ON BOIS
   C      E PROJECT
13        READ(5,6)(ERRAC(K),K=1,65)
14 6       FORMAT(10F8.0)
   C      VA(K)=SALE VALUE OF CROPS MINUSCOST OF SEEDE FERTILIZERRS FARM MACHINERY E
   C      TC INCLUDING WATER CHARGES
15        READ(5,7)(VA(K),K=1,65)
16 7      FORMAT(10F8.0)
17        READ(5,9)(ECC(K),K=1,6)
18 9      FORMAT(10F8.4)
19        READ(5,9)(ECC(K),K=7,65)
   C      C1(K)=COSSUMPTIVE USE WATER REQUIREMENT PER ACRE FOR 3 CROP PATTERN
   C      C2(K)=CONSUMPTIVE USE WATER REQUIREMENT PER ACRE FOR 7 CROP PATTERN
20 60     READ(5,70) (C1(K),K=1,12),(C2(K),K=1,12)
21 70       FORMAT (12F5.2/12F5.2)
   C      ENT(K)=PRIME RATE OF INTEREST FOR THE YEAR K
22        READ (5,75) (ENT(K),K=1,6)
23 75     FORMAT (10F8.4)
24        READ (5,75) (ENT(K),K=7,65)
   C      PLI(K)=PRODUTIVITY OF LABOUR INDEX
25        READ(5,15) (PLI(K),K=1,12)
26 15     FORMAT(16F5.2)
27        READ(5,15) (PLI(K),K=13,65)
   C      OMC=OPCRATION CR MAINTENANCE COST
```

```
          READ (5,15) (OMC(K),K=1,12)
          READ (5,15) (OMC(K),K=13,65)
C         TPROF=TOTAL PROFIT PER CYCLE
          TPROF=0
C         NC=NUMBER OF YEARS INA CYCLE
          NC=69
C         SAIRR=SUM OF AREA ACTUALLY IRRIGATED
110       SAIRR=0.
C         SAREA=INITIAL PROJECT TARGET AREA
          SAREA=174000
C         INITIAL RESERVOIR CAPACITY
          SCAP=200000
C         INITIAL ANNUAL INVEST MENT
          SCOST=SAREA*CPA*0.0485*0.50+SCAP*CPAF*0.0485*1.00
C         SOBLG=OBLIGATION DUE IN 1974 ON INITIAL INVESTMENT
          SOBLG=SCOST*16.985
C         SSALV=SALVAGE VALUE OF INITIAL PROJECT IN 1974
          SSALV=(SAREA*CPA+SCAP*CPAF)*.52
C         GPW=PRESENT WORTH OF THE PROJECT AFTER COUNTING GROSS PROFIT SALVAGE
C         & OBLIGATION IN 1974
          GPW=SSALV-SOBLG
120       DO 630 I=1,NC
C         OPERATION STUDY TO COMPUTE POSSIBLE IRRIGATION AREAS WITH AVAILABLE WATER
          J=J+1
C         DEM=TOTAL WATER DEMAND
          DEM=0
C         DEFY=DEFICIENCY OF WATER PER YEAR
           DEFY=0
C         IEAR=YEAR OF OPERATION
C         F(1)=INFLOW IN THE RIVER IN OCTOBER IN 100ACREFT F(2)= DITTO NOV.
130       READ,IEAR,F(1),F(2),F(3),F(4),F(5),F(6),F(7),F(8),F(9),F(10),F(11)
         *,F(12)
          TF=(F(1)+F(2)+F(3)+F(4)+F(5)+F(6)+F(7)+F(8)+F(9)+F(10)+F(11)+F(12)
         *)*100.
140       DO 480 K=1,12
150       IF(IEAR.GT.50) GO TO 180
C         D(K)=TARGET AREA*MONTHLY WATER REQUIREMENT
160       D(K)=AREA*C1(K)
170       GO TO 190
180        D(K)=AREA*C2(K)
C         F(K)= MONTHLY RIVER INFLOW
190       F(K)=100.*F(K)
200       STOR=STOR+F(K)-REL-D(K)
210       IF(STOR.LE.0)GO TO280
C         DSTOR(K)=WATER DEFICIENCY DURING THE MONTH
220       DSTOR(K)=0
C         DAC=AREA NOT IRRIGATED DUE TO WATER SHORTAGE
230       DAC=0
C         SPILL=WATER WASTED DUE TO INSUFFICIENT RESERVOIR CAPACITY
240        SPILL=STOR-CAP
250       IF(SPILL.LE.0)SPILL=0
260       STOR=STOR-SPILL
270       GO TO 420
280       DSTOR(K)=STOR*(-1.)
290       IF(D(K).EQ.0)GO TO 400
300       DAC=AREA*DSTOR(K)/D(K)
310       GO TO 410
400        DAC=0
410       SPILL=0
420       MONTH=K+9
```

```
C       AIRR(K)=AREA IRRIGATED IN A MONTH
  430   AIRR(K)=AREA-DAC
  460   IF(MONTH.GT.12)MONTH=K-3
  470   IF(STOR.LE.0)STOR=0.
        DEFY=DEFY+DSTOR(K)
        DEM=DEM+D(K)
  480     CONTINUE
C       BJL=AREA IRRIGATED IN JULY-AREA IRRIGATED IN AUGUST
        BJL=AIRR(10)-AIRR(11)
        IF(BJL.LT.0) BJL=0
C       BJN=AREA IRRIGATED IN JUNE-AREA IRRIGATED IN JULY
        BJN=AIRR(9)-AIRR(10)
        IF (BJN.LT.0) BJN=0
C        BSP= AREA IRRIGATED IN SEPTEMBER -AREA IRRIGATED IN AUGUST*ADDL WATER REQ
C       UIREMENT IN SEPTEMBER
        BSP=(AIRR(12)-AIRR(11))*0.41
        IF(BSP.LE.1) BSP=0
C       EQAREA=EFFECTIVE IRRIGATED AREA
        EQAREA=AIRR(11)+0.65*BJL+0.30*BJN+0.20*BSP
  510   SAIRR=SAIRR+EQAREA
C       COMPUTATION OF BENIFITS & COSTS ONTHE BASIS OF EQVT.IRR.AREA&PR COSTS
C       VAA(J)=NET VALUE OF CROPS IRRIGATED PER ACRE=VA(K)/ERRAC(K)-O&M COST
        VAA(J)=VA(J)/ERRAC(J)*ECC(J)-OMC(J)
C       GVA(I)=NET BENIFIT FROM CROPS
        GVA(I)=EQAREA *VAA(J)
C       COST(I)=PRICE OF WATER PERR ACRE INCLUDING ANNUAL CAPITAL COST INTERESTO
C       +LABOUR COST PERACRE
        IF (AREA.EQ.SAREA.AND.CAP.EQ.SCAP) COST(I)=SCOST+EQAREA*PLI(J)
        IF (AREA.EQ.SAREA.AND.CAP.NE.SCAP) COST(I)=SCOST+EQAREA*PLI(J)
     *    +((CAP-SCAP)*CPAF*ENT(J))/(1-(1+ENT(4))**(-100))
        IF (AREA.NE.SAREA.AND.CAP.EQ.SCAP) COST(I)=SCOST+EQAREA*PLI(J)
     *     +((AREA-SAREA)*CPA*ENT(J))/(1-(1+ENT(J))**(-100))
        IF (AREA.NE.SAREA.AND.CAP.NE.SCAP) COST(I)=SCOST+EQAREA*PLI(J)
     *     +((AREA-SAREA)*CPA*ENT(J))/(1-(1+ENT(J))**(-100))
     *    +((CAP-SCAP)*CPAF*ENT(J))/(1-(1+ENT(4))**(-100))
C       PROFIT(I)=BENIFIT-COST
        PROF(I)=GVA(I)-COST(I)+ADPROF
        YDEF(I)=DEFY
        YDEM(I)=DEM
        IF (I.GT.10) GO TO 555
         GPROF=GPROF+PROF(I)
        ADPROF=GPROF*ENT(J)
        GO TO 630
  555    DO 565 IL=1,9
        GVA(IL)=GVA(IL+1)
        COST(IL)=COST(IL+1)
        PROF(IL)=PROF(IL+1)
        YDEM(IL)=YDEM(IL+1)
  565   YDEF(IL)=YDEF(IL+1)
        YDEF(10)=DEFY
        COST(10)=COST(I)
         GVA(10)=GVA(I)
        PROF(10)=PROF(I)
        TYD=0
        TD=0
        TGVA=0
        TCOST=0
        DO 128 M=1,10
        TCOST=TCOST+COST(M)
        TGVA=TGVA+GVA(M)
```

```
C       TYD=WATER DEFICIENCY FOR 10 (OR 5) YEARS
188     TYD=TYD+YDEF(M)
C       TD=TOTAL YEARLY DEMAND OF WATER OF TARGET AREA
        TD=D(1)+D(2)+D(3)+D(4)+D(5)+D(6)+D(7)+D(8)+D(9)+D(10)+D(11)+D(12)
C       YPER=PERCENT RATIO  10 YEAR DEFFICIENCY TO ONE YEAR REQUIRE MENT
        YPER=100.*TYD/TD
CC      ATYD=AVERAGE 10 (OR5) YEAR DEFICIENCY
        ATYD=TYD/10.
C       APROF=AVERAGE PROFITFOR 10 (5) YEARS
        APROF=GPROF/10.
C       ACOST=AVERAGE COST """""""
        ACOST=TCOST/10.
C       AGVA=AVERAGE BENIFITS""""""
        AGVA=TGVA/10.
         GPROF=GPROF+PROF(I)
        ADPROF=GPROF*ENT(J)
C        RATIO=TOTAL BENIFIT/TOTAL COST
        RATIO=TGVA/TCOST
        PAREA=AREA
        PCAP=CAP
C         CONDITIONS FOR INCREASE IN TARGET AREA OR STORAGE CAPICITY OF RESERVOIR
         IF(YPER.GT.100.000000.AND.AGVA.GT.(1+ENT(J))*ACOST)CAP=CAP+ATYD
        IF(YPER.LT.50.000.AND.AGVA.GT.(1+ENT(J))*ACOST)AREA=AREA*1.10
        IF (AREA.GT.570000) AREA=570000
        IF (CAP.GT.1500000) CAP=1500000
        OBLG=((AREA-PAREA)*CPA+(CAP-PCAP)*CPAF)*ENT(J)*(1+ENT(J))**100./
       *((1+ENT(J))**100.-1)
       **((1+ENT(J))**(J+32)-1)/(ENT(J)*(1+ENT(J))**(J+32))
         SALV=((AREA-PAREA)*CPA+(CAP-PCAP)*CPAF)
       **(0.25+(0.0075)*(J+32))
         PW=SALV-OBLG
         GPW=GPW+PW+PROF(I)
490      WRITE(6,500) IEAR,TF,AREA,EQAREA,CAP,GVA(I),COST(I),ADPROF,GPROF
500      FORMAT('0',T9,'19',I2,F15.0,5X,F12.0,4X,F7.0,2X,F9.0,3X,F10.0,5X,
       *F10.0,T103,F10.0,2X,F12.0)
630      CONTINUE
         STOP
         END

$ENTRY
```

TABLE B-1 POSSIBLE NONFED IRRIGATION DEVELOPMENT

WITH3000ACFT.MINREL174000 ACRE INITIALIRRIGATION AND 200000 ACFT STORAGE

WATER YEAR	INFLOW (ACFT)	PRAREA (ACRE)	EQAREA (ACRE)	RES-CAP (ACFT)	BENFIT DOLLARS	COST DOLLARS	INT ON PROFT DOLLARS	ACPROF DOLLARS
1920	1548200.	174000.	128882.	200000.	1106347.	1292203.	-329515.	-6373594.
1921	2905100.	174000.	150519.	200000.	1092250.	1459747.	-375449.	-7070605.
1922	2444900.	174000.	144155.	200000.	1863626.	1397347.	-338519.	-6979775.
1923	1766600.	174000.	157070.	344764.	1657083.	1488468.	-334605.	-7149679.
1924	892300.	174000.	102609.	506549.	583094.	1133388.	-376822.	-8034578.
1925	2336600.	174000.	174000.	631602.	1758694.	1780009.	-379472.	-8432714.
1926	1114300.	174000.	174000.	631602.	952940.	1834990.	-426546.	-9694236.
1927	2673000.	174000.	174000.	631602.	1727203.	1813607.	-438909.	-10207180.
1928	2434500.	174000.	174000.	631602.	1592041.	1788859.	-439138.	-10842910.
1929	1338500.	174000.	174000.	631602.	1683116.	1799573.	-507234.	-11398500.
1930	1344200.	174000.	174000.	631602.	934930.	1782791.	-561158.	-12753600.
1931	946600.	174000.	174000.	631602.	357308.	1755181.	-603218.	-14712630.
1932	1922800.	174000.	174000.	631602.	-348423.	1779080.	-819837.	-17443340.
1933	1587400.	174000.	174000.	631602.	1144602.	1727341.	-772683.	-18845920.
1934	1080500.	174000.	174000.	631602.	1137346.	1707766.	-789390.	-20189000.
1935	1585000.	174000.	174000.	631602.	840279.	1664680.	-734754.	-21802780.
1936	1984800.	174000.	174000.	631602.	882288.	1631872.	-707928.	-23287120.
1937	1166400.	174000.	174000.	631602.	896756.	1615160.	-716690.	-24713440.
1938	2625800.	174000.	174000.	631602.	425841.	1580932.	-773630.	-26585210.
1939	1379000.	174000.	174000.	631602.	266884.	1534731.	-758607.	-28626680.
1940	1612700.	174000.	174000.	631602.	438141.	1499428.	-776388.	-30446570.
1941	1404800.	174000.	174000.	631602.	1239299.	1468062.	-820890.	-31451710.
1942	1682800.	174000.	174000.	631602.	2107620.	1433262.	-824714.	-31598240.
1943	3563800.	174000.	174000.	631602.	2483379.	1397889.	-814774.	-31337450.
1944	1258300.	174000.	174000.	631602.	2249386.	1360228.	-797208.	-31263070.
1945	1682600.	174000.	174000.	631602.	2162001.	1322681.	-733693.	-31220960.

COMPUTER PROGRAM

Plan B (5)

1. Same as Plan A (10).
2. Same as Plan A (10).
3. Same as Plan A (10).
4. Repeats the process for five years.
5. Increases the project size on the basis of average equivalent irrigated area, and accumulated profits for five years, as per conditions specified for Plan B (5).
6. Repeats the process for next five years and increases the project size on the basis of results of these five years and conditions specified for Plan B (5).

```
$JOB DALJIT (XXXXXXX,241-19-8997)
C       PLAN B(5)
C       RESERVE  STORAGE  FOR DIFFERENT  PARAMETERS
 10     DIMENSION D(12),F(12),WUF(12),AIRR(72),USAGE(12),C1(12),C2(12)
       *,USTOR(12),ENT(73)
        DIMENSION ERRAC(70),VA(70),TVA(70),ECC(70),PLI(73),OMC(70)
       *,YDEF(70),A8(12),VAA(70)
 20     WRITE(6,30)
 30     FORMAT ('1',T9,'TABLE 8-2 POSSIBLE NONFED IRRIGATION DEVELOPMENT'//
       */T9,'WITH3000ACFT.MINREL174000  ACRE INITIALIRRIGATION AND 200000
       *ACFT STORAGE'///T8,'WATER'
       *,8X,'INFLOW',11X,'PRAREA', 6X,'EQAREA',4X,'RES-CAP', 6X,
       *'BENFIT',6X,' COST ',11X,'INT ON PROFT',6X,'ACPROF '
       *//T9,'YEAR',8X,'(ACFT)',10X,'(ACRE)', 7X,'(ACRE)', 3X,'(ACFT)'
       *,8X,'DOLLARS',8X,'DOLLARS',10X,'DOLLARS',6X,'DOLLARS')
C       IRS=NO OF YEARS OF OPERATION
        IRS=0
C       STOR=RESERVOIR CONTENTS
        STOR=0
C       J=NUMBER RELATING VARIABLE TO THE YEAR
        J=0
C       ADPROF=INTEREST ON PROFIT
        ADPROF=0
C       GPROF=GROSS PROFIT
        GPROF=0
C       GPW=PRESENT WORTH OF THE PROJECT AFTER COUNTING GROSS PROFIT SALVAGE
C       & OBLIGATION IN 1974
        GPW=0
C       CPA =COST PER ACRE
C       CPAF=COST PER ACREFT OF RESERVOIR CAPACITY
        READ,CPA,CPAF
C       AREA=TARGET AREA
 50     READ,AREA
C       CAP= STORAGE CAPICITY OF RESERVOIR
C       REL=MINIMUM  INSTREAM FLOW PER MONTH
 40     READ,REL,CAP
C       ERRAC(K)=AREA IRRIGATED AS PER TERRY NELSON,S UNPUBLISHED SCENERIO ON BOIS
C       E PROJECT
        READ(5,5)(ERRAC(K),K=1,4)
 5      FORMAT(4F7.0)
        READ(5,6)(ERRAC(K),K=5,69)
 6       FORMAT(10F8.0)
C       VA(K)=SALE VALUE OF CROPS MINUSCOST OF SEEDE FERTILIZERRS FARM MACHINERY E
C       TC INCLUDING WATER CHARGES
        READ(5,8)(VA(K),K=1,4)
 8      FORMAT(4F8.0)
        READ(5,7)(VA(K),K=5,69)
 7      FORMAT(10F8.0)
 9      FORMAT(10F8.4)
        READ(5,9)(ECC(K),K=1,69)
C       C1(K)=COSSUMPTIVE USE WATER REQUIREMENT PER ACRE FOR 3 CROP PATTERN
C       C2(K)=CONSUMPTIVE USE WATER REQUIREMENT PER ACRE FOR 7 CROP PATTERN
 60     READ(5,70) (C1(K),K=1,12),(C2(K),K=1,12)
 70       FORMAT (12F5.2/12F5.2)
C       ENT(K)=PRIME RATE OF INTEREST FOR THE YEAR K
        READ (5,75) (ENT(K),K=1,69)
 75     FORMAT (10F8.4)
C       PLI(K)=PRODUTIVITY OF LABOUR INDEX
        READ(5,15) (PLI(K),K=1,69)
 15     FORMAT(16F5.2)
```

```
C      OMC=OPERATION C& MAINTENANCE COST
       READ (5,15) (OMC(K),K=1,69)
C      TPROF=TOTAL PROFIT PER CYCLE
       TPROF=0
C      NC=NUMBER OF YEARS INA CYCLE
C      SAREA=INITIAL PROJECT TARGET AREA
       SAREA=174000
C      INITIAL RESERVOIR CAPACITY
       SCAP=200000
C      INITIAL ANNUAL INVEST MENT
       SCOST=SAREA*CPA*0.0485*0.50+SCAP*CPAF*0.0485*1.00
       PAREA=SAREA
       PCAP=SCAP
C      SOBLG=OBLIGATION DUE IN 1974 ON INITIAL INVESTMENT
       SOBLG=SCOST*16.985
C      SSALV=SALVAGE VALUE OF INITIAL PROJECT IN 1974
       SSALV=(SAREA*CPA+SCAP*CPAF)*.52
       PW=SSALV-SOBLG
       DO 630 KL=1,15
90     NC=5
C      SAIRR=SUM OF AREA ACTUALLY IRRIGATED
110    SAIRR=0.
120    DO 520 I=1,NC
C      OPERATION STUDY TO COMPUTE POSSIBLE IRRIGATION AREAS WITH AVAILABLE WATER
       J=J+1
       IF (J.GE.70) GO TO 630
       TGVA=0
       TCOST=0
       TSALV=0
       TOBLG=0
C      TINT=TOTAL INTEREST FOR THE PERIOD
       TINT=0
C      IEAR=YEAR OF OPERATION
C      F(1)=INFLOW IN THE RIVER IN OCTOBER IN 100ACREFT F(2)= DITTO NOV.
130    READ,IEAR,F(1),F(2),F(3),F(4),F(5),F(6),F(7),F(8),F(9),F(10),F(11)
      *,F(12)
       IF (IEAR.LT.10) GO TO 520
       TF=(F(1)+F(2)+F(3)+F(4)+F(5)+F(6)+F(7)+F(8)+F(9)+F(10)+F(11)+F(12)
      *)*100.
140    DO 480 K=1,12
150    IF(IEAR.GT.50) GO TO 180
C      D(K)=TARGET AREA*MONTHLY WATER REQUIREMENT
160    D(K)=AREA*C1(K)
170    GO TO 190
180     D(K)=AREA*C2(K)
C      F(K)= MONTHLY RIVER INFLOW
190    F(K)=100.*F(K)
200    STOR=STOR+F(K)-REL-D(K)
210    IF(STOR.LE.0)GO TO280
C      DSTOR(K)=WATER DEFICIENCY DURING THE MONTH
220    DSTOR(K)=0
C      DAC=AREA NOT IRRIGATED DUE TO WATER SHORTAGE
230    DAC=0
C      SPILL=WATER WASTED DUE TO INSUFFICIENT RESERVOIR CAPACITY
240     SPILL=STOR-CAP
250    IF(SPILL.LE.0)SPILL=0
260    STOR=STOR-SPILL
270    GO TO 420
280    DSTOR(K)=STOR*(-1.)
290    IF(D(K).EQ.0)GO TO 400
```

```
300   DAC=AREA*DSTOR(K)/D(K)
310   GO TO 410
400    DAC=0
410   SPILL=0
420   MONTH=K+9
C     AIRR(K)=AREA IRRIGATED IN A MONTH
430   AIRR(K)=AREA-DAC
460   IF(MONTH.GT.12)MONTH=K-3
470   IF(STOR.LE.0)STOR=0.
480     CONTINUE
C     BJL=AREA IRRIGATED IN JULY-AREA IRRIGATED IN AUGUST
      BJL=AIRR(10)-AIRR(11)
      IF(BJL.LT.0) BJL=0
C     BJN=AREA IRRIGATED IN JUNE-AREA IRRIGATED IN JULY
      BJN=AIRR(9)-AIRR(10)
      IF (BJN.LT.0) BJN=0
C      BSP= AREA IRRIGATED IN SEPTEMBER -AREA IRRIGATED IN AUGUST*ADDL WATER REQ
C     UIREMENT IN SEPTEMBER
      BSP=(AIRR(12)-AIRR(11))*0.41
      IF(BSP.LE.1) BSP=0
C     EQAREA=EFFFECTIVE IRRIGATED AREA
      EQAREA=AIRR(11)+0.65*BJL+0.30*BJN+0.20*BSP
510   SAIRR=SAIRR+EQAREA
C     COMPUTATION OF BENIFITS & COSTS ONTHE BASIS OF EQVT.IRR.AREA&PR COSTS
C     VAA(J)=NET VALUE OF CROPS IRRIGATED PER ACRE=VA(K)/ERRAC(K)-O&M COST
      VAA(J)=VA(J)/ERRAC(J)*ECC(J)-OMC(J)
C     GVA    =NET BENIFIT FROM CROPS
      GVA=EQAREA*VAA(J)
C     COST    =PRICE OF WATER PERR ACRE INCLUDING ANNUAL CAPITAL COST INTERESTQ
C     +LABOUR COST PERACRE
      IF (AREA.EQ.SAREA.AND.CAP.EQ.SCAP) COST    =SCOST+EQAREA*PLI(J)
      IF (AREA.EQ.SAREA.AND.CAP.NE.SCAP) COST    =SCOST+EQAREA*PLI(J)
     *    +((CAP-SCAP)*CPAF*ENT(J))/(1-(1+ENT(4))**(-100))
      IF (AREA.NE.SAREA.AND.CAP.EQ.SCAP) COST    =SCOST+EQAREA*PLI(J)
     *     +((AREA-SAREA)*CPA*ENT(J))/(1-(1+ENT(J))**(-100))
      IF (AREA.NE.SAREA.AND.CAP.NE.SCAP) COST    =SCOST+EQAREA*PLI(J)
     *     +((AREA-SAREA)*CPA*ENT(J))/(1-(1+ENT(J))**(-100))
     *    +((CAP-SCAP)*CPAF*ENT(J))/(1-(1+ENT(4))**(-100))
C     PROFIT    =BENIFIT-COST
      PROF=GVA-COST+ADPROF
      GPROF=GPROF+PROF
C     ADPROF=INTEREST EARNED OR PAID ON PROFIT ORLOSS FOR THE YEAR
      ADPROF=GPROF*ENT(J)
C     AVINT=AVERAGE INTEREST FOR THE PERIOD
      DSTOR(1)=DSTOR(11)
      OBLG=((AREA-PAREA)*CPA+(CAP-PCAP)*CPAF)*ENT(J)*(1+ENT(J))**100./
     *((1+ENT(J))**100.-1)
     **((1+ENT(J))**(J+32)-1)/(ENT(J)*(1+ENT(J))**(J+32))
      SALV=((AREA-PAREA)*CPA+(CAP-PCAP)*CPAF)
     **(0.25+(0.0075)*(J+32))
      GPW=GPW+PW+PROF
      PW=SALV-OBLG
490   WRITE(6,500) IEAR,TF,AREA,EQAREA,CAP,GVA    ,COST    ,ADPROF,GPROF
500   FORMAT('0',T9,'19',I2,F15.0,5X,F12.0,4X,F7.0,2X,F9.0,3X,F10.0,5X,
     *F10.0,T103,F10.0,2X,F12.0)
      TGVA=TGVA+GVA
      TCOST=TCOST+COST
      TINT=TINT+ADPROF
      TPROF=GPROF
520   CONTINUE
```

```
C        RATIO=TOTAL BENIFIT/TOTAL COST
         RATIO=TGVA/TCOST
         AGVA=TGVA/5.
         ACOST=TCOST/5.
         APROF=GPROF/5.
         AVINT=TINT/5.
         L=0
         AVEIRR=SAIRR/5.
         ADSTR=DSTOR(1)+DSTOR(2)+DSTOR(3)+DSTOR(4)+DSTOR(5)
          AVDSTO=ADSTR/5.
610      WRITE (6,620) AVEIRR,CAP,AGVA,ACOST,AVINT,APROF
620      FORMAT ('0'/T22,'AVERACE FOR LAST 5 YEARS',T50,F7.0,2X,F9.0,3X,F10
        *.0,5X,F10.0,T103,F10.0,2X,F12.0)
         IRS=IRS+5
         WRITE(6,700)IRS,GPROF
700       FORMAT (//'0', T85,'THE NET PROFIT FOR LAST',I2,'YEARS','=''$  ',
        *F12.0)
         PAREA=AREA
         PCAP=CAP
C         CONDITIONS FOR INCREASE IN TARGET AREA OR STORAGE CAPICITY OF RESERVOIR
          IF(AVEIRR.LT.0.8*AREA.AND.AGVA.GT.(1+ENT(J))*ACOST)CAP=CAP+200000
         IF(AVEIRR.GE.0.8*AREA.AND.AGVA.GT.(1+ENT(J))*ACOST)AREA=AREA+100000
         IF (AREA.GT.570000) AREA=570000
         IF (CAP.GT.1500000) CAP=1500000
630      CONTINUE
         STOP
         END

$ENTRY
```

TABLE B-2 POSSIBLE NONFED IRRIGATION DEVELOPMENT .
WITH3000ACFT.MINREL174000 ACRE INITIALIRRIGATION AND 200000 ACFT STORAGE

WATER YEAR	INFLOW (ACFT)	PRAREA (ACRE)	EQAREA (ACRE)	RES-CAP (ACFT)	BENFIT DOLLARS	COST DOLLARS	INT ON PROFT DOLLARS	ACPROF DOLLARS
1910	2756500.	174000.	134748.	200000.	130272.	1448684.	-63416.	-1318412.
	AVERAGE FOR LAST 5 YEARS		26950.	200000.	26054.	289737.	-12683.	-263682.
						THE NET PROFIT FOR LAST 5YEARS='$		-1318412.
1911	2494000.	174000.	172561.	200000.	427174.	1775531.	-131322.	-2730183.
1912	2477200.	174000.	158719.	200000.	262246.	1638251.	-203824.	-4237508.
1913	2060600.	174000.	152463.	200000.	422351.	1571776.	-268915.	-5590756.
1914	2133100.	174000.	137507.	200000.	733866.	1429790.	-315324.	-6555595.
1915	967400.	174000.	94910.	200000.	586565.	1048196.	-352696.	-7332550.
	AVERAGE FOR LAST 5 YEARS		143232.	200000.	117313.	209639.	-70539.	-1466510.
						THE NET PROFIT FOR LAST10YEARS='$		-7332550.
1916	2593300.	174000.	174000.	200000.	2435498.	1718881.	-335191.	-6968628.
1917	2257800.	174000.	174000.	200000.	2641567.	1704961.	-306263.	-6367212.
1918	2035500.	174000.	134240.	200000.	1891048.	1356810.	-295297.	-6139236.
1919	1674600.	174000.	117665.	200000.	1739275.	1208509.	-283971.	-5903767.
1920	1548200.	174000.	128882.	200000.	1106347.	1292203.	-329515.	-6373594.
	AVERAGE FOR LAST 5 YEARS		145757.	200000.	221269.	258441.	-65903.	-1274718.
						THE NET PROFIT FOR LAST15YEARS='$		-6373594.
1921	2905100.	174000.	150519.	200000.	1092250.	1459747.	-375449.	-7070605.
1922	2444900.	174000.	144155.	200000.	1863626.	1397347.	-338519.	-6979775.
1923	1766600.	174000.	157070.	200000.	1657083.	1488468.	-334605.	-7149679.
1924	892300.	174000.	74922.	200000.	425758.	821859.	-369590.	-7880385.

BIBLIOGRAPHY

In addition to the following materials, the project histories of the Boise Project prepared by the Bureau of Reclamation, the annual reports of the Bureau, and the files of the Bureau in the Boise regional office, annual financial statements of the counties, and files of the Idaho Department of Water Resources have been used extensively.

Busch, John R. Methodology for Obtaining Least Cost Irrigation System Specifications. University of Idaho, Ph.D. Thesis, 1974.

Caldwell, H.H., and M. Wells. Economic and Ecological History Support Study. A Case Study of Federal Expenditures on a Water and Related Land Resources Project: Boise Project, Idaho and Oregon. OWRT Title II Project C-4202. Idaho Water Resources Research Institute, University of Idaho, Moscow, Idaho, 1974.

Claiborn, B.A. Predicting Attainable Irrigation Efficiencies in the Upper Snake River Region. M.S. Thesis, Department of Civil Engineering, University of Idaho, 1975.

Eckstein, O. Water Resource Development, The Economics of Project Evaluation. Harvard University Press, Cambridge, Mass., 1958.

Golze, A.R. Reclamation in the United States. McGraw-Hill Book Company, Inc., 1952.

Goldfield, E.D. Statistical Abstract of the U.S. U.S. Department of Commerce, Bureau of the Census, Washington, D.C., 1967.

Halcrow, H.G. Agricultural Policy of the United States. Prentice-Hall, Inc., 70 Fifth Avenue, New York, 1953.

Haas, W.T. and R.W. Schermerhorn. Plan of Study Subproject Report. A Case Study of Federal Expenditures on a Water and Related Land Resource Project: Boise Project, Idaho and Oregon. OWRT Title II Project C-4202. Idaho Water Resources Research Institute, Moscow, Idaho, 1974.

Hirshleifer, J, J.C. Dehaven, J.W. Milliman. Water Supply-Economics, Technology and Policy. The University of Chicago Press, Chicago, 1960.

Huffman, R.E. Irrigation Development and Water Policy. Ronald Press, New York, 1953.

Idaho Department of Commerce. The Idaho Almanac. Territorial Centennial Edition 1863-1963, Boise, Idaho, 1963.

Idaho Water Resource Board. Potentially Irrigable Lands in Idaho. Summary Report Number One. Idaho Water Resource Board, 1365 N. Orchard, Boise, Idaho, 1970.

James, L.D., R.R. Lee. Economics of Water Resources Planning. McGraw-Hill Book Company, New York, 1971.

Linsley, R.K. and J.B. Franzini. Water Resources Engineering. McGraw-Hill Book Company, Inc., New York, 1964.

Mead, E. "Present Policy of the United States Bureau of Reclamation Regarding Land Settlement". Journal of Proceedings of American Society of Civil Engineers, Volume 52, March 1926.

Murphy, P.L. Irrigation in the Boise Valley, 1863-1903: A Study in PreFederal Irrigation. M.A. Thesis, University of California, 1948.

Moley, Raymond. What Price Federal Reclamation? No. 455 in the series "National Economic Problems". American Enterprise Association, Inc., New York, Ny, 1955.

National Water Commission. Water Policies for the Future. Water Information Center, Inc., Port Washington, NY, 1973.

Pacific Northwest River Basins Commission. Columbia-North Pacific Region Comprehensive Framework Study of Water and Related Lands, Appendix IX, Irrigation. Pacific Northwest River Basins Commission, Vancouver, WA, 1971.

Shepherd, R.E. "The Financing of Irrigation Development by Private Capital." Journal of Proceedings of American Society of Civil Engineers, Volume 52, March, 1926.

Simons, W.D. Irrigation and Streamflow Depletion in Columbia River Basin. U.S. Geological Survey Water Supply Paper 1220, Washington, DC , 1953.

Sutter, R.J. and G.L. Corey. Consumptive Irrigation Requirements for Crops in Idaho. University of Idaho College of Agriculture Bulletin No. 516, July, 1970.

U.S. Bureau of the Census. Census of Agriculture 1910, 20, 25, 35, 40, 45, 50, 54, 59, 64, 69. Washington, DC, U.S. Government Printing Office.

U.S. Bureau of the Census. Statistical Abstract 1967 (88th Edition). Washington, DC, 1967.

U.S. Bureau of the Census. Statistical Abstract of the United States-1975. U.S. Government Printing Office, Washington, DC, 1975.

U.S. Department of Interior. Revised Allocation of Cost, Bureau of Reclamation, 1953.

U.S. Department of Interior. Reclamation Project Data, Bureau of Reclamation, 1953.

U.S. Department of Agriculture. Irrigation Under the Provisions of the Carey Act. Washington, Office of the Secretary, Circular 124, 1919.

U.S. Department of Agriculture. Agricultural Statistics 1952, 1967, 1975. U.S. Government Printing Office, Washington, DC.

U.S. Geological Survey. Water Resources Data for Idaho. Part 1. Surface Water 1970 to 1974. Water Resources Division, U.S. Geological Survey, Boise, Idaho, 1975.

U.S. Department of Defense. Definite Project Report on Lucky Peak Dam. Corps of Engineers, 1949.

Warnick, C.C. and C.E. Brockway. Hydrology Support Study. A Case Study of Federal Expenditures on a Water and Related Land Resources Project: Boise Project, Idaho and Oregon. OWRT Title II Project C-4202. Idaho Water Resources Research Institute, University of Idaho, Moscow, Idaho, 1974.

Water Master, Boise River. Water Distribution of Boise River, District 63, 1975.

Widstoe, J.A. "History and Problems of Irrigation Development in the West". Journal of Proceedings of American Society of Civil Engineers, Volume 52, March, 1926.

Williams, M.H. The History of Development and Current Status of the Carey Act in Idaho. Special Report, Idaho Department of Reclamation, 1970.