RESEARCH TECHNICAL COMPLETION REPORT

OWRT TITLE II PROJECT C-6276

A DYNAMIC REGIONAL IMPACT ANALYSIS OF FEDERAL EXPENDITURES OF A WATER AND RELATED LAND RESOURCE PROJECT -- THE BOISE PROJECT OF IDAHO

PART III

ECONOMIC SCENARIO OF THE BOISE REGION "WITHOUT" A FEDERAL IRRIGATION PROJECT

ECONOMICS SUBPROJECT

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Submitted to

Office of Water Research and Technology
United States Department of Interior
Washington, D.C. 20240

This project was supported primarily with funds provided by the United States Department of Interior, Office of Water Research and Technology as authorized under the Water Resources Research Act of 1964.

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University of Idaho
Moscow, Idaho

March 1979

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INTRODUCTION

In accordance with the Principles and Standards for Planning Water and Related Land Resources issued by the Water Resources Council (15), all federal water projects must include "with" and "without" proposed project analyses. As stated in the Principles and Standards:

> "In planning water and land resources beneficial and adverse effects of a proposed plan should be measured by comparing the estimated conditions with the plan with the conditions expected without the plan. Thus, in addition to projecting the beneficial and adverse effects expected with the plan in operation, it is necessary to project the conditions likely to occur in absence of a plan. Economic, social and environmental conditions are not static, and changes will occur even without a plan. Only the new or additional changes that can be anticipated as a result of a proposed plan should be attributed as beneficial and adverse effects of the plan."

Though stated in terms of ex-ante analysis, the above statement is also relevant to ex-post analysis. Ex-post analysis as implied by the Principles and Standards involves measuring the actual consequences of the project by comparing the observed state with a hypothetical alternative - the state of the world "without" the project.

The last two sentences of the above quote state two important aspects that should be included in project evaluation. First, it states "...changes will occur even without a plan." This warns the analyst not to make a simple "before" and "after" comparison. Whether "with" or "without" the project, the analysis should be dynamic allowing for changes in economic growth and technological change.

Secondly, "...only the new or additional changes that can be anticipated as a result of a proposed plan should be attributed as beneficial and adverse effects of a plan." Project justification should only include those additional benefits generated from the investment in the project. In an irrigation project, productivity of the soil and water is improved via the investment in storage facilities over the productivity naturally inherent to the system. The point being that the land and water even "without" the project has some inherent productivity whether through dry land farming or some limited form of irrigation. The first objective of this report will be to present one possible scenario of what might have occurred "without" the Boise Project. Secondly, by comparing the historical development against the hypothetical "without" scenario present, as defined in the Principles and Standards, those benefits and costs attributable to the Boise Reclamation Project.

Project justification or evaluation requires weighting federal investment alternatives whether by benefit-cost ratios, internal rates of return, or net economic efficiency. This is necessary to prioritize federal investments as well as to determine the profitability of individual projects. If the decision was only to determine whether to develop or not develop then there would be no need to look beyond net returns "with" and "without" the project. When the decision must also rank federal investments, projects must be evaluated in terms of the increased productivity they create, in order to learn which projects offer the greatest return on investment. The "with-without" criterion forms the basic reference point in guiding water resources planning.

Traditionally, the decision whether to develop, or not to develop, has been made on the basis of estimating (projecting) the direct and/or indirect benefits of a project and then comparing these benefits to the costs of the project. Since the Principles and Standards states that it is necessary to also project conditions likely to occur in the absence of a project, it becomes necessary to estimate two conditions rather than one condition, i.e., "with" and "without" the project. Both of these conditions represent two independent economic development alternatives, i.e., one situation does not depend upon nor is it responsible for the other - each of these alternatives has its own set of independent impacts. In other words, an analysis of the impact of a project will be conducted utilizing two sets of assumptions and based upon these assumptions, two sets of independent economic development alternatives will be derived. Further, there generally are many alternatives for development and to estimate the benefits of a project by taking the difference between only two alternatives would not reflect a sufficient analysis.

For these reasons, the "with" and "without" analysis must be viewed with extreme caution. Since analysis for planning purposes must be conducted by comparing two sets of outcomes based entirely upon assumptions, the results may, or may not, reflect a realistic view.

In this report, the "with" situation can be analyzed since it is an ex-post analysis. However, as is pointed out in Part I of the Economics Subproject report, data and methodology to measure, with great precision, what actually did happen in the "with" situation is lacking. As a consequence, even the measurement of the "with" situation in an ex-post situation must be viewed with caution.

In short, any "with" or "without" comparisons are, in a sense, dangerous because it implies that it is a valid comparison and, in fact, it is not because the entire analysis is based upon assumptions which may, or may not, be valid. Nevertheless, this report illustrates how this analysis may be conducted by developing a scenario and the accompanying assumptions upon which the scenario is built to portray the "without" situation. The "with" situation will then be compared with the "without" situation to show the change which may have occurred due to the Federal Project.

This analysis will focus on the following points:

(1) Development of a hydrologic model capable of projecting crop production for the "without" scenario.

(2) Simulation of the regional economy "without" the Project.

(3) Estimation of indirect income derived from the Project.

(4) Comparison of "with" and "without" conditions to determine benefits and costs attributable to the Project.

(5) Demonstration of a methodology for determining the economic efficiency of the Project.

The end result of this analysis should give a complete picture of the productivity of the federal investment in the Boise Project given the assumptions made about development without federal investment.

BACKGROUND INFORMATION

Definition of Benefits

The federal provision of irrigation water in the Boise Region has given rise to several kinds of benefits: (1) the increase in value over dryland or marginal irrigated farming of farm outputs on Project irrigated lands due to more intensive cultivation, higher valued crops, and expanded acreage; (2) the increase in net incomes of industries either supplying, transporting, or processing the increased agricultural production (pecuniary externalities); and, (3) the increase in values caused by technological external economies, receiving goods or services from the Project without paying.

The first benefit mentioned above is usually referred to as the direct or primary benefit of a project. Part 1 of the Economics Subproject Report (9) dealt with estimating the crop value-added income earned "with" the Boise Project. This report will develop an estimate of the crop value-added income that might have been earned "without" the Project. The "Without" scenario will be based on the hydrologic conditions, cropping patterns, water requirements, and crop yields expected "without" federal investment in the area. The direct benefits attributable to the Project would thereby be defined as the change in crop value-added income caused by the increased productivity of the land and water after federal investment in storage facilities.

The second category of benefits are the indirect benefits, those benfits resulting either from forward production linkages to those industries processing project outputs or from backward linkages to those industries providing goods and services to the project area. Potatoes produced by an irrigation project must be processed and marketed a number of times before they are sold, profiting each intermediary. Likewise the production of potatoes requires the purchase of fertilizers, farm machinery, and other materials and thus initiates a chain reaction profiting all these business and all those who in turn supply them. Again these benefits are indirect, they are either "induced by" or "stem from" the project's production of crops.

Those benefits accruing through techological external economies are most often defined as secondary benefits. Secondary benefits arise as a direct result of a project but may not have been included in the original purposes of the project. The Boise Project was originally planned primarily for irrigation though the Project also generates economic benefits from power, flood control, and recreation, as well. Secondary benefits will be discussed in other sections of the post-audit study, the concern in this report will be with the direct and indirect economic benefits of irrigation.

Formulation of the "Without" Project Scenario

The objective of the following process is to generate a realistic picture of the agricultural development and its indirect impact on the Boise Region had the Boise Reclamation Project not existed. Needless to say, there are a myriad of alternatives that might have occurred under these circumstances. The "without" scenario will be based on specific assumptions and decision rules that hopefully provide a reasonable simulation. No one knows with assurity what might have happened "without" federal investment, so any answer must be interpreted in relation to the criteria and assumptions used in its formulation.

Two models were employed to develop a "without" scenario. The first shall be referred to as the "hydrologic" model. The hydrologic model will look at the natural, unregulated flows of the Boise and Payette Rivers to determine the total irrigable acreage available without storage. Combining the irrigable acreage with cropping patterns, yields, and prices, a simulation of the crop production can be generated under the condition of use of the natural, unregulated flows. The crop production from the hydrologic model, in turn, can be fed into a "trade flow" model (input-output) to demonstrate the indirect impacts a change in agricultural production will have on the rest of the economy. These two models, their assumptions, structure, and results will be discussed in more detail.

HYDROLOGIC MODEL

Model Formulation

The Boise Reclamation Project consists of two divisions, the Arrowrock (Boise Valley) Division and the Payette (Payette Valley) Division. In order to provide a comparable analysis of development "without" the Project, the potential irrigation from both the Boise and Payette Rivers must be examined. Without storage, only the diversion of the natural, unregulated flows would have been available for irrigation. Most of the precipitation within the two watersheds occurs as snow in the high mountains so that the heaviest runoff is recorded during the spring as the snow melts. As the summer progresses, flows rapidly taper off, leaving less and less water for irrigation when it is critically needed, hence the value of storage from federal investment. Table 1, displaying this change, shows the monthly, natural runoff of the Boise River from 1910 to 1974. Table 2 provides similar data for the Payette River below Horseshoe Bend. August flows were often as little as 15 percent of those occurring in June. Often the annual flows fluctuated tremendously from one year to the next; for example, the yearly flow for the Boise River in 1924 was only 50 percent of the runoff experienced during the previous year. An operational study of the natural, unregulated flow provides information on the availability of water, allowing the estimation of irrigable acreage, and consequently, of the associated potential income.

In developing the guidelines for the "without" federal expenditure scenario considerable research was done into the history of the project; particularly into the economic conditions that prevailed, the water rights situation and the hydrologic patterns of the river flows. The formulation of the scenario was built around seven major assumptions as follows:

1. The water rights as stipulated by a court degree limited development in the Boise River Basin to those lands having water rights as of 1906.
2. The land available within the Payette River watershed for irrigation was limited to the actual acreage developed below Horseshoe Bend as of 1954.

3. The natural, unregulated flows of the Boise and Payette Rivers were a limit to irrigation development and hydrologic variations in flow limited acreage both from month to month and from year to year.
4. The pattern of crops raised would be a crop system or systems as had historically developed, governed by market, transportation, and technological limitations.
5. Prices and yields were assumed to be the same in the "without" scenario as occurred historically.
6. Storage developments were not likely because financing was not available.
7. Groundwater development was assumed to be the same "without" as "with" the Project.

Justification will now be presented for each of these assumptions:

Water Rights Restraint

A study of the water rights on the Boise River revealed that as of 1906, 174,000 acres of land had adjudicated rights to water from the Boise River. This was defined by the Stewart Decree (16 Idaho 526, 1909). The record of these water rights is recorded in the Report of Boise River Watermaster of 1973 (1). At the time of the court decision, it was indicated that all natural flow was appropriated and a sliding scale allocating water to holders of water rights was specified for meeting periods of flow deficiency. On the basis of this decree, it was decided that the "without" scenario should have an upper limit of irrigation acreage of 174,000 acres to comply with the court ruling.

Land Development Restraint

The operation study on the Payette River was also based on an upper limit of irrigation not to exceed 87,000 acres. This was based on the amount of irrigated land that had developed in the Payette River drainage below Horseshoe Bend by 1954 as reported in a study by the U.S. Bureau of Reclamation by George W. Carter (2). There has not been an adjudication of water rights on the Payette River as on the Boise River. It was felt that irrigation

Table 1. Total Monthly, Unregulated and R*-value Flows of Boise River.

Year	JUNE Unregulated (ac-ft)	JULY Unregulated (ac-ft)	AUGUST Unregulated (ac-ft)	SEPTEMBER Unregulated (ac-ft)
1910	310360	110040	55970	56390
1911	740660	233040	74906	59636
1912	677560	173980	83380	66080
1913	413420	158660	82964	54290
1914	307700	124130	58742	52654
1915	191900	83872	40926	39672
1916	594764	293818	80102	53686
1917	643322	260216	65224	43950
1918	462460	112526	56292	51122
1919	240872	69736	36404	34262
1920	333468	117324	40586	39234
1921	718728	175390	62908	48784
1922	659864	148066	65210	47974
1923	376208	192504	67552	42946
1924	76792	35296	24426	25320
1925	367370	152598	60730	47302
1926	104636	42192	30858	29480
1927	729736	234042	74454	57570
1928	305760	115962	51846	38016
1929	285968	96482	35716	31802
1930	257700	77726	44922	36050
1931	110844	34042	23952	23940
1932	458224	154044	57524	42730
1933	538198	106458	43964	32200
1934	85624	36200	23570	26072
1935	363262	98220	38058	29980
1936	319284	79080	43354	38360
1937	178996	59986	25948	25746
1938	558138	201292	71190	46910
1939	136300	60358	28454	30436
1940	227258	64910	30808	39548
1941	266776	85452	54496	41720
1942	362374	139112	46790	35496
1943	627754	359598	100484	53192
1944	247726	106326	43264	35352
1945	405996	139040	51630	39020
1946	378822	125920	56618	45272
1947	297240	110646	46168	38466
1948	459706	109372	44612	36580
1949	304424	93542	41120	31176
1950	548282	239398	76620	48176
1951	440580	195068	70970	42550
1952	518282	171498	68760	49854
1953	588956	254470	73246	48328
1954	339666	179018	66360	41668
1955	419360	131738	56754	40794
1956	582588	188844	62734	55716
1957	518012	148306	51944	53366
1958	501566	142466	61766	54424
1959	362156	104896	48432	67634
1960	333350	81574	45758	46244
1961	229386	56820	40060	38212
1962	425398	142912	57452	49586
1963	411904	149768	53310	56736
1964	407856	152946	50092	52798
1965	778888	338964	118326	77252
1966	178048	65000	39052	37766
1967	526106	177282	49100	45416
1968	278606	76126	72200	55250
1969	396216	128856	51278	48678
1970	571508	205552	61036	54950
1971	708614	297436	90500	64046
1972	745556	208518	70876	61488
1973	227082	75108	41870	45360
1974	787716	238736	78966	54292

Table 2. Total monthly unregulated flow of the Payette River, 1906-1975.(14,16)

Year	June	July	August	September
	Acre Feet			
1906	390,000	178,000	69,200	53,200
1907	780,000	491,000	167,000	84,500
1908	450,000	275,000	87,900	74,400
1909	901,000	325,000	106,000	82,700
1910	405,000	149,000	65,800	59,100
1911	898,000	335,000	110,000	60,700
1912	786,000	224,000	95,300	67,800
1913	696,000	232,000	93,500	73,200
1914	419,000	157,000	66,400	59,000
1915	283,000	117,000	60,600	49,300
1916	797,000	506,000	121,000	69,600
1917	838,000*	405,000*	82,300*	49,000*
1918	752,000*	125,000*	73,000*	53,200*
1919	357,000*	80,000*	46,500	40,500
1920	514,000	172,000	62,100	56,100
1921	881,000	218,000	95,300	67,800
1922	768,000	170,000	73,800	51,100
1923	588,000	261,000	78,700	57,100
1924	105,000	55,800	39,500	36,300
1925	474,000	154,000	68,900	55,400
1926	118,000	60,400	45,800	39,700
1927	958,000	341,000	96,500	82,700
1928	432,800	138,200	60,500	48,200
1929	388,000	100,400	40,000	38,100
1930	285,500	75,600	46,400	39,800
1931	114,800	44,300	33,100	25,200
1932	638,000	159,900	55,900	45,100
1933	785,900	118,200	57,900	29,300
1934	125,300	48,200	30,000	28,700
1935	388,600	86,700	36,700	27,800
1936	396,700	83,800	48,200	38,400
1937	275,000	73,800	36,700	31,100
1938	758,300	220,600	66,900	52,200
1939	164,100	68,600	36,000	35,100
1940	325,000	77,400	40,200	51,900
1941	400,500	111,900	74,400	58,500
1942	478,300	151,300	59,000	45,300
1943	788,600	416,500	102,500	64,700
1944	300,500	104,000	48,100	38,900
1945	556,500	158,700	65,700	51,300
1946	486,600	151,800	68,100	60,500
1947	496,000	150,300	66,800	54,700
1948	724,800	143,800	66,600	48,900
1949	397,000	98,800	50,000	41,800
1950	751,700	310,300	87,100	62,600
1951	510,500	204,700	76,700	57,800
1952	651,500	196,700	71,900	49,300
1953	832,200	294,300	80,800	45,700
1954	519,200	231,000	75,700	49,100
1955	554,300	178,100	50,200	46,500
1956	719,200	197,500	78,300	48,400
1957	676,900	152,800	56,600	41,100
1958	613,200	135,400	65,600	46,600
1959	545,100	120,400	52,900	102,600
1960	497,100	90,400	56,000	44,300
1961	431,900	61,500	36,600	47,900
1962	519,100	120,400	55,100	42,800
1963	528,200	140,300	51,400	60,500
1964	701,000	184,300	64,500	61,600
1965	878,600	304,000	121,900	82,400
1966	259,700	63,300	30,800	33,800
1967	766,100	210,100	49,800	45,400
1968	399,300	86,100	71,400	57,500
1969	499,900	124,600	37,100	51,100
1970	860,600	237,700	57,500	70,900
1971	960,400	351,000	88,300	59,600
1972	894,900	199,400	75,400	60,700
1973	269,000	56,700	24,100	46,500
1974	1,199,500	399,100	91,200	65,600
1975	796,200	364,800	105,600	59,400

*figures done by estimation through correlation with Boise River @ Twin Springs.

development "without" the Project could not physically exceed the acreage irrigated historically below Horseshoe Bend so an upper limit of 87,000 acres was placed on the Payette River.

Natural Flow Restraint

In developing the model it was recognized that natural flow fluctuations would limit the amount of productive irrigation that could be expected each year. Farmers would not have been able to expand or contract their operations each year to correspond to the actual river flows. Thus estimating irrigated solely from natural, unregulated flows would have resulted in overestimation of the acreage that would have been irrigated. In order to make the analyses more realistic, a means of limiting the acreage irrigated over time was sought. A modification of rule of thumb shortage criteria was used for planning the irrigation water supply. The shortage criteria is stated in the Comprehensive Framework Study of Water and Related Lands of the Pacific Northwest River Basins Commission which states that "...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 one year's diversion requirement" (11). This appears to speak to a total year's supply. In this study the criteria was applied to requirements for each month. The method developed indicates what amount of water could be designated for irrigation use on an annual basis for each month. This required a hydrologic operation study on both rivers over time.

The low flows during July and August would have determined the maximum amount of land that could have been irrigated for the entire season. It was assumed some partial irrigation would have taken place in the early summer and again in the fall with the additional water available in June and September.

Cropping Pattern Restraint

It was recognized that to make any type of operation model of what would have happened "without" the federal Project, that a decision had to be made as to crops that would have been grown. It was decided that prior to 1950 the combination of drought, depression, and unavailability of markets would have dictated a non-intensive cropping pattern of forage and grain crops. After this date more favorable economic and hydrologic conditions together with the development of market facilities in other nearby irrigated areas would have encouraged the production of some intensive row crops such as potatoes and sugar beets. On those lands receiving only a partial irrigation, the cropping pattern was limited to the production of hay and pasture. Partial irrigation would have allowed for early spring grazing, for cutting of one or two crops of hay, and for the greening of fall pastures.

Market and Technology Restraint

It was assumed that the prices received and yields obtained for crops grown under the "without" conditions would have been the same as for the actual project. The rationale for this assumption was that the project, in and of itself, did not significantly affect market prices nor did it generate new technology that would have improved yields. The "without" scenario in essence was credited with experiencing the same economic conditions and an equal opportunity to adopt the technological improvements as were historically experienced. These assumptions appeared reasonable, based on the fact that at least ninety percent of the irrigated acreage in the "without" scenario was devoted to forage and grain crops. Grains, being relatively non-perishable, are easily marketed and their prices are largely determined on a world market so that local changes on supply should have had little affect on price. The production of forage crops would have been nearly the same "without" as "with" the Project, so that no change in price was predicted for hay and pasture.

By using the same prices for products and inputs, and the same yields on full service acreage, it was implicitly assumed that "without" the Project the same plant varieties, cultural and harvest techniques, irrigation practices, and management skills were available for adoption, though not necessarily utilized on the same scale. Those acres in the "without" scenario receiving only partial irrigation would probably have been farmed quite differently than those receiving full supplies. Consequently, an assumption was made that on the partially serviced acreage the cropping patterns and yields would have changed according to the amount of water they received and that the prices for farm inputs and crop production would have remained constant.

Storage Development Restraint

Under the federal project a system of reservoirs developed to extend the capabilities of the Boise and Payette watersheds, however, indications are that in the early part of the 1900's there were a number of attempts at private development. Most private endeavors fell through due to financial failure and private development essentially ceased. This is indicated by a quote from a History of the Development and Current Status of the Carey Act in Idaho (17). This states:

> "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 lands to the general public, or to find people willing to invest as stockholders in a construction company."

The Carey Act, in its wording, was not specific in stating any particular method of development. Generally the concept called for the states to contract with private construction companies for the building of irrigation works. The construction companies would then sell water rights to settlers in order to reimburse themselves for the cost of construction. Recall that the west was capital deficient during the early 19th century, and by making the construction companies the middle-men in the delivery of water required them to show a high rate of profit to attract capital (4). With the lack of capital and risk of failure it was highly questionable as to whether or not enough private investment could have been secured for constructing a private irrigation project on the Boise River. With the poor economic conditions experienced during the depression and drought, it would seem improbable that any private investment in irrigation could have taken place until after World War II. By that time, the enormous amount of capital required, coupled with problems of land acquisition, would have probably limited any further development again to the federal government.

Following the above rationale no provision for storage was provided in the "without" scenario of agricultural development. Though not included in the final report, several alternatives that included storage were examined during the course of study. An in-depth, unpublished thesis by Jawa (6) tried a wider spectrum of models that included storage alternatives. Based on his conclusions the scenario presented here appears to offer a very reasonable and economically sound alternative for comparison with the historical record.

Groundwater Development Restraint

The study team felt that sprinkler irrigation would not have been practiced on any more land than was actually irrigated from groundwater "with" the Project. Groundwater development "without" the Project probably would have followed a pattern of growth similar to the actual case. Technological development of pumping for irrigation did not develop until after World War II. There are some hydrologic indications that the practice of flood irrigation has played an important role in recharging groundwater aquifers. "Without" the Project, the supply of available groundwater might have limited development of pump irrigation to levels below those which have occurred historically. The assumption was made that there would not have been any difference in the amount of groundwater irrigation either "with" or "without" the Boise Project and since groundwater (sprinkler) irrigation was not included as a direct benefit "with" there was no need to include it "without".

The hydrologic model is based on the assumption that the acres irrigated would have been limited by what could have been irrigated from the natural, unregulated flows of the Boise River and the Payette Project. Slightly different approaches are necessary in treating the analysis for the respective rivers.

Boise River System

For this study, the input data for water supply is the unregulated flow data as reported by the Boise River Watermaster. A further restraint was that 174,000 acres was the amount of land within Boise River drainage that had decreed water rights at the beginning of federal support of the Boise Project. This was based on a study made of the Stewart Decree. The amount of irrigated land projected for development and irrigated in any year was also limited by the natural flow restraint based on the shortage criteria developed by the Pacific Northwest River Basin Commission (11). This was applied on a month by month basis and was always limited by the flow for the month of August.

An operation study was made of diversions for each year. The diversion demand for the early years was based on a three-crop program for the period 1904 to 1950 in which full supply acreage would have been devoted to the following crops in the percentages shown:

Grain Crops	32%
Hay Crops	40%
Pasture Crops	28%

This is based on a historical study of the crop reports for the projects. It is recognized there were a few minor acreages devoted to other crops, but this would not have changed the pattern of diversions to any extent. Required acreage diversion rates were estimated by making a weighted average of irrigation requirements for the three crops at the Caldwell as indicated by Sutter and Corey (13). The diversion for the year was taken as an average year condition of runoff. The average diversion rate per acre for the entire Boise River was based on the diversions for the normal year of 1951.

The required average diversion rate per month for the three-crop plan was computed as follows:

May	0.69 Ac. Ft./Ac. = D_M
June.	1.37 Ac. Ft./Ac. = D_{JU}
July.	1.83 Ac. Ft./Ac. = D_{JL}
August.	1.08 Ac. Ft./Ac. = D_A
September	0.41 Ac. Ft./Ac. = D_S

The month by month operations study has been made for computing acreage that could have possibly been irrigated using the following criteria:

Let R_i = Runoff available in month,i, according to natural unregulated flows. (Acre-feet)

R^*_i = Runoff available in month,i, according to the shortage criteria. (Acre-feet)

D_i = Diversion rate for month,i. (Acre/feet/acre)

A_i = Acreage irrigated in month,i. (Acres)

If $R_i > R^*_i$ then water in month, i, will be limited by the shortage criteria and

$A_i = \frac{R^*_i}{D_i}$, If $R^*_i > R_i$, then $A_i = \frac{R_i}{D_i}$

where $A_i > 174{,}000$, then $A_i = 174{,}000$, A_i cannot exceed the acreage of decreed water rights.

The operations study revealed that August always governed the amount of land that could be served with a full water supply. During June, July, and September, it was hypothesized that a partial supply of water would have been available as follows:

$$B_{JL} = A_{JL} - A_A$$

Where B_{JL} = acreage with partial water supply that would have yielded the equivalent of two crops of hay and valued approximately 0.65 the full annual crop value. The full annual crop value is defined as the average net value added per acre by a given crop as historically occurred on the Boise Project for that year.

$$B_{JU} = A_{JU} - A_{JL}$$

Where B_{JU} = acreage of pasture irrigated only through June and would receive an income value equivalent to 0.30 the annual full supplied crop value.

The partial supply for September is a more complex situation. Those acres for which water might be available, over and above the water required for the crop acreage receiving full water supply, would have been deficient in soil moisture by September. These acres receiving a partial supply in September would then need higher diversions than the fully supplied corps.

Let R'_S = Water runoff available in September for irrigation above that needed to supply the full service croplands. Full service lands being limited by August water would be A_A. (Acre-feet)

0.41 = Diversion requirement for September with the three crop program. (Acre-feet/acre)

If $R_S < R^*_S$, then $R'_S = R_S - A_A\ 0.41$

If $R_S > R^*_S$, then $R'_S = R^*_S - A_A\ 0.41$

Then $$B_S = \frac{R'_S}{D'_S}$$

where B_S = Additional partial service lands that could be irrigated in September which would have a pasture production with a crop value equivalent to 0.20 the full supplied crop value. (Acres)

D'_S = Needed diversion requirement in September for partial service lands = 1.0 acre-feet/acre.

With August always being the limiting month, the August acreage, A_A, determines what acreage will receive a full supply of water. A_A then receives full crop values for the crop pattern previously identified.

For the period from 1950 to 1974 a more intensive type of irrigated agriculture was assumed to have prevailed in the Boise River Valley. An eight-crop plan based on historical patterns in the area was projected for the operational study as follows:

Grain	20%
Hay	30%
Pasture	20%
Sugar Beets	13%
Seed Crops	7%
Potatoes	5%
Vegetables	3%
Fruit	2%

The average diversion rate for these crops were computed to be as follows:

April . . . . 0.05 Ac. Ft./Ac. = D_A
May . . . . 0.58 Ac. Ft./Ac. = D_M
June. . . . . 1.29 Ac. Ft./Ac. = D_{JU}
July. . . . . 1.92 Ac. Ft./Ac. = D_{JL}
August. . . . . 1.24 Ac. Ft./Ac. = D_A
September . . . . 0.41 Ac. Ft./Ac. = D_S
October . . . . 0.03 Ac. Ft./Ac. = D_O

A month by month operations study was made with the 8-crop plan as with the 3-crop plan outlined earlier.

Diversion and irrigated acreage permitted by this operations study for the Boise River system are shown on Tables 3 and 4, respectively.

Payette River System

This alternative was based on an assumption that irrigation development and flow depletion above Horseshoe Bend on the Payette River would have been the same as has historically occurred. Unregulated flows for the Payette River was obtained by taking data prepared by R. J. Sutter of the Idaho Department of Water Resources for period 1928-1975 (14). This gives flows that would have been in the river if no reservoir regulation had occurred. It does provide for depletions to upstream irrigation. Flow data for the 1906 to 1928 period was taken from U.S. Water Supply Paper 1317, (16). There are a few missing records in 1917, 1918, and 1919. These were estimated by graphical correlation using data from Boise River measurements at Twin Springs for each of the months of April through September.

The operation study on the Payette River was based on an upper limit of irrigation not to exceed 87,000 acres. This was based on amount of irrigated land that had developed in the Payette River drainage below Horseshoe Bend by 1954 as reported in study by the U.S. Bureau of Reclamation by George N. Carter (2). There has not been an adjudication of water rights on the Payette River so the restraint by water rights could not be used as it was on the Boise River.

Table 3. Boise River Irrigation Diversions, acre feet 1910-1973.

Year	"Without" Project Diversions				
	June	July	Aug.	Sept.	Total
1910	82,200	109,800	55,970	29,424	277,394
1911	97,818	130,662	62,703	37,145	328,328
1912	113,436	151,524	65,992	46,749	377,701
1913	129,054	158,660	69,198	54,290	411,202
1914	144,672	124,130	58,742	52,634	380,178
1915	160,290	83,872	40,926	39,672	324,763
1916	175,908	158,934	71,040	53,686	459,568
1917	191,526	158,932	65,224	43,950	459,632
1918	207,144	112,526	56,292	51,122	427,084
1919	222,762	69,736	36,404	34,262	363,164
1920	238,380	117,324	40,586	39,234	435,524
1921	238,380	126,915	58,093	48,784	472,172
1922	238,380	126,914	58,096	47,974	471,364
1923	238,380	136,918	58,045	42,946	466,289
1924	76,791	35,296	24,426	25,320	161,833
1925	238,380	105,127	50,753	46,408	440,668
1926	104,636	42,192	30,858	29,480	207,166
1927	181,523	73,657	44,122	42,739	342,041
1928	181,523	73,661	44,117	38,016	337,317
1929	181,523	77,586	35,716	31,802	326,627
1930	181,526	77,586	44,922	36,050	340,084
1931	110,844	34,042	23,952	23,940	192,778
1932	146,183	55,809	38,348	36,666	277,006
1933	146,183	55,814	38,349	32,200	272,546
1934	85,625	36,200	23,570	26,072	171,467
1935	150,595	56,267	38,056	29,980	274,898
1936	196,559	70,336	40,456	35,982	343,333
1937	178,995	59,986	25,948	25,746	290,675
1938	187,773	65,163	36,420	33,929	323,285
1939	136,299	60,358	28,454	30,436	255,547
1940	166,433	63,559	30,808	33,662	294,462
1941	200,506	73,850	36,287	36,090	346,733
1942	200,400	73,847	36,293	35,496	346,136
1943	200,506	73,851	36,285	36,916	347,558
1944	238,380	87,463	41,115	35,352	402,310
1945	238,380	87,465	42,652	39,020	407,517
1946	238,380	90,259	42,648	41,109	412,396
1947	238,830	105,405	46,168	38,466	428,419
1948	238,830	105,405	44,612	36,580	424,977
1949	238,830	93,542	41,120	31,176	404,218
1950	224,460	126,271	54,690	42,955	448,376
1951	224,460	136,472	54,728	42,550	458,210
1952	224,460	136,471	56,695	44,614	462,240
1953	224,460	136,468	56,701	44,617	462,246
1954	224,460	144,647	60,020	41,668	470,795
1955	224,460	131,738	56,754	40,794	453,746
1956	224,460	148,459	62,734	46,231	481,884
1957	224,460	148,306	51,944	48,171	472,811
1958	224,460	142,466	61,766	50,415	479,107
1959	224,460	104,896	48,432	54,111	431,899
1960	224,460	81,574	45,758	46,244	398,036
1961	215,991	56,820	40,060	38,212	351,083
1962	224,460	121,694	57,452	49,586	453,192
1963	224,460	121,694	53,310	53,958	453,422
1964	224,460	121,687	50,092	52,798	449,037
1965	224,460	121,690	57,857	58,147	462,154
1966	178,048	54,000	39,052	37,766	308,866
1967	224,460	96,243	49,100	54,416	415,219
1968	224,460	76,126	54,308	53,989	408,883
1969	224,460	89,535	51,278	48,678	413,951
1970	224,460	93,523	56,591	54,474	429,048
1971	224,460	129,534	60,075	57,298	471,367
1972	224,460	129,535	60,727	58,588	473,210
1973	213,821	75,108	41,870	45,360	276,159

Table 4. Boise River Irrigated Acreage, acres, 1910-1973.

Year	"Without" Project Acres		
	Full	Partial	Total
1910	51,824	8,176	60,000
1911	58,059	13,341	71,400
1912	61,103	21,697	82,800
1913	64,072	30,128	94,200
1914	54,390	51,210	105,600
1915	37,894	79,106	117,000
1916	65,778	62,622	128,400
1917	60,393	79,407	139,800
1918	52,122	99,078	151,200
1919	33,707	128,893	162,600
1920	37,579	136,421	174,000
1921	53,790	120,210	174,000
1922	53,792	120,208	174,000
1923	53,745	120,255	174,000
1924	22,616	33,436	56,052
1925	46,994	127,096	174,000
1926	28,572	47,805	76,377
1927	40,854	91,645	132,499
1928	40,849	91,650	132,499
1929	33,070	99,429	132,499
1930	41,594	90,907	132,501
1931	22,178	58,730	80,908
1932	35,507	71,196	106,703
1933	35,509	71,194	106,703
1934	21,824	40,676	62,500
1935	35,237	74,687	109,924
1936	37,459	106,015	143,474
1937	24,026	106,628	130,654
1938	33,722	103,339	137,061
1939	26,348	73,141	99,489
1940	28,526	92,958	121,484
1941	33,599	112,756	146,355
1942	33,605	112,746	146,351
1943	33,597	112,758	146,355
1944	38,069	135,931	174,000
1945	39,492	134,508	174,000
1946	39,489	134,511	174,000
1947	42,748	131,252	174,000
1948	41,307	132,693	174,000
1949	38,074	135,926	174,000
1950	44,105	129,895	174,000
1951	44,135	129,865	174,000
1952	45,721	128,279	174,000
1953	45,726	128,274	174,000
1954	48,404	125,596	174,000
1955	45,769	128,231	174,000
1956	50,592	123,408	174,000
1957	41,890	132,110	174,000
1958	49,811	124,189	174,000
1959	39,058	134,942	174,000
1960	36,902	137,098	174,000
1961	32,306	135,129	167,435
1962	46,332	127,668	174,000
1963	42,992	131,008	174,000
1964	40,397	133,603	174,000
1965	46,652	127,348	174,000
1966	31,494	106,528	138,022
1967	39,597	134,403	174,000
1968	43,797	130,203	174,000
1969	41,353	132,647	174,000
1970	45,638	128,362	174,000
1971	48,447	125,553	174,000
1972	48,973	125,027	174,000
1973	33,766	131,987	165,753

For the operational analysis the diversion demand for the period 1928-1950 was based on a three-crop program in the crops and percentages shown:

Grain crops	31%
Alfalfa Hay crops . . .	36%
Pasture crops	33%

Required average diversion rates were estimated by making a weighted average of irrigation requirements for the three-crop pattern based on requirements listed by Sutter and Corey (13) at Ola, Idaho and Weiser, Idaho. The diversion for the year was taken as the average for the low Payette River valley for the years 1950 through 1953 which was 6.66 acre feet per acre. The required average diversion rate per month for the three-crop program was computed to be as follows:

April	0.05 Ac. Ft./Ac. = D_{AP}
May	0.90 Ac. Ft./Ac. = D_M
June.	1.64 Ac. Ft./Ac. = D_J
July.	2.04 Ac. Ft./Ac. = D_{JL}
August.	1.43 Ac. Ft./Ac. = D_A
September	0.47 Ac. Ft./Ac. = D_S
October	0.13 Ac. Ft./Ac. = D_O

The month by month operation study was applied similarly to the technique and analysis used on the Boise River with exception that

> $A > 87{,}000$, then $A_i = 87{,}000$; A cannot exceed this upper limit of acreage that would have been developed in any one year.

In the period 1950-1975 an eight-crop program was simplified and used as shown below:

Grain	30%
Alfalfa Hay	26%
Pasture	27%
Row Crops	8%
Potatoes.	1%
Sugar Beets	2%
Seed Crops.	3%
Vegetables.	3%
Orchard	9%

The required acreage diversion rate per month for this simplified eight-crop program was to be as follows:

April	0.03 Ac. Ft./Ac. = D_{AP}
May	0.82 Ac. Ft./Ac. = D_M
June.	1.57 Ac. Ft./Ac. = D_{JU}
July.	2.02 Ac. Ft./Ac. = D_{JL}
August.	1.50 Ac. Ft./Ac. = D_A
September	0.57 Ac. Ft./Ac. = D_S
October	0.15 Ac. Ft./Ac. = D_O

Tables 5 and 6 show the diversions and irrigated acreage estimated for the Payette River System.

Table 5. Payette River Irrigation Diversions, acre-feet, 1910-1973.

Year	"Without" Project Diversions				
	June	July	Aug.	Sept.	Total
1910	39,360	48,960	34,320	11,280	133,920
1911	44,692	61,912	43,329	14,241	169,074
1912	60,024	74,664	52,338	17,202	204,228
1913	70,356	87,316	61,347	20,163	239,682
1914	80,688	100,368	66,400	24,590	272,046
1915	91,020	113,220	60,600	33,040	297,880
1916	101,352	126,072	88,374	29,046	344,844
1917	111,684	138,924	82,300	37,597	370,505
1918	122,016	125,000	73,000	47,344	367,360
1919	132,348	80,000	46,500	40,500	299,348
1920	142,680	159,700	62,100	56,100	420,580
1921	142,680	159,706	77,170	61,400	440,950
1922	142,680	159,700	73,800	51,100	427,280
1923	142,680	159,700	76,460	57,100	435,940
1924	105,000	55,800	39,500	36,300	236,600
1925	142,680	130,450	68,900	55,400	397,430
1926	118,000	60,400	45,800	39,700	263,900
1927	142,680	98,150	64,660	55,180	360,670
1928	142,680	98,150	60,500	48,200	349,530
1929	142,680	100,400	40,000	39,100	321,180
1930	142,680	75,600	46,400	39,800	304,480
1931	114,800	44,300	33,100	25,200	217,400
1932	142,680	78,730	51,220	44,800	317,430
1933	142,680	78,730	51,220	29,300	301,930
1934	125,300	48,200	30,000	28,700	232,200
1935	142,680	76,200	36,700	27,800	283,380
1936	142,680	83,800	46,570	37,030	310,080
1937	142,680	73,800	36,700	31,100	284,280
1938	142,680	80,660	44,150	35,550	303,040
1939	142,680	68,600	36,000	35,100	282,380
1940	142,680	77,400	40,200	35,460	395,740
1941	142,680	87,720	44,920	38,020	313,340
1942	142,680	87,720	44,920	38,020	313,340
1943	142,680	87,720	44,920	40,300	315,620
1944	142,680	97,600	48,100	38,900	327,280
1945	142,680	101,230	52,320	47,180	343,410
1946	142,680	107,960	53,700	50,100	354,440
1947	142,680	120,660	61,130	54,700	379,170
1948	142,680	120,660	61,130	48,900	373,370
1949	142,680	98,800	50,000	41,800	333,280
1950	136,590	152,000	70,700	56,160	415,450
1951	136,596	159,800	70,700	56,160	423,250
1952	136,590	161,500	71,900	49,300	419,290
1953	136,590	161,500	72,850	45,700	416,640
1954	136,590	175,740	75,700	49,100	437,130
1955	136,590	175,740	50,200	46,500	409,030
1956	136,570	175,740	76,220	48,400	436,950
1957	136,590	152,800	56,600	41,100	387,090
1958	136,590	135,400	65,600	46,600	384,190
1959	136,590	120,400	52,900	54,460	364,350
1960	136,590	90,400	56,000	44,300	327,290
1961	136,590	61,500	36,600	47,900	282,590
1962	136,590	120,400	55,100	42,800	354,890
1963	136,590	130,930	51,400	52,400	371,320
1964	136,590	130,930	59,790	52,950	380,260
1965	136,590	130,930	61,740	54,240	383,500
1966	136,590	63,300	30,800	33,800	264,490
1967	136,510	107,650	49,800	45,400	339,440
1968	136,590	86,100	55,340	53,570	331,600
1969	136,590	100,460	37,100	51,100	325,250
1970	136,590	105,500	51,450	55,270	348,810
1971	136,590	131,500	56,070	67,630	381,790
1972	136,590	137,050	56,400	60,700	390,740
1973	136,590	56,700	24,100	46,500	263,890

Table 6. Payette River Irrigated Acreage, acres, 1910-1973.

Year	"Without" Project Acres		
	Full	Partial	Total
1910	124,000	0	24,000
1911	130,300	0	30,300
1912	36,600	0	36,600
1913	42,900	0	42,900
1914	46,434	2,766	49,200
1915	42,378	13,122	55,500
1916	61,800	0	61,800
1917	57,552	10,548	68,100
1918	61,049	23,351	74,400
1919	32,517	48,183	80,700
1920	43,427	43,573	87,000
1921	53,965	33,035	87,000
1922	51,608	35,392	87,000
1923	53,469	33,531	87,000
1924	27,622	36,402	64,024
1925	48,182	39,818	87,000
1926	32,028	39,923	71,951
1927	45,217	41,783	87,000
1928	42,308	44,692	87,000
1929	27,972	59,028	87,000
1930	32,448	54,552	87,000
1931	23,147	46,853	70,000
1932	35,818	51,182	87,000
1933	35,818	51,182	87,000
1934	20,979	55,423	76,402
1935	25,664	61,336	87,000
1936	32,566	54,434	87,000
1937	25,664	61,336	87,000
1938	30,874	56,126	87,000
1939	25,175	61,825	87,000
1940	28,112	58,888	87,000
1941	31,413	55,587	87,000
1942	31,413	55,587	87,000
1943	31,413	55,587	87,000
1944	33,636	53,364	87,000
1945	36,587	50,413	87,000
1946	37,552	49,449	87,000
1947	42,748	44,252	87,000
1948	42,748	44,252	87,000
1949	34,965	52,035	87,000
1950	47,133	39,867	87,000
1951	47,133	39,867	87,000
1952	47,933	39,067	87,000
1953	48,567	38,433	87,000
1954	50,467	36,533	87,000
1955	33,467	53,533	87,000
1956	50,813	36,187	87,000
1957	37,733	49,267	87,000
1958	43,733	43,267	87,000
1959	35,267	51,733	87,000
1960	37,333	49,667	87,000
1961	24,400	62,600	87,000
1962	36,733	50,267	87,000
1963	34,267	52,733	87,000
1964	39,860	47,140	87,000
1965	41,160	45,840	87,000
1966	20,533	66,467	87,000
1967	33,200	53,800	87,000
1968	36,893	50,107	87,000
1969	24,733	62,267	87,000
1970	34,300	52,700	87,000
1971	37,380	49,620	87,000
1972	37,600	49,400	87,000
1973	16,057	70,933	87,000

Table 7. Total "Without" Project Irrigation Diversions, acre feet, 1910-1973*.

		"Without" Project Diversions				
Year	With Project Diversions	June	July	Aug	Sept	Subtotal
1910	NA	121,560	158,760	90,290	40,704	411,314
1911	NA	147,510	192,474	106,032	51,386	497,402
1912	NA	173,460	226,188	118,330	63,951	581,929
1913	NA	199,410	246,176	130,545	74,453	650,584
1914	NA	225,360	224,498	125,142	77,224	652,224
1915	978,838	251,310	197,092	101,526	72,712	622,640
1916	1,217,572	277,260	285,006	159,414	82,372	804,412
1917	1,058,228	303,210	297,856	147,524	81,547	830,137
1918	1,279,916	329,160	327,526	129,292	98,466	794,444
1919	1,176,828	355,110	149,736	82,904	74,762	662,512
1920	1,254,640	381,060	277,024	102,686	95.334	856,104
1921	1,361,022	381,060	286,615	135,263	110,184	813,122
1922	1,305,946	381,060	286,614	131,896	99,074	898,644
1923	1,469,530	381,060	286,618	134,505	110,046	902,229
1924	791,072	181,791	91,096	63,620	61,620	398,433
1925	1,498,354	381,060	235,577	119,653	101,808	838,098
1926	1,041,730	222,636	102,592	76,658	69,180	471,066
1927	1,519,235	324,203	171,807	108,722	97,919	702,711
1928	1,409,832	324,203	171,811	104,617	86,216	686,847
1929	1,324,063	324,203	177,986	75,716	69,902	647,807
1930	1,341,524	324,203	153,186	91,322	75,850	644,564
1931	1,088,376	255,644	78,342	57,052	41,140	410,178
1932	1,553,710	288,863	134,539	89,568	81,466	594,436
1933	1,454,571	288,863	134,544	89,569	61,500	574,476
1934	1,155,690	210,925	84,400	53,570	54,772	403,667
1935	1,455,529	293,275	132,467	74,756	57,780	558,278
1936	1,435,816	339,239	154,136	87,026	73,012	653,413
1937	1,282,432	321,675	133,786	62,648	56,846	574,955
1938	1,629,439	330,453	145,823	80,570	69,479	626,325
1939	1,453,049	278,979	128,958	64,454	65,536	537,927
1940	1,420,823	309,113	140,959	71,008	69,122	590,202
1941	1,585,307	343,186	161,570	81,207	74,110	660,073
1942	1,604,777	343,180	161,567	81,213	73,516	659,476
1943	1,804,808	343,186	161,571	81,205	77,216	663,178
1944	1,511,997	381,060	185,063	89,215	74,252	729,590
1945	1,625,411	381,060	188,695	94,972	86,200	750,927
1946	1,753,846	381,060	198,219	96,348	91,209	766,836
1947	1,835,965	381,060	226,065	107,298	93,166	807,589
1948	1,751,171	381,060	226,065	105,742	85,480	798,347
1949	1,984,024	381,060	192,342	91,120	72,976	737,498
1950	2,061,011	361,050	278,271	125,390	99,115	863,826
1951	2,144,220	361,050	296,272	125,428	98,710	881,460
1952	2,188,105	361,050	297,971	128,595	93,914	881,530
1953	2,132,515	361,050	297,968	129,551	90,317	878,886
1954	2,409,646	371,050	320,387	135,720	90,768	907,925
1955	2,116,532	361,050	307,478	106,954	87,294	862,776
1956	2,450,861	361,050	324,199	138,954	94,631	918,834
1957	2,228,416	361,050	301,106	108,544	89,271	859,971
1958	2,204,688	361,050	277,866	127,366	97,015	863,297
1959	2,246,186	361,050	225,296	101,332	108,511	796,189
1960	2,400,695	361,050	171,974	101,758	90,544	725,326
1961	2,031,231	352,581	118,320	76,660	86,112	633,673
1962	2,241,787	361,050	242,094	112,552	92,386	808,082
1963	2,182,180	361,050	252,624	104,710	106,358	824,742
1964	2,245,748	361,050	252,617	109,882	105,748	829,297
1965	2,311,995	361,050	252,620	119,597	112,387	845,654
1966	2,439,838	314,638	117,300	69,852	71,566	573,356
1967	2,313,321	361,050	203,893	98,900	90,816	754,659
1968	2,284,481	361,050	162,226	109,648	107,559	740,483
1969	2,404,903	361,050	189,995	88,378	99,778	739,201
1970	2,344,872	361,050	199,023	108,041	109,744	777,858
1971	2,405,939	361,050	261,034	116,145	114,928	53,157
1972	2,375,507	361,050	266,585	117,127	119,288	864,050
1973	2,303,905	250,411	131,808	65,970	91,860	640,049

* Total diversions of Boise and Payette Rivers, Table 3 and 5.

Table 8. Total "Without" Project Irrigated Acreage, acres, 1910-1973.*

Year	"With" Project Acres	"Without" Project Acres Full	Partial	Subtotal
1910	51,377	75,824	8,176	84,000
1911	63,575	88,359	13,341	101,700
1912	79,725	97,703	21,697	119,400
1913	76,265	106,972	30,128	137,100
1914	101,590	100,924	53,976	154,800
1915	132,127	80,272	92,228	172,500
1916	116,922	127,578	62,622	190,200
1917	157,024	117,945	89,955	207,900
1918	182,921	103,171	122,429	225,600
1919	224,282	66,224	177,076	243,300
1920	237,160	81,006	179,994	261,000
1921	241,700	107,755	153,245	261,000
1922	243,300	105,400	155,600	261,000
1923	249,500	107,214	153,786	261,000
1924	239,530	50,238	69,838	120,076
1925	227,038	95,176	165,824	261,000
1926	289,080	60,600	87,728	148,328
1927	283,070	86,071	133,428	219,499
1928	291,175	83,157	136,342	219,499
1929	296,270	61,042	158,457	219,499
1930	301,042	74,042	145,459	219,301
1931	297,335	45,325	105,583	150,908
1932	289,389	71,325	122,378	193,703
1933	287,715	71,327	122,376	193,703
1934	288,997	42,803	96,099	138,902
1935	284,283	60,901	136,023	196,924
1936	284,358	70,025	160,449	230,474
1937	271,358	49,690	167,964	217,654
1938	268,942	64,596	159,465	224,061
1939	270,300	51,523	134,966	186,589
1940	284,002	56,638	151,846	208,484
1941	284,616	65,012	168,343	233,355
1942	287,740	65,018	168,333	233,351
1943	285,193	65,010	168,345	233,355
1944	287,140	71,705	189,295	261,000
1945	287,894	76,079	184,921	261,000
1946	287,732	77,041	183,959	261,000
1947	289,772	85,496	175,504	261,000
1948	294,268	84,055	176,956	261,000
1949	298,723	73,039	187,961	261,000
1950	305,348	91,238	169,762	261,000
1951	317,525	91,268	169,732	261,000
1952	318,272	93,654	167,346	261,000
1953	321,484	94,293	166,707	261,000
1954	323,810	98,971	162,129	261,000
1955	327,519	79,236	181,764	261,000
1956	325,482	101,405	159,595	261,000
1957	327,604	79,623	181,377	261,000
1958	327,909	93,544	167,456	261,000
1959	326,778	74,325	186,675	261,000
1960	324,340	74,235	186,765	261,000
1961	322,623	56,706	197,729	254,435
1962	322,380	83,065	177,935	261,000
1963	348,399	77,259	183,741	261,000
1964	348,649	80,257	180,743	261,000
1965	345,793	87,812	173,188	261,000
1966	345,260	52,027	172,995	225,022
1967	346,850	72,797	188,203	261,000
1968	344,999	80,690	180,310	261,000
1969	343,411	66,086	194,914	261,000
1970	342,528	79,938	181,062	261,000
1971	340,333	85,827	175,173	261,000
1972	336,851	86,573	174,427	261,000
1973	340,613	49,833	202,920	252,753

*Total Acreage from Tables 4 and 6.

Table 9. "Without" Project Net Value-Added Income, 1910-1973.

Year	"With" Project*	"Without" Project Net Value-added Income		
		Boise River	Payette River	Total
1910	$ 81,176	$ 133,182	$ 40,979	$ 174,161
1911	189,453	254,960	86,818	341,778
1912	237,580	255,072	81,566	366,638
1913	264,639	443,450	171,046	614,496
1914	421,598	498,452	299,881	798,333
1915	965,848	326,400	381,227	707,627
1916	2,138,503	1,571,302	1,020,812	2,592,114
1917	4,482,035	2,560,422	1,815,554	4,375,976
1918	6,310,774	2,227,509	1,850,072	4,080,581
1919	8,903,234	1,762,821	1,434,211	3,197,032
1920	5,031,890	1,444,549	1,253,107	2,697,656
1921	5,462,042	1,120,681	748,415	1,905,096
1922	4,193,538	1,708,422	1,434,443	3,142,865
1923	5,181,865	1,392,480	1,108,799	2,501,279
1924	1,535,310	229,214	270,383	499,597
1925	3,588,214	1,322,457	1,031,871	2,354,328
1926	1,950,579	388,980	409,785	798,765
1927	4,180,981	973,636	874,666	1,848,302
1928	3,619,662	881,566	814,035	1,695,601
1929	4,881,456	868,502	801,529	1,670,031
1930	2,528,587	715,623	530,630	1,246,253
1931	191,625	120,670	110,501	231,171
1932	-673,203	7,189	668	7,857
1933	1,754,257	290,321	265,575	555,896
1934	1,896,513	183,278	200,260	383,538
1935	2,013,291	70,014	175,620	245,634
1936	3,673,312	199,249	219,341	418,590
1937	2,502,414	187,743	218,714	406,457
1938	1,496,593	123,762	137,212	260,974
1939	1,309,314	67,358	65,598	132,956
1940	1,338,758	151,235	137,391	288,626
1941	3,707,068	485,529	431,466	916,995
1942	8,598,370	1,136,982	976,751	2,116,733
1943	12,844,913	1,727,294	1,429,056	3,156,350
1944	13,451,100	1,755,023	1,364,843	3,119,866
1945	15,221,022	1,796,625	1,438,807	3,235,432
1946	16,454,940	1,727,698	1,432,207	3,159,905
1947	19,448,121	2,322,925	1,965,199	4,288,124
1948	19,410,105	2,590,216	2,216,976	4,807,192
1949	16,165,811	2,001,260	1,577,165	3,578,425
1950	13,521,991	2,519,909	2,233,165	4,753,074
1951	19,056,826	3,720,997	3,192,076	6,913,073
1952	18,847,122	4,525,452	3,187,253	7,712,705
1953	12,689,685	1,602,488	1,590,453	3,192,941
1954	15,504,428	2,780,716	2,943,708	5,724,424
1955	16,262,036	2,850,434	2,844,469	5,694,903
1956	18,496,377	4,006,612	3,621,587	7,628,199
1957	16,648,853	2,765,154	2,117,864	4,883,018
1958	17,823,322	2,642,588	2,065,006	4,707,594
1959	23,208,302	3,386,040	3,240,078	6,626,118
1960	22,353,313	3,131,295	3,120,417	6,261,712
1961	25,692,651	2,621,591	2,578,772	5,200,363
1962	24,524,549	3,770,912	3,422,519	7,193,431
1963	26,353,046	3,324,896	2,817,656	6,142,552
1964	22,749,344	2,873,424	2,403,578	5,272,002
1965	24,824,959	3,145,496	2,590,067	5,735,563
1966	27,005,835	2,473,240	1,712,625	4,185,865
1967	25,193,062	2,762,058	1,886,513	4,648,571
1968	25,665,194	2,883,948	1,922,002	4,816,950
1969	28,574,500	3,251,768	2,042,903	5,294,671
1970	27,365,822	3,449,412	1,987,640	5,437,052
1971	32,129,063	5,319,482	4,057,081	9,376,563
1972	37,401,183	5,704,344	3,944,258	9,648,602
1973	54,740,496	5,538,011	3,106,791	8,644,802

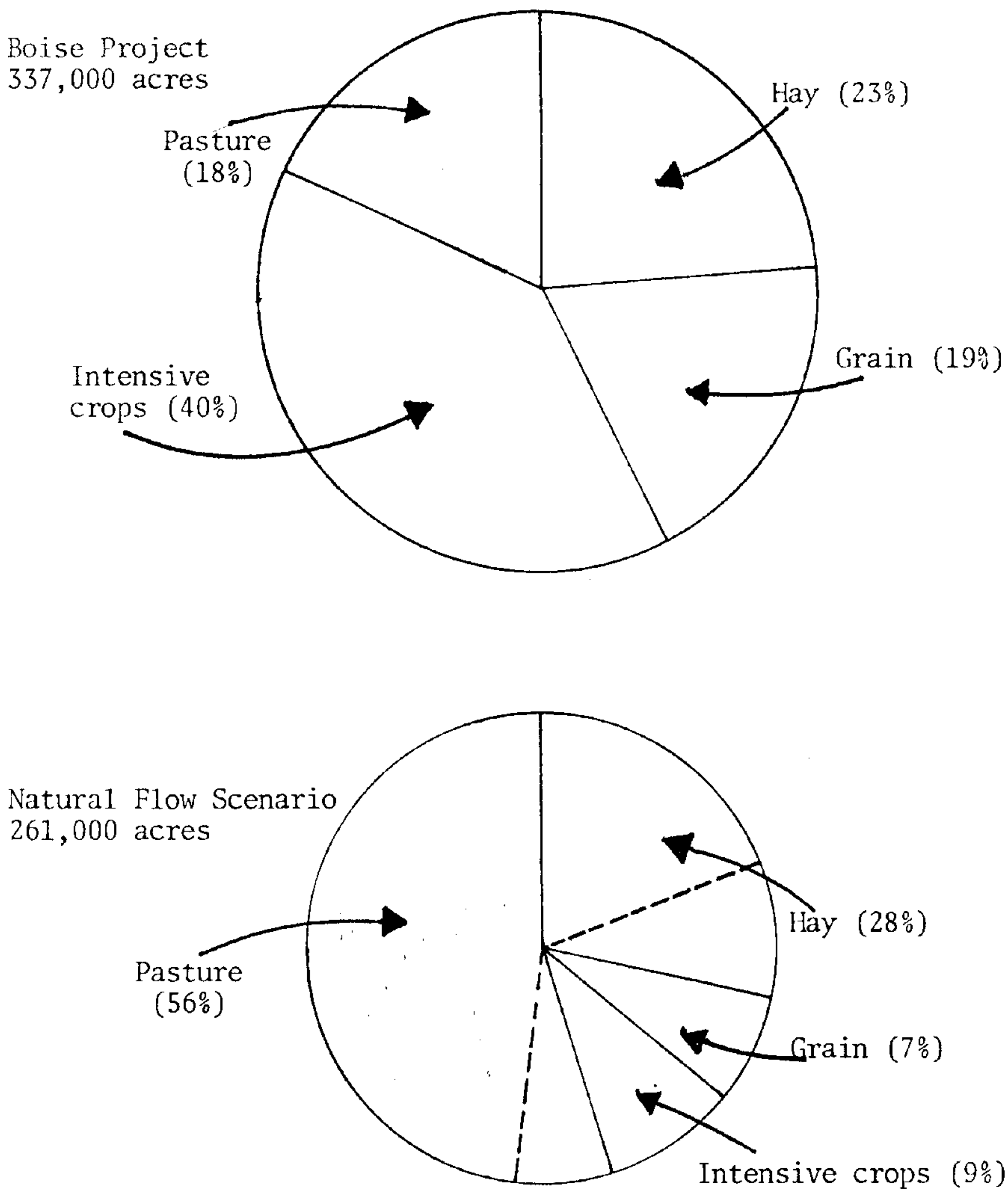
*From Table , Economic Subproject Report, Part I(9).

Hydrologic Model Results

The results of the operational study are summarized in Tables 7, 8, and 9 showing total (Boise and Payette Rivers) irrigation diversions, total irrigated acreage and total crop value-added income, respectively. The historical accomplishments of the Boise Project are included on these tables for comparison.

The annual diversions for the natural flow scenario ranged from a low of 398,400 acre feet in 1924 to a high of 918,000 acre feet in 1956, while over the entire period, the average irrigation diversion was 705,000 acre feet. With this amount of water available under the natural flow situation, the irrigated acreage was considered to have been able to increase from 84,000 acres to 261,000 acres. Crops produced on this acreage would have generated $174,000 in 1910 and $8,600,000 by 1973. The results in 1972 would have represented approximately 77 percent of the actual project's acreage, 36 percent of its diversion, and 18 percent of its income. This phenomena is dramatized by the circle diagrams in Figures 1, 2, and 3. A change in the size of the circles takes place as less water becomes available for irrigation. These diagrams help to explain the powerful income effect which results from being able to provide full irrigation and consequently, raise more intensive crops. While Figure 1 shows only a small reduction in total area of the two circles, there is a significant reduction in area receiving full water supply and even a greater change in acreage devoted to the production of intensive crops. The intensive crops (potatoes, sugar beets, seed crops, vegetables, and fruits), even though they represent only a small portion (9%) of the acreage irrigated in the "without" scenario, generate nearly 40 percent of the income earned for 1972. The reduction in the size of the circles representing net value-added income dramatizes the importance the Boise Project has played by furnishing a greater supply of irrigation water throughout the entire irrigation season.

Figure 1: Irrigated Acreage, 1972*



*Shaded portion indicates area partially irrigated, unshaded area is fully irrigated.

Figure 2: Irrigation Diversions, 1972

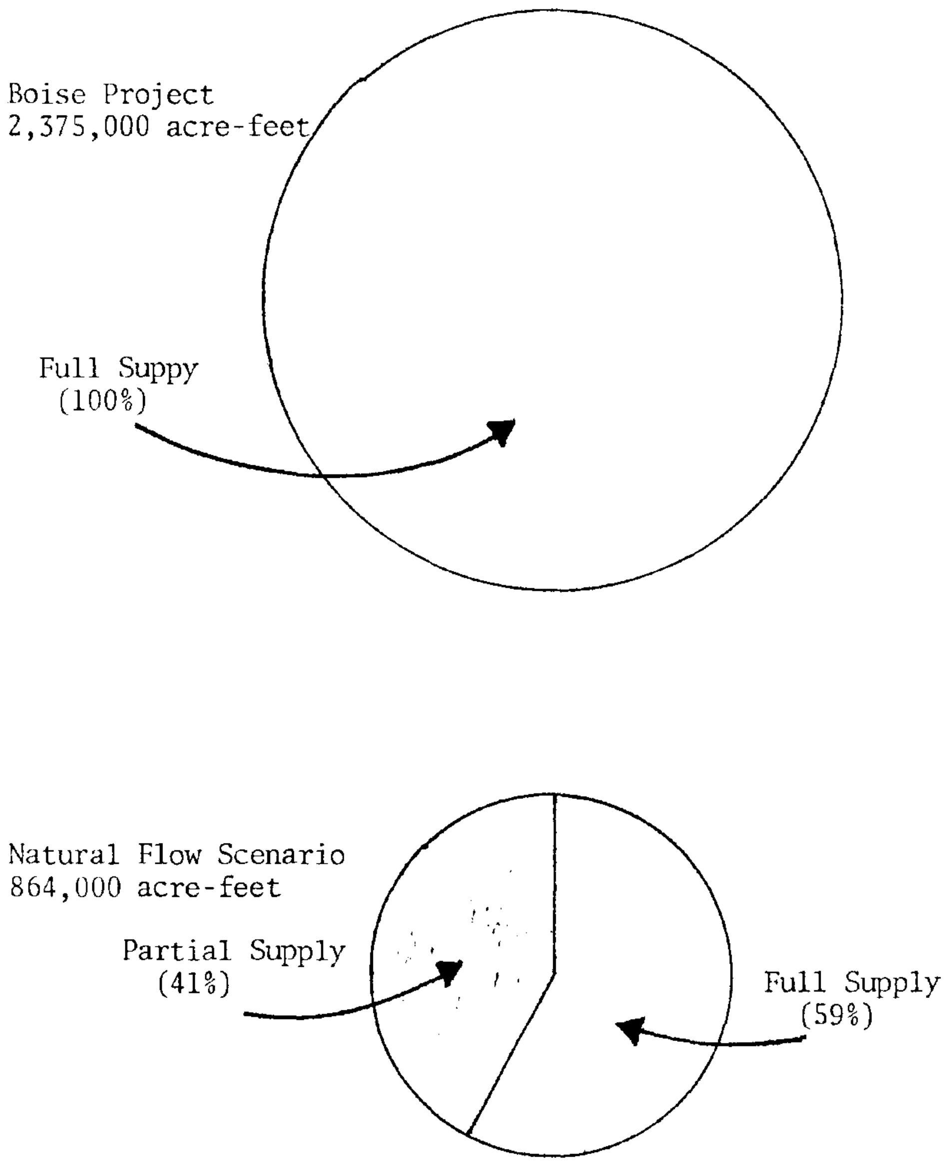
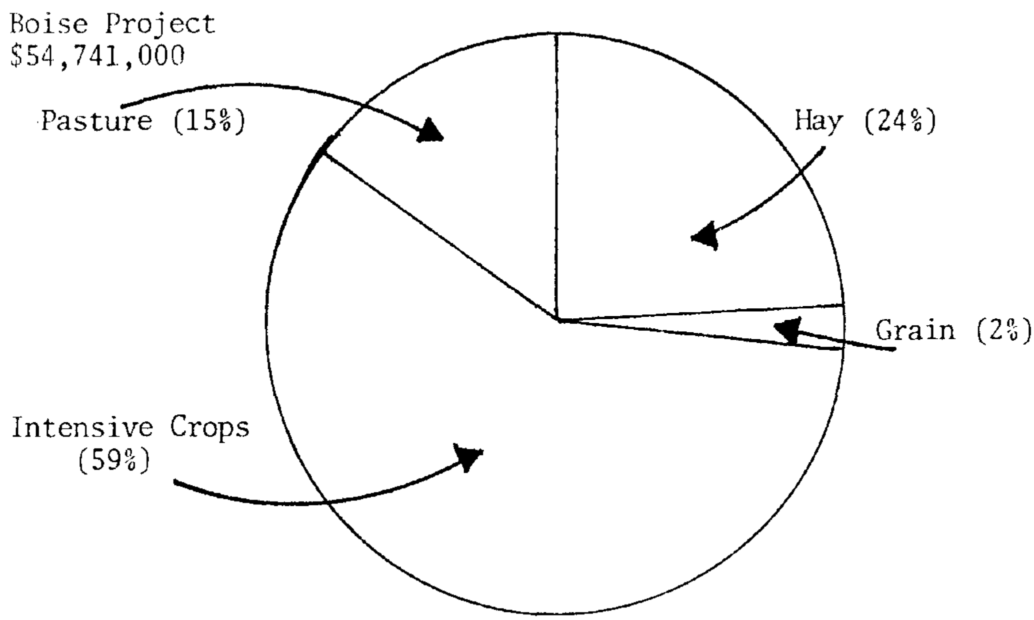
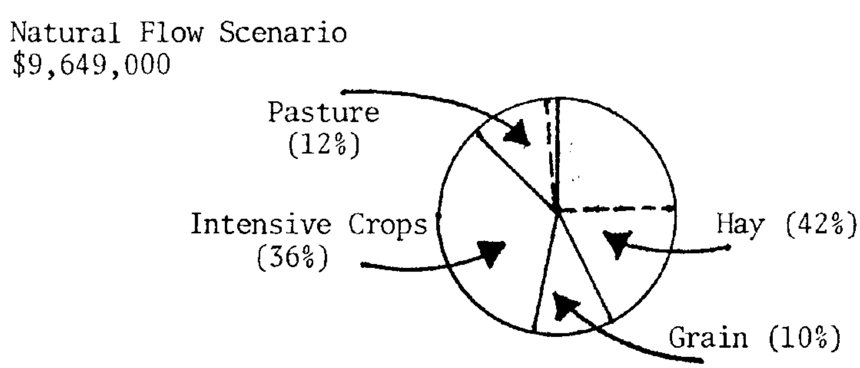


Figure 3: Net Value Added Income, 1972*





*Shaded portion indicates income from partially irrigated lands, unshaded from fully irrigated lands.

Annual Cost of the "Without" Scenario

Just as the Boise Reclamation Project has involved construction, operation, and maintenance costs, so would have any private attempts at irrigation. The irrigation from natural, unregulated flows would have required canals, drains, and diversion dams in order to divert and to allocate water over the 261,000 acres of irrigable land. The formation of private irrigation districts would have been necessary to operate and to maintain the private irrigation system.

The construction costs for the structures in the "without" scenario were based on actual unit costs of similar diversion dams, canals, and drains built for the Boise Project. The completion dates were assumed to have been 1910 for the dams and 1920 for the canals and drains. Table 10 displays the per unit investment costs for the Boise Project and the estimated investment from these unit costs for structures assumed to have been built in the "without" scenario. After converting all costs to 1910 dollars, Boise Diversion Dam and the canals and drains had average costs per unit of $1.33 per acre and $21.19 per acre, respectively. The direct construction costs were estimated by applying these unit costs to the number of units found in the "without" alternative. Table 10 shows that the natural flow scenario would have cost over $10,600,000, representing about 15 percent of the $69,000,000 total cost incurred in constructing the Boise Project.

Annual investment costs were computed using the same procedure employed in the analysis of the "with" project costs (9). First, each structure is depreciated over a 100 year life, then an alternative investment cost is computed on the remaining annual value. Alternative investment refers to the return that could have been earned if the money had been invested elsewhere. The return on alternative investments for the "without" project analysis was taken to be the long term prime commercial interest rate. Previously, the long term government bond rate was used to value the alternative investments for the Boise Project. Private investors, however, would have had to require a higher rate of return on their investments than would the Federal government.

Table 10. Direct Investment Costs

A. Boise Project Investment Costs

Year Completed	Structure	Cost[1]	Cost per Unit	WPI[2]	1910 Cost per Unit
1911	Lake Powell	$1,067,836	$ 6.32/AF	1.0866	$ 6.87/AF
1908	Boise Diversion Dam	372,000	1.33/A	1.0000	1.33/A
1918	Canals & Drains	9,490,559	39.54/A	0.5358	21.19/A

1. See Table , Economic Subproject Report, Part I(9).
2. Wholesale Price Index

B. "Without" Project Investment Costs

Year Completed	Structure	Cost per Unit	"Without" Scenario Units	"Without" Scenario Total Cost
1910	Diversion Dam (Boise River)	$ 1.33/A	174,000	$ 231,420
1910	Diversion Dam (Payette River)	1.33/A	87,000	115,710
1920	Canals & Drains	39.54/AF	261,000	10,319,940
			TOTAL	$10,667,070

The annual operation and maintenance costs for the "without" project alternative was based on the actual costs per acre incurred on Boise Project lands. The actual per acre cost was multiplied by the acres estimated to have been irrigated in the "without" scenario in order to arrive at the total operation and maintenance cost.

The annual cost for depreciation, alternative investments and operation maintenance for the "without" scenario is shown in Table 11. In 1973, the total annual cost for the natural flow alternative amounted to over $1,368,776 representing 25 percent of the actual, annual cost of $5,500,000 for the Boise Project in 1973.

Net Crop Return From the "Without" Project Scenario

Net crop returns are defined as the difference between the income added by the irrigation of crops in the "without" scenario and the annual cost of providing that irrigation. Under this definition the net returns from the natural flow scenario represent the inheritant productivity of the soil and water complex in the absence of federal investment in storage facilities. The net annual crop returns from the natural flow alternative are shown on Table 12. The net annual crop returns increased from $60,000 in 1910 to $7,300,000 in 1973 compared to $81,000 in 1910 and $54,700,000 in 1973 of net value-added income earned "with" the Projects.

This analysis shows the relative success of the natural flow alternative. Success would have been quite limited until after World War II, during the 1930's there was a ten year period (1931-1940) when benefits would not have covered investment costs. In such a situation, private irrigation in the Boise and Payette valleys may have folded instead of continuing. In a paper presented to the American Society of Civil Engineers (10), Nelson, Warnick, and Jawa develop a methodology for determining the financial feasibility of alternative levels of investment in the Boise Project area. Their findings suggest that there would have been enough collateral to justify the long periods of accumulated debt.

Subsequent sections of this report will discuss not only the net additional benefits from irrigation but also from indirect economic benefits.

Table 11. Annual Cost, "Without" Scenario, 1910-1973

Year	Depreciation	Alternative Investment	Operation and Maintenance Costs	Total Cost
1910	3,471	93,947	93,947	113,827
1911	3,471	98,614	98,614	118,340
1912	3,471	118,320	118,320	137,881
1913	3,471	219,937	219,937	377,215
1914	3,471	159,169	159,169	178,402
1915	3,471	138,581	138,581	157,650
1916	3,471	231,907	231,907	250,812
1917	3,471	262,534	262,534	281,275
1918	3,471	275,066	275,066	293,643
1919	3,471	202,528	202,528	220,941
1920	106,671	265,683	265,683	937,989
1921	106,671	282,527	282,527	924,949
1922	106,671	201,972	201,972	756,655
1923	106,671	185,503	185,503	741,787
1924	106,671	64,106	64,106	585,122
1925	106,671	168,570	168,570	665,058
1926	106,671	65,310	65,310	539,694
1927	106,671	48,503	48,503	485,351
1928	106,671	79,753	79,753	512,060
1929	106,671	93,915	93,915	548,785
1930	106,671	77,749	77,749	403,471
1931	106,671	39,395	39,395	461,992
1932	106,671	55,453	55,453	506,284
1933	106,671	51,579	51,579	464,276
1934	106,671	41,896	41,896	437,699
1935	106,671	62,019	62,019	420,688
1936	106,671	83,643	83,643	430,410
1937	106,671	77,718	77,718	426,025
1938	106,671	71,820	71,820	405,878
1939	106,671	65,931	65,931	379,994
1940	106,671	66,098	66,098	364,842
1941	106,671	71,990	71,990	350,700
1942	106,671	71,341	71,341	381,841
1943	106,671	202,016	66,023	374,710
1944	106,671	200,189	99,552	406,412
1945	106,671	188,781	99,929	395,381
1946	106,671	172,108	201,110	479,889
1947	106,671	174,423	208,887	489,981
1948	106,671	186,549	207,297	500,517
1949	106,671	174,146	346,883	627,700
1950	106,671	172,425	264,581	543,677
1951	106,671	188,264	375,373	670,308
1952	106,671	193,463	373,998	674,132
1953	106,671	209,096	374,572	690,339
1954	106,671	178,638	370,071	655,380
1955	106,671	195,925	217,556	520,252
1956	106,671	209,196	354,009	669,876
1957	106,671	231,984	349,337	687,992
1958	106,671	225,651	271,052	603,374
1959	106,671	263,413	244,441	614,525
1960	106,671	255,251	650,449	1,012,371
1961	106,671	244,090	204,203	554,964
1962	106,671	243,006	475,637	825,314
1963	106,671	241,815	521,419	869,905
1964	106,671	246,457	692,962	1,046,090
1965	106,671	245,529	766,264	1,118,464
1966	106,671	266,802	609,819	983,292
1967	106,671	272,507	833,656	1,213,834
1968	106,671	289,381	764,857	1,160,909
1969	106,671	329,707	714,728	1,151,106
1970	106,671	349,183	767,629	1,223,483
1971	106,671	298,022	923,874	1,328,567
1972	106,671	286,305	972,505	1,365,481
1973	106,671	313,656	948,449	1,368,776

Table 12. Net Annual Crop Returns, "Without" Scenario, 1910-1973

Year	Total Cost	Total Benefit	Net Crop Return
1910	113,827	174,161	60,334
1911	118,340	341,778	223,438
1912	137,881	336,638	198,757
1913	377,215	614,496	237,281
1914	178,402	798,333	619,931
1915	157,650	707,627	549,977
1916	250,812	2,592,114	2,341,302
1917	281,275	4,375,976	4,094,701
1918	293,643	4,080,581	3,786,938
1919	220,941	3,197,032	2,976,091
1920	937,989	2,697,656	1,759,667
1921	924,949	1,905,096	980,147
1922	756,655	3,142,865	2,386,210
1923	741,787	2,501,279	1,759,492
1924	585,122	499,597	-85,525
1925	665,058	2,354,328	1,689,270
1926	539,694	798,765	259,071
1927	485,351	1,848,302	1,362,951
1928	512,060	1,695,601	1,183,541
1929	548,785	1,670,031	1,121,246
1930	403,471	1,246,253	842,782
1931	461,992	231,171	-230,821
1932	506,284	7,857	-498,427
1933	464,276	555,896	91,620
1934	437,699	383,538	-54,161
1935	420,688	245,634	-175,054
1936	430,410	418,590	-11,820
1937	426,025	406,457	-19,568
1938	405,878	260,974	-144,904
1939	379,994	132,956	-247,038
1940	364,842	288,626	-76,216
1941	350,700	916,995	566,295
1942	381,841	2,116,733	1,734,892
1943	374,710	3,156,350	2,781,640
1944	406,412	3,119,866	2,713,454
1945	395,381	3,235,432	2,840,051
1946	479,889	3,159,905	2,680,016
1947	489,981	4,288,124	3,798,143
1948	500,517	4,807,192	4,306,675
1949	627,700	3,578,425	2,950,725
1950	543,677	4,753,074	4,209,397
1951	670,308	6,913,073	6,242,765
1952	674,132	7,712,705	7,038,573
1953	690,339	3,192,941	2,502,602
1954	655,380	5,724,424	5,069,044
1955	520,252	5,694,903	5,174,651
1956	669,876	7,628,199	6,958,323
1957	687,992	4,883,018	4,195,026
1958	603,374	4,707,594	4,104,220
1959	614,525	6,626,118	5,613,747
1960	1,012,371	6,261,712	5,249,341
1961	554,964	5,200,363	4,645,399
1962	825,314	7,193,431	6,368,117
1963	869,905	6,142,552	5,272,647
1964	1,046,090	5,277,002	4,230,912
1965	1,118,464	5,735,563	4,617,099
1966	983,292	4,185,865	3,202,573
1967	1,213,834	4,648,571	3,434,737
1968	1,160,909	4,816,950	3,656,041
1969	1,151,106	5,294,671	4,143,565
1970	1,223,483	5,437,052	4,213,569
1971	1,328,567	9,376,563	8,047,996
1972	1,365,481	9,648,602	8,283,121
1973	1,368,776	8,644,802	7,276,026

THE TRADE FLOW MODEL

Model Formulation

Almost all water resource projects will cause indirect effects on other parts of the economy. The increased crop production stemming from the Boise Irrigation Project, for example, required additional processing, transporting, and selling activities to market those products. As agri-businesses grow so will their demand for intermediate goods and services from other sectors of the economy. Household income will rise in turn in proportion to the growth of the economy further stimulating the demand for consumption. This is the indirect change in the economy resulting from a direct change in crop production that we wish to measure as an indirect economic impact of the Boise Project.

In order to measure the indirect impact of the Project, it is necessary to determine the structure of the economy - the interdependences and linkages that exist between the Project's crop production and the rest of the economy. An input-output model was chosen to accomplish this measurement for its ability both to portray the flow of goods and services through the economy and to identify indirect impacts of exogenous changes in agricultural production.

The Boise area is the economic and transportation center for the state. Gravity theory from regional science is well illustrated by this situation - one small region with the greatest population surrounded by a larger, less populated area. The resources of the larger, surrounding region, can supply the major portions of the import requirements for the smaller region. Institutional, political, and financial ties are stronger within a state than among regions separated by state lines. The major indirect impacts from the Boise Project were felt to be contained within Idaho's economy, with the majority of the impact on the Boise locality, itself. The model was built around an interregional format to encompass the biregional nature of the Project's impact. The state of Idaho was broken down into two regions - the Boise region (Ada and Canyon counties) and the Rest of Idaho. The impact regions had to be chosen to correspond to existing political boundaries in order to accumulate the secondary data necessary to implement the model. A complete description of the interregional model - its format, requirements, and methodology can be found in Economic Subproject Part II by Roger Long (8).

Forty sectors were identified in the trade flow model - twenty sectors for each region: one livestock production sector, eight crop production sectors (grain, forage, potatoes, sugar beets, vegetables, seeds, fruits, and peas-lentils), five food processing sectors (livestock processing, grain processing, potato processing, vegetable-fruit processing, and sugar-miscellaneous processing), and six miscellaneous sectors (manufacturing, utilities, construction, trade, services, and households). This particular level of sector aggregation was chosen so that the change from a highly intensive agriculture "with" the Project could be easily discerned from the extensive farming that would have existed "without" the Project. This is quite important to demonstrate the affect a shift in cropping patterns would have had on the food processing industry.

Aggregation has often been the subject of criticism of input-output theory. Product homogenity within a given sector is an implicit assumption in the sense that all industries within that sector should have similar sales and purchasing patterns. The severity of the problem, "aggregation bias", is measured by the difference in outputs resulting from an aggregated model and an unaggregated model. Hewings (3) points out that the expected changes in final demand should dictate the pattern of aggregation. Hewings contends that the aggregation bias will be insignificant if the model is formulated so that changes in final demand occur in unaggregated sectors. In the interregional trade flow model only the interregional trade flow model only the disaggregated agricultural sectors experience an exogenous change in final demands.

The trade flow model, as all models, is a simulation and therefore cannot be expected to account for all the complexities of a modern economy. Through simulation the model attempts to simplify reality to give the analyst some insights as to the probable structure of the economy and to the economic impact caused by the Boise Project. Model results are always subject to specific assumptions; in the case of input-output models the most limiting assumptions are those of constant technology and linear production functions.

Exogenous Changes "Without" the Boise Project

The trade flow model was used to simulate the gross output and value-added income that might have been earned "without" the Boise Project. In implementing the simulation, an exogenous change in the level of agricultural production was furnished along with a series of trade flow matrices developed in Economic Subproject Report Part II, Appendix E (8). The exogenous change refers to the difference in crop production from the historical situation and the production predicted by the previous hydrologic model. This change was the result of a loss in productivity if no federal investment in the storage of irrigation water had taken place on either the Boise or Payette Rivers.

Additional assumptions had to be made about the effects of the above change in crop production on the livestock and agricultural processing sectors. These assumptions were necessary because of the inability of the model to fully adjust to the "without" scenario. Three assumptions and their rationale follow:

1. Viable livestock production and processing sectors would have existed "without" the Boise Project. This assumption was based on the fact that the "hydrologic" model projected very little change in the level of forage production which supports the livestock industry.
2. There would not have been any sugar processing within the Boise Region "without" the Project. This was deduced from the fact that sugar beet production would have been down by at least 75 percent and from knowledge only one sugar processor presently services the area. It was felt there would not have been sufficient production to attract a processing plant into the area.
3. The processing of potatoes, fruits, and other vegetables would have occurred in proportion to the level of crop production of these crops would have been between 35 and 40 percent of the historical yield. In addition six plants that process one or more of these crops were located within the Boise region in 1973 according to the Manufacturing Director of Idaho (5). The Directory also indicated

that plant size ranged from those employing only 25 to 40 employees to plants with over 1000 employees. Based on anticipated production and the number and scale of existing plants, the study team felt some processing of these crops would have taken place "without" the Boise Project.

The exogenous change fed into the trade flow model was based on the crop production from the hydrologic model and on the above assumptions about the livestock and agricultural processing sectors.

Methodology of the Trade Flow Simulation

The "without" project simulation of the exonomy was based on the model previously discussed in Economics Subproject Report Part II, Appendices A-F (8). The equation for the basic interregional trade model was:

$$(1)\quad \begin{bmatrix} X_B \\ X_R \end{bmatrix}_i = \begin{bmatrix} A_{BB} & A_{BR} \\ A_{RB} & A_{RR} \end{bmatrix}_i \begin{bmatrix} X_B \\ X_R \end{bmatrix}_i + \begin{bmatrix} Y_B \\ Y_R \end{bmatrix}_i$$

Where X_B is the vector of outputs for the Boise (B) region in year i and X_R is the vector of outputs for the Rest (R) of Idaho. A_{BB}, A_{RB}, A_{BR}, and A_{RR} represent submatrices of the direct trade coefficients corresponding to the intermediate demands of Boise from Boise, of Boise from Rest of Idaho, of Rest of Idaho from Boise, and of Rest of Idaho from Rest of Idaho, respectively. The Y_B and Y_R vectors represent exports to regions outside of Idaho originating from Boise or the Rest of Idaho. By providing estimates of X_B and X_R for each year i, in the analysis period, the model will provide estimates of a new trade coefficient matrix, Ai (see Appendix E, (8)). By taking the estimated A matrix, the historical outputs X_R and X_S, and the predicted agricultural production and processing outputs "without" the Project for each year i, the outputs of the remaining sectors of the "without" economy were simulated by the following steps:

1. Determine the change in output from "with" to "without" the Boise project for Boise's fourteen agricultural production and processing sectors. Let ΔX_{AGR} represent this change for any given i.

2. Assume that this change in output, ΔX_{AGR}, causes a change in the remaining six Boise sectors, as well as the twenty sectors in the Rest of Idaho. Also assume there is no change in exports for the 26 non-Boise agricultural sectors. The problem is to estimate this change in non-Boise agricultural (NBA) sectors, X_{NBA}. The balance equations can be rewritten for any given year i, in the form of:

$$(2) \quad \begin{bmatrix} \Delta X_{AGR} \\ X_{NBA} \end{bmatrix}_i = \begin{bmatrix} C1 & C2 \\ C3 & C4 \end{bmatrix}_i \begin{bmatrix} X_{AGR} \\ X_{NBA} \end{bmatrix}_i + \begin{bmatrix} Y_{AGR} \\ Y_{NBA} \end{bmatrix}_i$$

given $\Delta Y_{NBA} = 0$ where the trade coefficient matrix, Ai, is decomposed into four submatrices such that:

$$Ai = \begin{bmatrix} C1 & C2 \\ C3 & C4 \end{bmatrix}_i$$

and each C_R represents a partition of A such that C_1 is a 14 by 14 matrix, C_2 is a 14 by 26 matrix, C_3 is a 26 by 14 matrix, and C_4 is a 26 by 26 matrix.

(3) Equation (2) can be decomposed into the following equations:

(3a) $\Delta X_{AGR} = C_1 \, \Delta X_{AGR} + C_2 \, \Delta X_{NBA} + \Delta Y_{AGR}$

(3b) $\Delta X_{NBA} = C_3 \, \Delta X_{AGR} + C_4 \, \Delta X_{NBA} + 0$
for year i.

(4) Solving equation (3b) for ΔX_{NBA} we obtain:

(4) $\Delta X_{NBA} = (1 - C_4) - C_3 \Delta X_{AGR}$

for year i.

Note that $C_3 \Delta X_{AGR}$ can be interpreted as the change in intermediate demand purchases of the 14 Boise agricultural sectors from the remaining 26 sectors of the economy.

(5) Knowing ΔX_{NBA}, equation (3a) could then be solved for the last unknown, ΔY_{AGR}.

Where $\Delta Y_{AGR} = (1 - C_1) \ \Delta X_{AGR} - C_2 \Delta X_{NBA}$

for year i.

(6) After solving for ΔX_{NBA} for each year i, the "without" levels of output, X_i^*, would become:

$X_{AGRi}^* = X_{AGRi} + \Delta X_{AGRi}$ for the Boise agricultural sectors, and

$X_{NBAi}^* = X_{NBAi} + \Delta X_{NBAi}$ for the non-Boise agricultural sectors.

Consequently the sum of X_{AGRi}^* and X_{NBAi}^* would represent the total output produced in year i, "without" the Project.

(7) A final step converts output X_j^* to value-added income, I_j^*.

Where $I_j^* = X_j^* \ (A_{j20} + A_{j40})$ for year i;

X_j^* is the "without" output of the jth sector, A_{j20} and A_{j40} represent the value-added coefficients of the Boise and Rest of Idaho regions for the jth sector.

TABLE 13: Output "With" and "Without" the Boise Project, 1947-1970.

Year	"With" Project Output*			"Without" Project Output		
	Boise Region ($\$10^6$)	Rest of Idaho ($\$10^6$)	Total ($\$10^6$)	Boise Region ($\$10^6$)	Rest of Idaho ($\$10^6$)	Total ($\$10^6$)
1947	466.250	1,722.521	2,188.771	374.684	1,706.477	2,081.16
1948	482.170	1,783.416	2,265.585	386.708	1,768.975	2,155.683
1949	498.676	1,785.695	2,284.371	396.386	1,768.306	2,164.692
1950	524.633	1,838.578	2,363.211	456.152	1,822.577	2,278.730
1951	562.731	1,928.962	2,491.693	485.246	1,913.619	2,398.865
1952	588.033	2,028.042	2,616.074	507.153	2,017.426	2,524.579
1953	611.835	2,112.147	2,723.982	568.662	2,099.927	2,668.589
1954	644.156	2,135.631	2,779.787	569.750	2,118.484	2,688.234
1955	675.207	2,240.314	2,915.521	597.684	2,221.068	2,818.753
1956	742.198	2,463.722	3,205.919	660.245	2,445,233	3,105.478
1957	818.498	2,608.261	3,426.759	734.184	2,582.826	3,317.010
1958	882.562	2,773.157	3,655.719	787.749	2,743.112	3,530.860
1959	915.737	2,859.079	3,774.816	759.756	2,808.518	3,568.274
1960	950.501	2,962.042	3,912.544	778.282	2,907.188	3,685.470
1961	1,020.186	3,095.608	4,115.793	817.450	3,031.585	3,849.035
1962	1,111.081	3,296.939	4,408.020	982.833	3,251.814	4,234.645
1963	1,103.037	3,422.846	4,525.883	946.643	3,383.172	4,329.813
1964	1,159.305	3,507.420	4,666.723	985.861	3,452.414	4,438.273
1965	1,324.641	3,965.074	5,289.715	1,123.488	3,902.675	5,026.160
1966	1,392.305	4,116.402	5,508.707	1,079.980	4,014.586	5,094.563
1967	1,469.908	4,284.113	5,754,020	1,245.429	4,201.531	5,446.957
1968	1,577.676	4,540.250	6,117.926	1,316.354	4,448.367	5,764.719
1969	1,749.976	5,042.172	6,792.145	1,474.766	4,947.809	6,422.574
1970	1,789.546	5,480.102	7,403.141	1,628.801	5,371.363	7,000.160

* See Economic Subproject Report Part II (8).

TABLE 14: Net Value-Added Income "With" and "Without" the Boise Project, 1947-1970.

Year	"With" Project Income			"Without" Project Income		
	Boise Region ($\$10^6$)	Rest of Idaho ($\$10^6$)	Total ($\$10^6$)	Boise Region ($\$10^6$)	Rest of Idaho ($\$10^6$)	Total ($\$10^6$)
1947	164.765	536.464	701.229	125.428	531.053	656.481
1948	162.304	519.928	682.232	124.328	515.349	639.677
1949	162.656	510.352	673.008	125.869	505.102	630.971
1950	166.529	515.102	681.630	141.447	510.238	651.685
1951	178.784	527.481	706.266	148.730	523.048	671.778
1952	182.820	551.399	734.219	153.713	548.502	702.215
1953	185.193	572.869	758.062	164.967	569.257	734.223
1954	202.018	593.640	795.658	174.487	588.666	763.153
1955	209.438	616.683	826.121	180.590	611.098	791.687
1956	229.288	678.988	908.276	199.340	673.607	872.947
1957	271.501	772.336	1,043.837	237.259	764.511	1,001.769
1958	286.454	807.157	1,093.612	248.945	797.976	1,046.921
1959	314.820	872.631	1,187.451	256.578	856.621	1,113.199
1960	317.541	888.960	1,206.501	257.645	871.915	1,129.560
1961	336.983	906.538	1,243.521	267.179	887.263	1,154.443
1962	373.184	986.240	1,359.424	322.246	972.336	1,294.583
1963	361.178	1,011.805	1,372.984	301.633	999.741	1,301.374
1964	374.811	1,025.919	1,400.730	314.530	1,009.077	1,323.608
1965	446.070	1,218.148	1,664.218	373.836	1,198.341	1,572.177
1966	468.109	1,256.484	1,724.593	365.502	1,224.005	1,589.507
1967	500.980	1,326.495	1,827.475	419.742	1,299.768	1,719.510
1968	527.117	1,374.244	1,901.361	438.224	1,345.285	1,783.509
1969	594.412	1,558.321	2,152.733	495.877	1,527.977	2,023.854
1970	660.301	1,706.459	2,366.760	556.710	1,671.212	2,227.923

Trade Flow Simulation Results

A trade flow simulation was run for a twenty-four year period from 1947 to 1970. The model provides estimates of output and value-added income for each of the forty sectors included in the "without" Project scenario. Both the "with" and "without" project outputs and incomes are summarized by region for the entire twenty-four year period in Tables 13 and 14. The "with" output in the Boise region, as shown in Table 13, had grown from $466 million dollars in 1947 to $1.8 billion in 1970 compared to a growth from $375 million to $1.6 billion "without" the Boise Project. Similarly, income grew from $165 million to $660 million during the twenty-four year period "with" the Project and from $125 million to $557 million "without" the Project. The trade flow model simulates the economy for the Boise region and the entire state providing estimates of the outputs and incomes that would have been generated "without" the Project for each sector in the model. This gives a complete picture of what the economy of Boise and of Idaho might have appeared based on the previously stated assumptions.

INDIRECT BENEFITS OF THE BOISE PROJECT

Issue of Indirect Benefits

When the resources of the economy are fully employed and mobile among jobs, it must be that an expanding activity causes at least a temporary contraction in those areas from which its labor and capital were drawn. Indirect benefits may then only represent a transfer of income from one region to another. This would not constitute a project benefit from the national point of view but could be important from a regional stance.

When conditions of full employment and labor mobility fail to hold, however, situations may arise in which real national benefits could be generated by industries indirectly related to the project. The wages of those who would otherwise be unemployed without the project represents a real increase in national benefits. Long term growth of industry indirectly related to the project also generates benefits that can be attributed to the project.

The concepts of indirect benefits have often been misused and abused; this does not imply they should be ignored. The Water Resource Council recommends in the Principles and Standards to analyze cost and benefits both from the national and the regional viewpoints. Project justification should depend on the federal government's goals and concerns about the income redistribution effects the project may bring about via indirect impacts.

Indirect Benefits Attributable to the Boise Project

The Boise Project, through the increased production of crops it brought about, further stimulated economic activity in the farm supply industry, and in the food processing sectors which in turn nutured additional growth in the provision of other goods and services. These linkages to the increased crop production are the indirect benefits attributable to the Boise Project.

The trade flow model provided estimates of the income earned for each sector in the hypothetical "without" scenario. The indirect benefits attributable to the Boise Project would be represented by the increased economic activity generated in each of the non-Boise agricultural sectors identified in the trade flow model.

In terms of the model, indirect benefits would equal the sum of the change in income for sector B, plus the change for Sector B_{10} through B_{20}, $(\Delta I_{B1} + \sum_{j=B_{10}}^{B_{20}} \Delta I_j)$, for the impact of the Boise region and the sum of sectors R_1 through R_{20} for the Rest of Idaho, $(\sum_{R_1}^{R_{20}} \Delta I_j)$. The indirect benefits of the Project, so defined, have been summarized for each of the twenty-four years in Table 15.

During the analysis period, the indirect benefits accruing to the Boise region grew from \$30 million dollars to \$117 million dollars for an overwhelming growth of 290 percent. Although the indirect effect of the project on the state grew at an even more astounding rate of 550 percent, 70 percent of the total impact accrues within the Boise area. In 1970 the Boise Project generated some \$22 million dollars of crop income over what would have been produced "without" the Project (\$27.4 million "with" minus \$5.4 million "without", see Table 9). This suggests that for every dollar earned from the Project in 1970 another \$3.70 (\$82 million/\$22 million) was generated elsewhere in the local economy. This indeed suggests that a significant indirect economic benefit has resulted from the investment in the Boise Reclamation Project.

Table 15: Indirect Benefits Attributable to Boise Project, 1947-1970.

Year	Indirect Benefits		
	Boise Region ($\$10^6$)	Rest of Idaho ($\$10^6$)	Total ($\$10^6$)
1947	24,177	5,411	29,588
1948	23,373	4,579	27,952
1949	24,201	5,250	29,451
1950	16,312	4,863	21,175
1951	17,911	4,433	22,344
1952	17,972	2,897	20,869
1953	10,729	3,612	14,341
1954	17,750	4,974	22,724
1955	18,281	5,585	23,866
1956	19,079	5,381	24,460
1957	22,476	7,825	30,301
1958	24,395	9,181	33,576
1959	41,659	16,010	57,669
1960	43,805	17,045	60,850
1961	49,309	19,275	68,584
1962	33,607	13,904	47,511
1963	39,324	12,065	51,389
1964	42,809	16,842	59,651
1965	53,142	19,807	72,949
1966	79,786	32,479	112,265
1967	60,684	26,727	87,411
1968	68,044	28,960	97,004
1969	75,254	30,344	105,598
1970	81,662	35,247	116,909

ECONOMIC EFFICIENCY OF THE BOISE PROJECT

"With" and "Without" Criterion Restated

As previously stated, the Water Resources Council's Principles and Standards require a comparison of "with" and "without" project conditions. Again, "only the new or additional changes that can be anticipated as a result of a proposed plan should be attributed as beneficial and adverse effects of the plan" (15). Based on this criteria, economic justification of the Boise Project requires an economic return from the Project's investment over and beyond the return that could have been earned without the construction and operation of federal storage facilities on the Boise and Payette Rivers.

Economic Efficiency

Economic efficiency has long been used as the basic criteria for judging the merits of federal water resource projects. Many factors, however, should enter the decision process besides the return of monetary benefits over cost.

Presumably, the goal of federal investments is to improve the general welfare of society. Perhaps the best-known social welfare criteria was that proposed by Vilfredo Pareto: any change in the social state is desirable if at least one person judges himself to be better off because of the change while no one else is made worse off by the change (12). While the Pareto criterion seem unexceptional as a basis for making judgments on changes in social states, it is inevitable someone will always be left worse off while others benefit from public policy decisions in the real world. Nicholas Kaldor and J.R. Hicks (7) carried the Pareto criterion one step further. They contended that a change in the allocation of resources should be regarded as increasing welfare if either the Pareto criterion is met or if the persons gaining from the resource reallocation could compensate the losers so that the latter are as at least as well off as before the reallocation. It is usually assumed compensation does not actually have to take place. The outcome of this is general acceptance of the proposition that a project with positive net effects (benefits in excess of costs) results in an increase in societies' welfare.

Unfortunately without actually paying compensation to those harmed, there is no way of insuring economic efficiency will always lead to an increase in welfare. Without compensation an explicit judgment is made that those made worse off deserve to be worse off. This is an ethical judgment about what should be the desired income distribution. A second criticism recognizes that compensation is not costless. If compensation payments were actually to be paid, the informational costs of determining beneficiaries and cost bearers may be large enough to effect the desirability of the project itself. Often it is not only the redistribution of monetary resources that affect welfare, but intangible values not measurable by the monetary system. The losers from a public decision may be those who loved the free flowing river before the dam or who cherished the solitude of the desert before the havoc of a developing city. The proposition is that economic efficiency should not be considered in and of itself as the sole creteria for judging the worthiness of public projects.

During the process of determining economic efficiency only those changes that would not have taken place "without" the Project should be included in the analysis. The accounting framework for determining the economic efficiency of the Boise Reclamation Project is shown in Figure 4. The net value-added "with" the Project, the subject of the previous Economic Subproject Report Part I (9), was determined by subtracting the cost of farm inputs from gross agricultural output. Net value-added "without" the Project was estimated following an identical procedure while relying on the hydrologic model's projection of crop production. Reduced costs represent those investment and operation costs of the "without" federal development scenario, a cost foregone "with" the Boise Project. The difference in value-added income plus the reduced costs provides an estimate of those benefits directly attributable to the project. At the national level direct benefits are usually used in the calculation of project justification. When the impact to a given region is of concern indirect benefits attributable to the project are often included in the calculation. The indirect benefits attributable to the Boise Project were the product of the interregional trade flow model previously discussed.

The real cost of the Project that needs to be justified includes all federal investment in the construction and operation and maintenance of the Boise Project. The comparison of real costs of the Project with the direct and/or indirect benefits attributable to the Project provides a measure of the Project's economic efficiency.

The annual benefits and costs determined by following the accounting framework described above are shown in Table 16. Except during the early history of the Project, on an annual basis, benefits have always exceeded costs. By 1970 there were $23 million dollars of direct benefits attributable to the Project and $82 million dollars of indirect benefits. These benefits exceeded the annual cost of some $5.5 million dollars in 1970 by 300 and 1800 percent, respectively. Considering the annual stream of economic benefits and costs from irrigation, it is obvious that the Boise Project has achieved economic efficinecy, i.e. total benefit attributable to the Project exceeding federal investment and operation costs.

The reader should not conclude that the Boise Reclamation Project was a successful federal investment based on the above analysis alone. The Project has also produced other benefits and costs not yet examined - recreation, power and flood control, as well as beneficial and detrimental environmental and sociological impacts.

Figure 4: Accounting Framework for the Economic Efficiency of the Boise Reclamation Project.

Benefits

Gross Agricultural Output
"with" the project

less:

Purchases of Farm Inputs
not including labor, rent, or interest

gives:

Net Value-Added "with" Project

less:

Net Value-Added "Without" Project
computed as above

plus:

Reduced Costs "With" Project
the annual costs necessary "without" project

gives:

Direct Benefits Attributable to Project
criteria used to define benefits at national level

plus:

Indirect Benefits Attributable to Project
change in value-added income of non-Boise Agricultural sectors

gives:

Direct and Indirect Benefits Attributable to Project
criteria often used to define benefits at regional level

Costs

Investment Costs
federal investment in the project

gives:

Real Investment Costs
the investment that changed the productivity of the water and soil complex which increased benefits earned "with" project

plus:

Operation and Maintenance Cost
the cost for operating and maintaining Boise Project facilities

gives:

Real Cost of the Project
total federal expenditures on the Boise Project

Table 16: Economic Efficiency Analysis, Boise Project, 1910-1970

Year	Net Value-Added Income ($10^6) "With" (1)	Net Value-Added Income ($10^6) "Without" (2)	Reduced Costs ($10^6) (3)	Benefits Attributable to Project ($10^6) Direct (4)	Indirect (5)	Total (6)	Federal Investment Costs ($10^6) (7)
1910	$0.081	$0.171	$0.114	$0.021	$ -	$0.021	$0.092
1911	0.189	0.342	0.118	-0.034	-	-0.034	0.158
1912	0.238	0.367	0.138	0.039	-	0.039	0.178
1913	0.265	0.614	0.377	0.027	-	0.027	0.227
1914	0.422	0.798	0.178	-0.199	-	-0.199	0.215
1915	0.966	0.708	0.158	0.416	-	0.416	0.535
1916	2.138	2.592	0.251	-0.204	-	-0.204	0.569
1917	4.482	4.376	0.281	0.389	-	0.389	0.634
1918	6.311	4.081	0.294	2.524	-	2.524	1.223
1919	8.903	3.197	0.221	5.927	-	5.927	1.120
1920	5.032	2.698	0.938	3.271	-	3.271	1.357
1921	5.462	1.905	0.925	4.482	-	4.482	1.317
1922	4.194	3.143	0.757	1.808	-	1.808	1.090
1923	5.182	2.501	0.742	3.432	-	3.432	1.076
1924	1.535	0.500	0.585	1.621	-	1.621	1.084
1925	3.588	2.354	0.665	1.899	-	1.899	1.072
1926	1.950	0.799	0.539	1.691	-	1.691	1.003
1927	4.181	1.848	0.485	2.817	-	2.817	0.916
1928	3.620	1.696	0.512	2.436	-	2.436	1.003
1929	4.881	1.670	0.548	3.759	-	3.759	1.110
1930	2.529	1.246	0.403	1.685	-	1.685	0.821
1931	0.192	0.231	0.462	0.422	-	0.422	0.937
1932	-0.673	0.008	0.506	-0.175	-	-0.175	0.987
1933	1.754	0.556	0.464	1.662	-	1.662	0.910
1934	1.897	0.384	0.438	2.411	-	2.411	0.954
1935	2.013	0.246	0.421	2.189	-	2.189	0.887
1936	3.673	0.419	0.430	3.685	-	3.685	0.895
1937	2.502	0.406	0.426	2.522	-	2.522	0.912
1938	1.497	0.261	0.406	1.642	-	1.642	0.848
1939	1.309	0.133	0.380	1.557	-	1.557	0.831
1940	1.339	0.289	0.365	1.416	-	1.416	0.795
1941	3.707	0.917	0.351	3.141	-	3.141	0.751
1942	8.598	2.117	0.382	3.863	-	3.863	0.814
1943	12.845	3.156	0.375	10.063	-	10.063	0.802
1944	13.451	3.120	0.406	10.738	-	10.738	0.872
1945	15.221	3.235	0.395	12.381	-	12.381	0.846
1946	16.455	3.160	0.480	13.775	-	13.775	0.878
1947	19.448	4.288	0.490	15.650	24.177	39.827	0.918
1948	19.410	4.807	0.501	15.104	23.373	38.477	1.310
1949	16.166	3.578	0.628	13.216	24.201	37.417	1.441
1950	13.522	4.753	0.544	9.313	16.312	25.625	2.449
1951	19.057	6.913	0.670	12.814	17.911	30.725	2.571
1952	18.847	7.713	0.674	11.808	17.972	29.780	2.609
1953	12.690	3.193	0.690	10.187	10.729	20.916	2.731
1954	15.504	5.724	0.655	10.435	17.750	28.185	2.511
1955	16.262	5.695	0.520	11.087	18.281	29.368	2.731
1956	18.496	7.628	0.670	11.538	19.079	30.617	3.290
1957	16.649	4.883	0.688	12.454	22.476	34.930	3.482
1958	17.823	4.708	0.603	13.718	24.395	38.113	3.358
1959	23.208	6.626	0.614	17.196	41.659	58.855	3.723
1960	22.353	6.262	1.012	17.103	43.805	60.908	4.191
1961	25.693	5.200	0.555	21.048	49.309	70.357	3.571
1962	24.524	7.193	0.825	18.156	33.607	51.763	3.894
1963	26.353	6.142	0.870	21.081	39.324	60.405	3.990
1964	22.749	5.272	1.046	18.518	42.809	61.327	4.164
1965	24.825	5.736	1.118	20.209	53.142	73.351	4.215
1966	27.006	4.186	0.983	23.803	79.786	103.589	4.444
1967	25.193	4.649	1.213	21.757	60.684	82.441	4.672
1968	25.665	4.817	1.161	22.020	68.044	90.064	4.776
1969	28.574	5.295	1.151	24.430	75.254	99.684	5.164
1970	27.366	5.437	1.223	23.152	81.662	104.814	5.456

Column
(1) See Table 9, Economic Subproject Report - Part I, (9)
(2) Table 9, page
(3) Table 11, page
(4) = (1)-(2)+(3)
(5) Table 15, page
(6) = (4)+(5)
(7) See Table 17, Economic Subproject Report - Part I (9)

SUMMARY

The "without" simulation was accomplished by estimating the gross crop outputs that could have been obtained by using a hydrologic model based on natural, unregulated flows of the Boise and Payette Rivers and from implementing an interregional trade flow model based on the information supplied by the hydrologic model. Together these two models expressed a complete picture of the economic conditions expected in both the Boise region and the Rest of Idaho in the absence of federal investment in irrigation within the Boise Region.

The direct and indirect benefits attributable to the Project, as defined in the Principles and Standards (15), were identified by observing the change in productivity in the Boise region made possible by the federal investment. The relative success the Project has had over time was justified on the basis of economic efficiency. An obvious conclusion was reached that the Boise Bureau of Reclamation Project has developed into a highly successful investment yielding annual returns well in excess of its annual costs.

The purpose of this report was to create a scenario of what might have happened if the Boise Reclamation Project had not been built. Through the creation of this scenario a framework was outlined to show how the information from the "without" scenario could be used in project evaluation. The projections made were dependent on specific assumptions. With different assumptions other outcomes could be expected, so the results presented may or may not be the most realistic. Hopefully, the methodology used in this post-audit study to the Boise Project will aid the efforts of planners in the future.

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