AN ECONOMIC STUDY OF THE POTENTIAL FOR WATER MARKETS IN IDAHO

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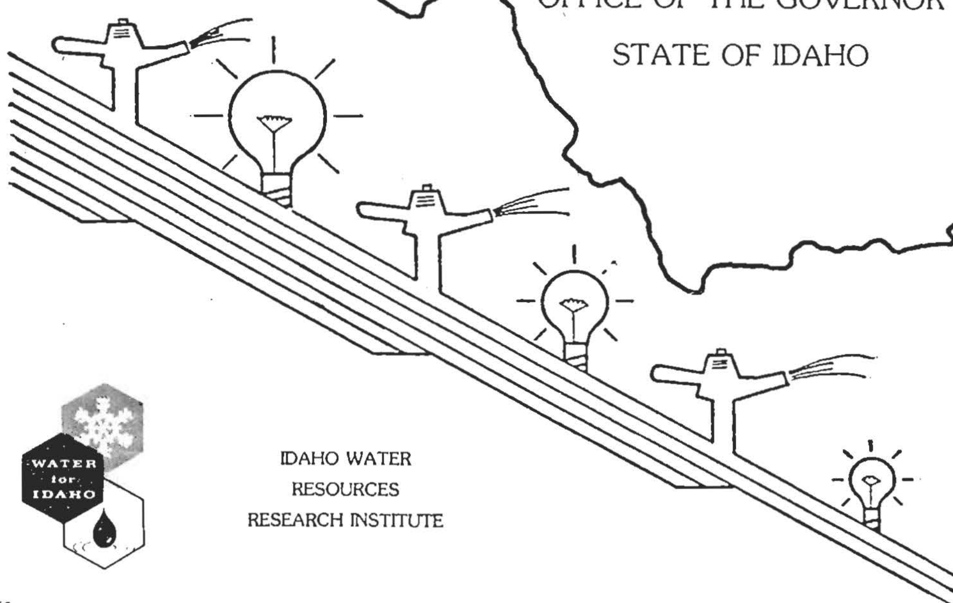
FOR THE

SNAKE RIVER STUDIES ADVISORY COMMITTEE

OFFICE OF THE GOVERNOR

STATE OF IDAHO



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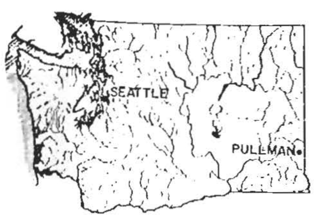

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ABSTRACT

This study investigated the economic potential for water markets that would exchange water from irrigated agricultural to hydropower production in southern Idaho. Two kinds of water market were considered. The first involved the marketing of stored water that is now owned by agricultural interests but is seldom used for irrigation. The second was an option lease program that would depend on water currently used for irrigation.

A market for stored water is currently working but could be modified to increase the market value of the water. The value that could be created by selling stored water for hydropower far exceeds its current value in storage or for agricultural uses. It is conservatively estimated that the power value of this water ranges from $10 to $22 per acre-foot, while the current price being paid for power production is $2.50 per acre-foot.

The option lease program also appears to be economically feasible. This program would allow agriculture to use the water in most years and require its use for hydropower only during critical flow periods. Thus, agriculture remains intact while the water continues to create value in hydropower. The program analyzed would reduce average agricultural income about $2.50 per acre while the value of hydropower created would be about ten times this amount.

Key words: Water market, hydropower, irrigation.

EXECUTIVE SUMMARY

A December 1984 Executive Order authorized the creation of a Snake River Technical Studies Committee to promote research relative to the management of the water resources of the Snake River. The committee operated with funds appropriated by the 1985 legislature and grants from the Idaho Power Company. This report is one of several economic studies authorized by that committee.

Chapter I outlines the background and objectives of this study. The study was motivated by concerns growing out of the Swan Falls controversy over how to achieve equitable and efficient allocation of the water from the Snake River. Water markets had been advanced as one way to improve the way water is allocated.

The objectives of this study were to: (1) develop a model to study water marketing alternatives and strategies, (2) identify optimal farmer responses to water supply interruption, (3) estimate the value of interruptable water for irrigation and for hydropower, and (4) estimate economic consequences of increased use of markets for stored water.

Chapter II provides a general background on how water markets might work and what their benefits might be.

In many contexts our economy relies quite successfully on markets to allocate resources among competing users. In general the most productive use is best able to pay. Because of the special attributes of water, it has historically not been allocated by markets. In Idaho, water has instead been allocated by appropriation, made appurtenant to the land. Concern over third party effects have resulted in severe restrictions on transfer of water rights. As water becomes increasingly short, these restrictions could hinder the efficient use of Idaho´s water.

This report examines two kinds of water markets. The first is an option lease market that would allow farmers and an electric utility to enter into a contract so that the irrigators could use the water in most years, but the utility could use the water in very dry years to bolster its electric generation potential.

The second market studied is a market for the rarely used storage water located in the upper Snake River reservoirs. This is the water that is presently exchanged in the Idaho Water Bank under annual arrangements. It is our contention that this market might also utilize long-term contracts and extract substantially greater benefits from the marketed water.

The usefulness of the kind of water market studied in this research results from the erratic nature of weather and streamflow. The average flow of the Snake River at Murphy between 1928 and 1978 ranged from 7,178 to 16,701 average cfs. The potential hydropower generation varied similarly. Power customers place a great premium on supply reliability, so only that firm power available in the critical lowest flow years can be sold at high prices to firm load customers, while the rest brings lower prices as nonfirm or surplus power. While Idaho Power has successfully relied on exchange agreements with other utilities and spot purchases of power to meet its firm loads in dry years, it is questionable whether this is a viable long-term strategy.

The intent of the markets proposed in this report is to make more water available for power generation in low flow years, and consequently increase the available firm power supply. Based on the streamflow record from 1928 to 1978, the quantity and frequency of water needed to maintain any selected flow at Murphy is shown. For example, 625,715 acre-feet of water would need to be available to assure an annual average flow of 8042 cfs. At least some part of this water would be needed in 19.6 percent of the years, but in most years not all would be needed.

The value of this market water for power generation has two parts. The first is the value of the power actually generated in the dry years when power is delivered. This power is going to fill firm power sales commitments, so is quite valuable. The second value component is the increased value of power generated in all other years because of the market. Because the market guarantees increased power supplies in dry years, the utility can legitimately take on more firm sales commitments in all other years and thus increase its revenue. Using the example of a market assuring an 8042 cfs flow at Murphy, using water originating in or above American Falls Reservoir, the contract should increase hydropower value by $39 annually per acre-foot under contract, or $473 per acre-foot of water actually delivered.

Chapter III applies these principles to a market where farmers enter into an option lease arrangement whereby they get the use of the water in most years, but the water is available for power generation in very dry years.

A model is constructed to study how farmers would likely respond under these circumstances. The model uses eleven representative farms with a variety of application systems, crop mixes, pumping lifts, and locations to illustrate this behavior. Budgets were constructed to represent enterprise costs and returns. It was assumed that farmers were allowed to contract for delivery of up to half of their water to the utility for power generation. The model then simulated how farmers would be expected to respond as their water supply is cut back by the market as water delivery is called for in dry years. Farmers would be expected to optimize by balancing the profitability of various enterprises against expenses such as the labor cost of improving the efficiency of water use. As water availability is reduced, water use efficiency will increase, consumptive use will decrease, and eventually irrigated crop acreage will be reduced. The resulting income losses in dry years can be taken as an estimate of the cost to the farmer of participating in such a water market. These costs range up to $48 per year depending on the severity of the water shortage imposed. However, the average loss over time for all participating farms would be about $2.50 per acre. It was found that a good irrigation manager can make many adjustments to a temporary water shortage that will help to minimize farm income losses. The hydropower benefits of an option lease water market are approximately ten times as great as the farm income losses imposed by the market.

Some high pump lift farms would experience a net gain in farm income if participating farmers were given an opportunity to buy nonfirm power for pumping water committed to the market in years when it is not required for power production. The present value of hydropower generated within the Idaho Power Company system over the same 25 year period would range between $400 and $500 per acre of land in the market. The present value of farm income losses over the same period would be about $45 per acre. An important feature of this water market scheme is that agriculture would be left relatively undisturbed by the existence of the market. Under the assumptions of this analysis, no more than 50 percent of the water normally consumptively used by a farm could be committed to the water market in any year, an average of about 9 acre inches per irrigated acre. However, over time the average loss of water to the market would be about 0.75 acre inches per acre. The water could be used by agriculture and still create value in hydropower most years. Only in about one year out of 50 would the full 9 acre-inches per acre have to be given up for power production. In about 7 years out of 50 a smaller amount would be given to the market and in all other years no interruption would be required.

Chapter IV examines the possibility for expanded markets for stored water. The present Idaho Water Bank is a closely regulated market for stored water. Only annual transactions are allowed, which restricts the hydropower value of this water to Idaho Power. Even so, this water probably has a hydropower value in the range from $11 to $23 per acre-foot sold, depending on the electricity supply-demand conditions and water supply conditions in each individual year. This appears to justify a higher price than the $2.50 per acre-foot now charged, and perhaps a price that varies depending on yearly conditions.

Allowing long-term contracts for stored water may result in much higher hydropower value than the present Water Bank. The utility would be able to use this water to firm up otherwise nonfirm power supplies. While these values would be much higher (in the range of $37 to $40 per acre-foot under contract with much smaller amounts actually delivered in most years), it will take a detailed river operations study to show how much water could be contracted with sufficient certainty to make it useful as a source of firm power supplies. It should be possible to coordinate an option lease market and a storage water market.

Chapter V lists the conclusions of the study and discusses a range of related issues and problems.

The main conclusion is that the potential hydropower benefits of markets such as those proposed in this report are very large relative to the costs that market participation would impose. Thus, such markets appear to be economically feasible, and in fact, could be a valuable source of much needed supplemental income to farmers and irrigation-dependant rural communities. While severe engineering, organizational, and legal problems remain, the potential benefits of such markets to all concerned suggest that it may be possible to overcome these problems.

The most difficult engineering problem is how to monitor and control water adequately to assure that less is used consumptively for irrigation and more becomes available for hydropower generation. Presently diversions are only imperfectly monitored and controlled, and consumptive use is not even well known. Farmers free to switch water sources might do so under a market. Third party impacts are a real danger and must be anticipated and guarded against.

There are a number of legal uncertainties surrounding water markets. The appropriation doctrine for water admonishes farmers to "use it or lose it". Legal changes might be necessary to allow farmers to market water that they do not have an immediate need for on their own crops.

How to properly organize a water market remains an open issue. It is probably not wise to rely on a completely free market because of the problem of third party effects, and because of the imbalance of one major buyer versus many potential farmer-sellers. Some State agency such as the Idaho Department of Water Resources would probably have to play a major role in supervising such a market. Perhaps the water delivery organizations can act as representatives for their farmer-members. The Idaho Public Utilities Commission also has a legitimate interest in the process as representative of the state´s electricity consumers. Other organizational issues include setting payment levels and schedules that are equitable and meet participant cash flow needs, and setting the criteria that determine the trigger conditions when water delivery will be required under the lease or contract.

CHAPTER I

INTRODUCTION

A significant share of the nation´s crop output comes from irrigated lands. Moreover, the portion of total cropland in the nation receiving irrigation water is increasing. There are memorable publications which illustrate the importance and value of water in agricultural production. Robert Young and S. Lee Gray, in the National Water Commission Report to the President, 1972, present estimates of water value in several alternative uses. Agriculture generally has the lowest marginal value of those uses compared. However, agriculture consumes more water than all other uses combined. These phenomena are certainly true in the Pacific Northwest and in particular, the state of Idaho which is the setting for this study. Water, at least in the western states, is still treated as a public resource whose value goes largely unrecognized until it is captured by an individual or group through a legal water right issued by the state. At that point, it essentially becomes a private good with all the characteristics thereof. The owner has exclusive use rights to a specific portion of water which he may use, misuse, and, in several states, sell or rent to others.

Water once captured and put to beneficial uses, is a highly valued factor of production. Most instream uses including hydropower, fisheries, navigation, and recreation are classified as public uses. However, as the scarcity of water for these uses becomes more acute the value of water also becomes more recognizable.

Therefore, when a water right is granted to an individual for a diversion use, it effectively transfers a portion of water from the domain of public or common property to private property. However, water right transfers in the other direction do not usually occur without compensation to individual owners. The courts and affected individuals recognize the value of the water to the declared owners.

Water is a highly prized and productive resource in agriculture. However, because of its fugitive nature, smooth working markets do not exist to establish its value on a par with, say, land, machinery or fertilizer. It is generally not possible to distinguish one acre-foot of water from another or to exercise the usual rights of ownership over a unit of water. Agricultural water rights normally specify some seasonal rate of flow of which some is consumed and the remainder is passed on to other users. Unfortunately, when we attempt to apply the principles of market exchange to water, we encounter a wide array of legal, institutional, political, sociological, economic, and physical obstacles.

Over the past several years the Idaho Legislature has grappled with a number of difficult water use and allocation issues. The conflict between irrigators and Idaho Power Company over water rights at Swan Falls was a recent cause that brought water concerns to the floor of the legislature. In the spring of 1985, the Idaho Legislature and the Idaho Water Resource Board implemented the six point Swan Falls agreement that was first signed in October, 1984, by Idaho's Governor and Attorney General, and by Idaho Power Company.

This agreement resolved the immediately important problems. It solidified the water rights of recently developed irrigation in the upper Snake that had been cast in doubt by the Swan Falls conflict. It assured a minimum stream flow at Swan Falls, thus giving protection to a minimum level of hydropower generation. It also allowed for a limited amount of additional irrigation development in the upper Snake, subject to state control and public interest provisions.

A point briefly touched in the 1985 Swan Falls Agreement was an issue that played an important part in discussions at that time -- water markets. The signers agreed to promote the concept of water markets. One of the messages inherent in the Swan Falls controversy is that water is indeed a scarce commodity, and that the waters of the upper Snake are now fully appropriated for various beneficial uses. Expanding one water use can only come at the expense of reducing some other water use. Given this growing realization that water reallocation involves tradeoffs among competing uses, questions arise about the laws and institutional arrangements that allocate water to various uses in Idaho. Can present water institutions allocate water in a way that will encourage efficiency of water use, allow for economic development, protect both state and private interests, and yet function in the climate of increasing water scarcity that the future seems certain to bring? Will changes to increase reliance on market forces for allocating water among uses be an improvement over the present rigid administrative mechanisms for allocating water?

In the 1985 legislative session, several bills were passed that went part way toward improving the climate for a water market in Idaho. Another bill authorized the Snake River Technical Studies Committee to administer funding for a number of studies of water related issues, including water markets. This report presents the results of research on the feasibility and economic consequences of water markets, funded in part by that committee.

The specific objectives of this research were:

1. to develop an analytical model for analyzing agricultural water marketing alternatives and strategies,
2. to identify optimal farm production plans when faced with an interruptable water supply,
3. to estimate the value of marketable water to farmers under alternative scenarios of farm location and probability of interruption,
4. to identify alternatives for and estimate economic consequences of increased use of markets for stored water.

CHAPTER II

WATER MARKETS AND THEIR APPLICATION IN IDAHO

In contrast with centrally planned economies that try to allocate resources by administrative decision, the American economy relies heavily on markets to accomplish this allocation. Even with sophisticated computer models, the centrally planned economies have found it very difficult to assimilate the large amounts of information necessary to set prices that balance supply and demand, and are fair to buyer and seller. For most items in the United States, prices and quantities are set by market forces. The result of this free market exchange in most cases is equitable, efficient, and flexible in responding to changing conditions. Gardner cites the wheat market as an example:

> "The wheat market continually interprets information about such things as 1) current supplies of wheat, 2) the world crop outlook, 3) changing weather patterns, 4) prices of other grains, 5) world demands for wheat, 6) foreign exchange rates, and 7) prospective changes in agricultural and economic policies. The wheat market translates all this information and more into a coherent set of prices that also allow for transport costs between locations, storage costs over time, and quality differences". [Gardner, 1985, page 1]

Water is one of a small number of resources in this country that have usually been allocated by non-market mechanisms. The special treatment of water reflects its crucial role in the economic development of the arid lands of the west. In the western states water rights have traditionally been acquired by appropriation, followed by beneficial use. Since irrigation was necessary for agriculture, it was a reasonable step to make water rights appurtenant, or attached to the land being irrigated. To make irrigation feasible, water rights had to be as secure as possible, and especially secure from damages caused by someone else´s actions. To protect against these "third party" effects, transfers among uses and places of use have been severely restricted by state laws.

Many of the concerns that led to special treatment of water in the past will continue to be valid concerns in the future. Any move toward greater reliance on market mechanisms will have to recognize the central role of water in economic development, and the danger of third party effects when water is shifted among uses and locations of use.

In spite of water´s special role in the economy of the west, many people are beginning to ask whether the western state´s water institutions are too rigid to deal with today´s problems, and whether a move in the direction of market forces might prove beneficial. While the issue of water markets has received some attention in the economics literature for three decades, there has been heightened recent interest -- for example; Anderson [1983], Whittlesey and Houston [1984], Wong and Eheart [1985], Gardner and Miller [1983], and Houston and Whittlesey [1986]. This interest reflects the growing pressure on water supplies in many regions of the country, the increasing realization that institutional changes are probably necessary to improve the efficiency of water use, and the growing mood of the country to rely on privatization and market mechanisms to address resource allocation problems. Gardner cites the benefits that greater reliance on markets might yield:

> "Flexible Water Use. Water in Idaho is locked into a fixed pattern of use by the historical precedents of prior appropriation. First in time means first in right, regardless of whether later, more valuable uses of water emerged. This is fine as long as water is still available for new uses, but the period of abundant water is rapidly drawing to a close. The future will bring increased conflicts between users and uses of water. Idaho's population will grow, new industries will arise, and new lands will be developed for irrigation. Recreation and environmental values will be increasingly recognized."
>
> "All this is both desirable and unavoidable. Yet it demonstrates the need to give our system of water rights the flexibility to adjust to future conditions. Without the ability to change, conflicts between water users and uses could boil into another Swan Falls controversy. Water markets would allow users to compete for limited water, so that the resource will go to the most beneficial uses.
>
> "A Voluntary Process. Water markets are consistent with a philosophy of free choice. Markets utilize the freedom of individual water right holders to make their own decisions.

The market approach is a voluntary process between willing buyers and sellers. Both parties must consider themselves better off with a transaction, or it will not be made.

"Water Given Value. Markets provide a way to convert water rights into money. Currently a farmer may know his water rights have value, but there is no way to get a return to this asset except through continued beneficial use or through the sale of the land and water. Markets would allow a person to sell excess storage rights or lease the water rights from a marginal field in a drought year. This may provide needed cashflow to finance improvements or to help survive the financial crisis in agriculture. Even if a rightholder chooses not to sell, markets provide one more option in managing finances.

"An Incentive for Efficiency. Perhaps most importantly, a water market would give a signal to all rightholders that is currently absent. The market price is a constant reminder that water is worth money. Water has economic value. If a use of some water does not generate as much profit as the market price of water, then a rightholder can rent to sell that water to increase his income.

"Improvements in water use efficiency would thus be encouraged. Perhaps water should be moved from a marginal field to more productive ground. Perhaps a canal should be lined. Two canal companies may be able to exchange water to make one better off. Perhaps a factory can recycle water, or a golf course can irrigate with effluent. A city may need to implement a conservation program. Perhaps a farmer has kept storage water, as "insurance" against drought, that could more profitably be leased or sold.

"Water markets would provide an incentive to conserve water that increases as water becomes more scarce. Yet markets would leave the ways to conserve open to the innovations of individual water users." [Gardner, 1985, pages 1-2]

Irrigation is the dominant consumer of water in the upper Snake River. Other consumptive uses such as municipal and industrial are minor in comparison to irrigation. Streamflows, including irrigation releases, are used nonconsumptively for generating electricity as the water passes through the region´s hydropower dams. However, since a portion of this water is consumed by the crops, this reduces flows and electricity generation at each downstream hydropower dam. This means that irrigation and hydropower are the principal competing uses for water and would likely be the principal, although not the only, participants in any water market.

A. Possible Market Mechanisms

The study objectives noted above imply two main kinds of water markets: first, a market in which farmers could sell or lease flow or storage water rights normally used for irrigation to some other water user, and second, a market in which storage water that is ordinarily in excess of current irrigation needs could be sold or leased to other users. Both types of market will be addressed in this report.

In the first kind of market, farmers might agree to use less water and sell or lease the unused water to someone else -- perhaps another irrigator, a municipality or industry, or an electric utility. Exactly what it means to use less water (whether it means less consumptive use, or just less diversion) is a topic that will be discussed in detail below.

The outright sale of some or all of a farmer´s water rights would make water available to the purchaser in all years. This study will also look at the possibility of "option leases" where the farmer would contract to make available a specified amount of water for hydropower generation in dry years. In normal years the water would be available for irrigation as usual. Farmers have a number of possible alternatives for coping with less water. They might irrigate more efficiently, so that a greater proportion of the limited water supply is available for the crops. They could shift to different crops that use less water. They might practice "deficit irrigation" in which a crop is intentionally given less water than it could use, and some yield reduction occurs. In the end, less water generally translates into lowered crop production, higher risks, or higher costs of production. Each of these possibilities involves costs to the farmer which establish the payment that would be necessary to induce the farmer to voluntarily sell or lease water.

The second type of water market, involving storage water has already seen limited application in Idaho in recent years. The Upper Snake River Water Bank essentially codified earlier practices of leasing or selling water, particularly in drought years, most often between members of an irrigation district or canal company. The market is also the outgrowth of a long-standing policy of charging users who exceed their storage rights and making payments to the owners of that storage space. The market is possible because past Bureau of Reclamation policy allowed farmers to insure against water shortage by acquiring more storage rights than they really needed. Water users can designate a stated portion of their water right as available to the Water Bank. Their cost of participating is measured by the increased likelihood that they themselves may run short of water in some future period, so any successful market would have to compensate them for this risk. While some Water Bank sales have been to other irrigation uses, by far the largest Water Bank purchaser in recent years has been Idaho Power Company (IPC).

Any Idaho water market needs to be closely attuned to the hydrologic realities of upper Snake river streamflow, irrigation systems, and aquifer. All three of these system components are closely linked. In some reaches the river loses large amounts of water by seepage to the aquifer. In other river reaches the aquifer discharges back to the stream. Irrigation diversions per acre are very high in much of the upper Snake -- sometimes as much as 10 to 15 acre-feet per acre (see Table 1). The relationship among stream diversion, farm water delivery, actual field application, and crop consumptive use is quite complex. Since crop consumptive use in most of this area is less than 2 acre-feet per acre, the rest becomes runoff, percolates to the aquifer, or returns to the river without ever being used as irrigation water. The percolation also generally returns to the river through the close streamflow-groundwater

Table 1. Selected Diversions During 1982 Irrigation Year from Snake River

Name	Total Diverted (acre-feet)	Area Irrigated (acres)	Ac-ft/ac Diverted
Canals Between Irwin and Lorenzo:			
Progressive Irr. Dist.	195,500 (a)	33,000	5.9
Farmers Friend	116,000	10,500	11.0
Enterprise	58,300	5,200	11.2
Butler Island	12,300	1,100	11.2
Harrison	146,600	13,000	11.3
Rudy Irr. Co.	90,000	5,000	18.0
Lowder Slough	18,400	1,000	18.4
Burgess	291,400	22,000	13.2
Clark & Edwards	26,100	1,940	13.5
East LaBelle	36,800	3,000	12.3
Rigby and Rigby Lateral	56,800	4,000	14.2
Island	54,500	5,500	9.9
W. LaBelle & Long Island	141,100	10,500	13.4
Parks & Lewisville	106,300	8,500	12.5
North Rigby	18,500	1,400	13.2
Sunnydell	55,900	3,780	14.8
Lenroot	47,000	3,100	15.2
Reid	47,100	5,500	8.6
Texas & Liberty	68,800	10,000	6.9
TOTAL	1,630,908	151,260	10.7
Canals Between Lorenzo and Blackfoot:			
Butte & Market Lake	67,900	20,000	3.4
Great Western & Porter	212,300	30,220	7.0
Idaho	287,600 (a)	35,850	8.0
Snake River Valley	177,900	20,790	8.6
Reservation	65,000 (a)	54,770	1.2
Blackfoot	102,600	15,000	6.8
New Lava Side	32,200	6,000	5.4
Peoples	98,600	20,000	4.9
Aberdeen	283,100	63,000	4.4
Corbett	43,100	6,000	7.2
Riverside	32,900	5,000	6.6
Danskin	54,300	8,000	6.8
Watson	31,800	3,000	10.6
TOTAL	1,589,480	302,400	5.3

(a) Not including additional water recieved from other sources

Source: Carlson, 1982.

linkage. The water that returns to the stream becomes someone else's water supply. In spite of the high per-acre diversions in the upper Snake, water is used and reused several times so the region is actually quite efficient in its use of water.

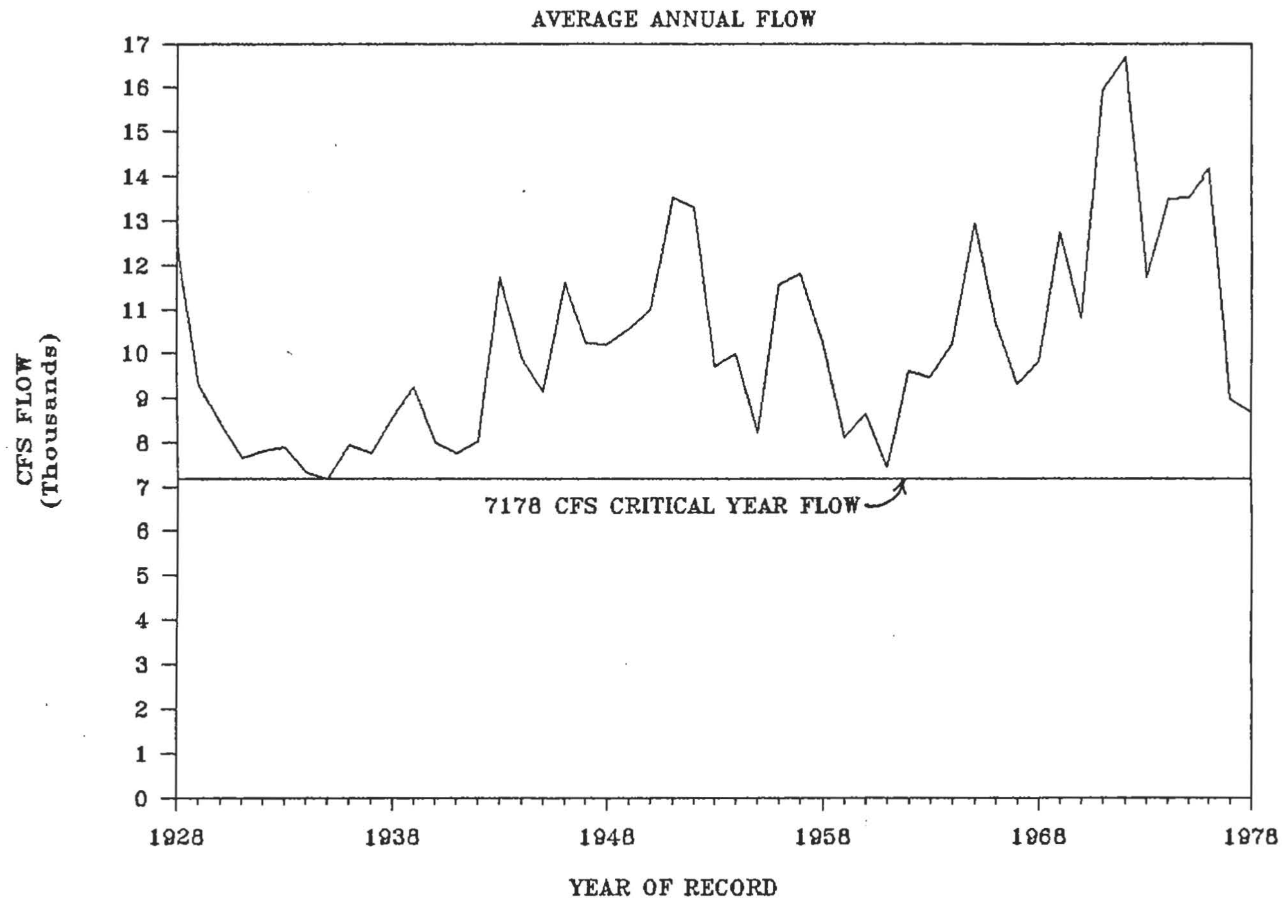
It is another reality of the hydrology of the upper Snake basin that water markets of the kind discussed in this report probably can not be applied to groundwater. While it is true that the aquifer and streamflow are closely linked, the linkage is not immediate enough and the third party effects are too strong to allow the water rights associated with wells to be moved to different locations by a market. This report deals only with the possibility of using markets for flow and storage rights, not for groundwater.

B. Snake River Streamflow and Value of Power Generation

Discussions of water markets in this report assume that most market transactions would be used to augment streamflow for the purpose of generating electricity. In the Pacific Northwest the majority of electricity is still generated by water power, especially in the IPC service area. This means that the amount of electricity generated is critically dependent on the weather determinants of snowpack and streamflow, and on irrigation depletions.

Figure 1 shows the historic streamflow at Swan Falls Dam (Murphy), at the lower end of the upper Snake River. This figure, based on streamflow models run by the Idaho Department of Water Resources for the study by Hamilton and Lyman (1984), shows what annual average flow would have occurred at Murphy over the 51 year period between 1928 to 1978, given the level of irrigation and

Figure 1. AVERAGE FLOW AT MURPHY



hydropower development present in 1980. While these 1928-78 flows averaged 10,215 cfs, they ranged from a high of 16,701 average cfs in 1972 to a low of 7,178 average cfs in 1935. Obviously, these river flows are erratic, and the hydropower generation based on these flows are similarly erratic.

Electricity consumers and hence electric utilities place a large premium on supply reliability. Consumers are willing to pay high prices for "firm power" that the utility guarantees will be available under any conditions. All other "nonfirm" or "surplus" power is sold for much lower prices. One way of estimating the firm power yield of hydroelectric generation systems is as the power that would be generated in the historic low-flow year of record. For Idaho Power Company this "critical year" is 1935, when average annual flow fell to 7178 cfs. This critical year flow corresponds to the horizontal line in Figure 1.

IPC does not now use this critical year procedure for power system planning. It uses instead a median year approach that relies on power exchange agreements with other utilities and on spot market electricity purchases to meet firm load commitments in dry years. The present electricity supply surplus in the Northwest, and the conservative "critical year" planning stance of Bonneville Power Administration (BPA) should make it possible for IPC to rely on power purchases to meet its needs for some years. However, as the power supply situation tightens in the next decade, IPC is likely to have to rely more on its own system for the resources to meet power needs in dry years. As this time approaches it may make sense for utilities like IPC to look at water markets as one possible way to augment hydropower generation in periods of low streamflow. This would allow the utility to get by with less generating capacity, to place less reliance on exchange agreements with other utilities, to rely less on the spot market for meeting periods of shortage, and yet sell more electricity to "firm" power users.

Policies to make better use of the region´s nonfirm power are a high priority in the the Northwest Power Planning Council´s 1986 Northwest Conservation and Electric Power Plan. They propose that the region:

> "Explore the opportunities and difficulties of making better use of the region´s nonfirm energy resources. Currently much of the region´s nonfirm energy resource is controlled by Bonneville. Better use of nonfirm energy for meeting firm loads could significantly benefit the region´s ratepayers by avoiding the development of new, more expensive resources." [Northwest Power Planning Council, 1986, Vol. I, page 9-2.]

The 1986 plan makes several proposals to accomplish this:

> "There are two major kinds of strategies to achieve increased use of nonfirm energy in the region. The first uses generating resources with low capital costs and relatively high variable costs that can be displaced by nonfirm energy whenever it is available... The example of this strategy examined in detail by the Council is the use of additional combustion turbines in the region. Other examples would be high-cost purchases from out of region -- for example, British Columbia or California --

to back up firm energy." [Ibid, Vol. II, page 7-12]

Our report suggests that water markets may be a third possible way to make better use of the region´s nonfirm power supplies.

There is enough storage capacity in the upper Snake system so that in low water years, flow timing can be manipulated to optimize irrigation and power generation, with little water being spilled. Realizing that this is an oversimplification, we will assume in this report that the annual average water condition is of primary importance for power generation. Table 2 identifies the water-short years in the 1928-78 streamflow record adjusted to the 1980 level of development. This table can be used to show the frequency and quantity of water needed to assure any given annual average streamflow, under the assumption that the flow probabilities seen in the 1928-78 record are representative. In this table, the years are reordered from driest to wettest. As noted, 1935 was the driest year, with 7,178 average cfs. The second driest year of record was 1934, with 7,333 average cfs. If IPC were relying on some sort of market to augment streamflow to enhance power generation, it would have taken 112,425 acre-feet of water to boost the annual average flow from 7,178 average cfs up to 7,333 average cfs. The table shows the probability and magnitude of intervention would be necessary in order to maintain river flows at any selected level.

For example, if IPC were committed to maintaining Swan Falls flows at an annual average flow of 8,042 cfs, then they would expect to take delivery from the water market 19.6 percent of the time. Of the block of 625,715 acre-feet that the utility must have under

Table 2. Additional Water Needed to Achieve Selected Annual Riverage Flows at Murphy

YEAR	OCT (31 days)	NOV (30)	DEC (31)	JAN (31)	FEB (28)	MAR (31)	APR (30)	MAY (31)	JUNE (30)	JULY (31)	AUG (31)	SEP (30)	AVG ANNUAL FLOW IN YEAR (CFS)	PROB OF INTER-VENTION TO SUSTAIN FLOW (%)	CONTRACT ACRE FEET NEEDED (AC-FT)
	CFS MONTHLY FLOW FROM IDWR STREAMFLOW MODEL														
1935	8238	8328	7940	7792	7996	7608	7087	6322	6674	5385	5806	7049	7178	0.0	0
1934	8425	8631	8460	8644	8147	7574	6858	6224	5923	5496	6290	7385	7333	2.0	112425
1961	8040	9088	9662	8390	8286	7647	7094	6171	5941	5249	6086	7612	7432	3.9	184077
1931	8492	8721	10087	8857	8320	7782	6843	6124	6227	5982	6556	7716	7640	5.9	334420
1941	8391	9424	10191	8962	8495	7790	6953	6623	6255	5704	6644	7523	7742	7.8	408831
1937	8583	9103	9909	8484	8196	7725	7643	6906	6778	5898	6509	7538	7769	9.8	428303
1932	8435	8629	8691	8627	8014	8533	7756	7373	7617	5942	6483	7728	7816	11.8	462249
1933	8538	9187	10065	8852	8394	8003	7233	7212	6862	6036	6638	7822	7901	13.7	523579
1936	8248	8499	8350	8502	8610	8419	8875	8135	7596	5976	6428	7738	7940	15.7	551947
1940	8591	9588	10035	8980	8511	8411	8142	7168	6617	5895	6394	7711	7999	17.6	594838
1942	8302	9321	10640	8426	8178	7983	8460	7709	7669	5781	6294	7788	8042	19.6	625715
1959	8577	9501	11363	9084	8706	9169	7672	6647	6696	5896	6241	7845	8114	21.6	677615
1955	6513	9614	10778	8650	8317	8831	10789	6802	6260	5974	6320	7803	6216	23.5	751578
1930	8513	9943	11729	9202	9395	11252	7225	6925	6581	6057	6499	7655	8413	25.5	894198
1938	8598	8899	10345	8881	8311	8247	8655	12160	7830	6581	6532	7661	8564	27.5	1003399
1960	8445	9291	11181	8392	10455	12261	10334	7085	6728	5927	6431	7590	8664	29.4	1076174
1978	7936	8083	10370	8608	8122	8244	12999	13136	6704	5563	5735	7961	8688	31.4	1093561
1977	10507	12615	11614	11960	11286	10164	7569	6756	6484	5563	6068	7311	8978	33.3	1303400
1945	8422	10318	11549	8797	9172	11365	10529	9880	8257	6373	6644	8437	9142	35.3	1422421
1939	6801	11818	11965	8720	10985	13354	9068	9171	6553	5989	6719	7909	9245	37.3	1496471
1929	8580	12491	11544	10034	11077	12207	11245	7408	6985	6241	6532	7644	9315	39.2	1547493
1967	9123	10230	10802	9229	8715	8818	10048	8906	14756	6599	6792	7897	9316	41.2	1548003
1963	8625	9336	11057	8798	9732	10579	11929	7121	16283	6109	6356	7872	9461	43.1	1652736
1962	8365	9521	10026	8499	9384	10885	18143	12284	7788	6030	6748	7682	9602	45.1	1755140
1953	8725	12081	11508	9784	13355	12147	9357	7129	11951	6446	6571	7993	9718	47.1	1839024
1968	8627	12373	11658	12461	13506	12209	9645	6558	8509	6008	7758	8997	9829	49.0	1919409
1944	10312	12904	13796	12713	11149	11586	10735	7657	7534	6230	6353	7682	9879	51.0	1955791
1954	8611	10499	11440	8889	11965	13298	15925	11432	7067	6382	6660	8005	9994	52.9	2039282
1948	8448	11834	11436	10698	14673	12088	10757	10988	10438	6447	6925	8039	10194	54.9	2183764
1964	8352	9254	11791	8867	11689	13443	15779	8843	14043	6086	6694	7847	10195	56.9	2184803
1947	9805	12879	11475	10532	14655	13412	12078	10744	7015	6160	6522	7813	10225	58.8	2206031
1958	8707	12013	11441	11379	12548	11664	10245	17127	7598	5940	6485	7834	10239	60.8	2216022
1949	9263	12644	11184	9415	11666	18161	11722	15156	6919	6111	6475	7842	10546	62.7	2438364
1966	10733	16558	17501	14674	12481	12591	8218	7620	6723	5895	6760	8318	10666	64.7	2525239
1970	8860	9684	11702	9920	15852	13253	10821	12609	15003	6698	6981	8702	10797	66.7	2620243
1950	8640	10558	11876	9364	16779	15305	20597	7293	7943	8149	7231	8738	10982	68.6	2754369
1956	8556	9622	11957	11267	18975	19683	18189	11645	8701	6112	6711	7948	11559	70.6	3171839
1946	10640	12773	14017	13708	16842	14965	19012	9752	7605	5984	6790	7913	11622	72.5	3217937
1943	8549	10225	10970	9787	10072	19621	28858	11022	8798	7485	6916	8519	11723	74.5	3290660
1973	12307	14810	18552	15876	13047	14308	12103	12661	6877	6028	6337	7763	11726	76.5	3292999
1957	8484	12965	11945	13142	18681	14521	18115	15106	8428	6225	6750	7987	11806	78.4	3350988
1928	11021	12415	14935	17426	20375	15193	19017	10856	7272	6472	7210	8087	12468	80.4	3829908
1969	11041	13482	13910	15601	22665	15718	16379	15311	8186	6597	6677	8171	12744	82.4	4030107
1965	6534	11361	13604	20348	17543	18537	21455	11138	9388	7018	7574	9376	12953	84.3	4181412
1952	10353	13030	12668	16022	18607	15349	24553	18798	9077	6952	7008	7807	13306	86.3	4436707
1974	6803	12773	10225	16658	20443	19132	26547	10819	16391	6199	6642	8244	13490	88.2	4570030
1975	10338	12529	15745	16936	18155	16639	16096	13650	15658	11450	6776	8497	13505	90.2	4580784
1951	11062	16052	17670	16414	22655	18878	17348	14976	6931	6018	6981	7901	13516	92.2	4588669
1976	10517	13832	16859	20199	17984	20039	21429	20801	7395	5882	7059	8114	14161	94.1	5055622
1971	9785	12560	12272	27542	21915	19267	25660	17244	19753	10225	7007	8691	15937	96.1	6341831
1972	12644	20164	19155	27594	22070	27581	20235	13039	14907	6958	7298	9218	16701	98.0	6894983
AVG MONTHLY FLOW:	8812	10809	11290	11332	12362	12292	12643	10200	8788	6361	6645	7979	AVE ANNUAL: 10215		

PERCENT OF CONTRACT WATER NEEDED TO MEET ASSURED FLOW IN YEAR:

YEAR	PROBABILITY OF INTERVENTION: 0.0 / ASSURED FLOW (CFS): 7178	2.0 / 7333	3.9 / 7432	5.9 / 7640	7.8 / 7742	9.8 / 7769	11.8 / 7816	13.7 / 7901	15.7 / 7940	17.6 / 7999	19.6 / 8042	21.6 / 8114	23.5 / 8216	25.5 / 8413
1935	0	100	100	100	100	100	100	100	100	100	100	100	100	100
1934	0	0	38.9	66.3	72.5	73.7	75.6	78.5	79.6	81.0	82.0	83.4	85.0	87.4
1961	0	0	0	44.9	54.9	57.0	60.1	64.8	66.6	69.0	70.5	72.8	75.5	79.4
1931	0	0	0	0	18.2	21.9	27.6	36.1	39.4	43.7	46.5	50.6	55.5	62.6
1941	0	0	0	0	0	4.54	11.5	21.9	25.9	31.2	34.6	39.6	45.6	54.2
1937	0	0	0	0	0	0	7.34	18.1	22.4	27.9	31.5	36.7	43.0	52.1
1932	0	0	0	0	0	0	0	11.7	16.2	22.2	26.1	31.7	38.4	48.3
1933	0	0	0	0	0	0	0	0	5.13	11.9	16.3	22.7	30.3	41.4
1936	0	0	0	0	0	0	0	0	0	7.21	11.7	18.5	26.5	38.2
1940	0	0	0	0	0	0	0	0	0	0	4.93	12.2	20.8	33.4
1942	0	0	0	0	0	0	0	0	0	0	0	7.65	16.7	30.0
1959	0	0	0	0	0	0	0	0	0	0	0	0	9.84	24.2
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	15.9
1930	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1938	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1939	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1929	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1944	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1947	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1946	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1943	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1928	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1952	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVERAGE PERCENT OF CONTRACT WATER REQUIRED TO ASSURE FLOW:	0.0	2.0	2.7	4.1	4.8	5.0	5.5	6.5	7.0	7.7	8.3	9.3	10.7	13.1

long-term contract to assure a 8,042 cfs annual flow, 100 percent would be required in 1 year out of 51, 82.0 percent would be required in another year, 70.5 percent in a third, and so on with lesser deliveries needed in other years. In all, some delivery would be expected in 10 years out of 51, but only 8.3 percent of the contract water would be needed in the long-term average. The situation is illustrated in Figure 2, where the shaded areas represent the amount of water that would have to be committed to a market to assure average annual streamflows of 8042 cfs.

If IPC could use a water market to augment low streamflows, it could avoid building new generating capacity or relying on contractual arrangements with other utilities to meet some of its firm sales commitments. Table 3 shows the avoided cost values for firm and nonfirm power set in a recent Idaho Public Utilities Commission decision. A crucial factor in setting these rates is the current surplus of power in the Northwest. Neither firm nor nonfirm power will have a very high value until this surplus begins to run out in the 1990′s. Thus 20 year contracts for cogeneration or small hydropower production have lower value than longer term contracts. The table also illustrates the seasonal value differences. Power is more valuable in the June-September period when streamflows are usually low, than in March-May when excess water is often spilled.

The value of this kind of flow augmentation scheme to an electric utility has two components. First, the power that is generated with water delivered by the market will be firm power (represented by the shaded areas in Figure 2). This power would be valued at 5.65 cents/kwh (using the rates specified in Table 3 for

Figure 2. WATER NEEDED TO ASSURE 8042 CFS FLOW

AVERAGE ANNUAL FLOW AT MURPHY

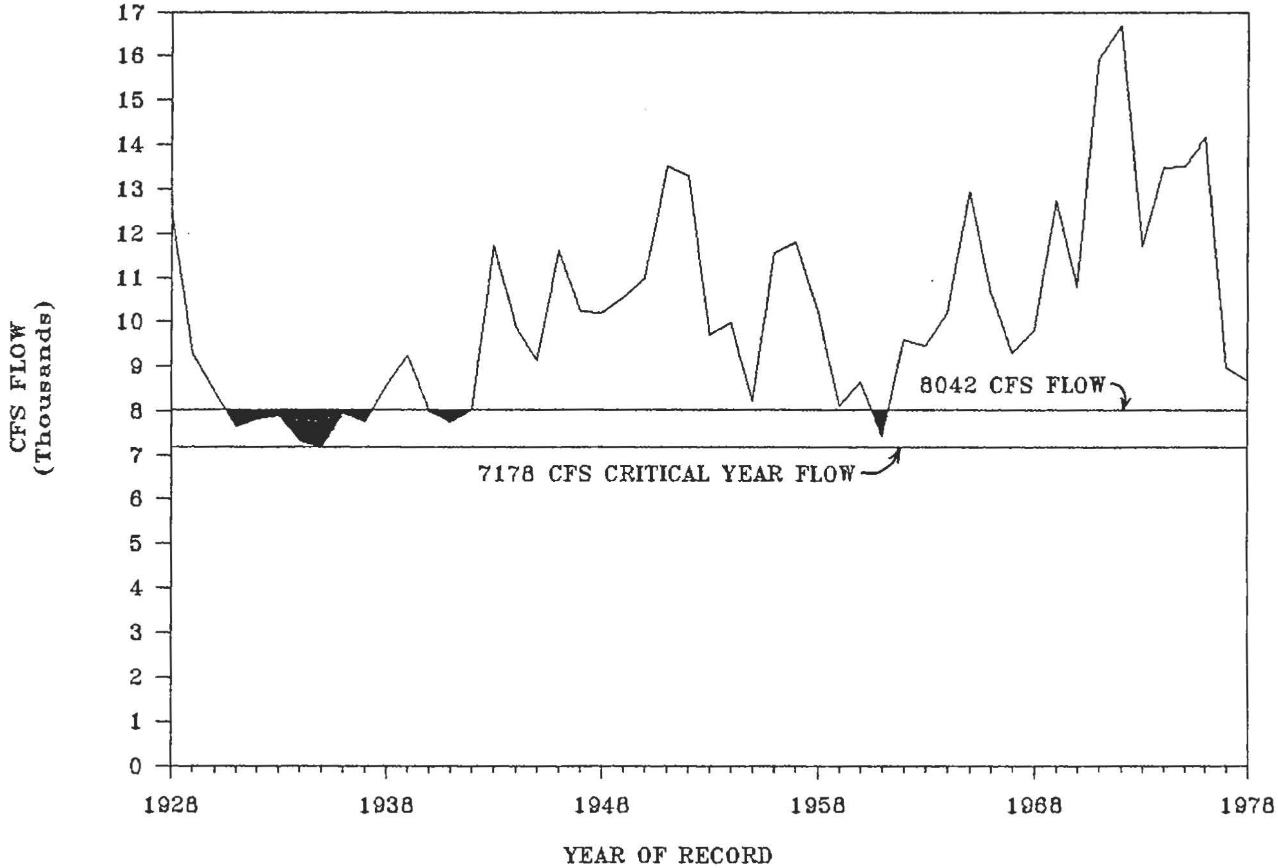


Table 3. Idaho Power Company 1986 Avoided Cost Rates for Cogeneration and Small Hydropower Producers.

Contract Terms	Yearly Average	Mar.-May	Jun.-Sep.	Oct.-Feb.
		Cents per KWH		
For 1986 Delivery:				
35 yr. contract	4.41	3.31	5.29	4.41
30 yr. contract	3.75	2.81	4.50	3.75
25 yr. contract	3.31	2.48	3.97	3.31
20 yr. contract	2.87	2.15	3.44	2.87
For 1987 or Later Delivery:				
35 yr. contract	4.70	3.53	5.65	4.70
30 yr. contract	4.00	3.00	4.80	4.00
25 yr. contract	3.53	2.65	4.23	3.53
20 yr. contract	3.06	2.29	3.67	3.06
Non-Firm Power:		1.92	2.77	2.16

Source: Idaho Public Utilities Commission Order 20350, March 28, 1986.

June-September delivery under a 35 year power contract). Second, the availability of this critical year generation capacity firms up a like quantity of power in all other years, increasing its value from 2.77 cents/kwh to 5.65 cents/kwh -- an increase of 2.88 cents/kwh of power firmed up. (This is represented by the unshaded areas between the two horizontal lines in Figure 2.) As the target flow and intervention probability increase, on average a greater percentage of contract water is delivered, so more is valued at 5.65 cents and less at 2.88 cents/kwh.

Table 4 summarizes the relationship between the intervention probability, required contract size, and the value of generation for the Idaho Power system. The expected annual value for power generation per acre-foot of water under long-term contract ranges from $37.09 at 1.96 percent expected intervention to $40.98 at 25.49 percent expected intervention. Since only a very small amount of water is actually delivered at the 1.96 percent intervention level, the power value is extremely high per acre-foot delivered -- $1891.58. Since the expected volume of delivery increases faster than expected annual contract value, the value per acre-foot of delivered water drops off rapidly, down to $313.32 at a 25.49 intervention percentage. Details of the computations behind Table 4 are presented in Appendix B of this report.

Subsequent sections of this report will show how these power values apply in the context of two types of water market; a market for water presently being used for irrigation, and a market for water in infrequently used storage. In both cases there will be costs that

Table 4. Relation Between Intervention Probability, Contract Size, and Hydropower Value for a Water Market

Probability of Intervention	Required Contract Acre-Ft	Ave % of Contract Actually Delivered	Ave Annual Value Of Contract Per Acre-Ft	Ave Value Per Delivered Acre-Ft	Present Value Of Contract Per Acre-Ft
2.0	112,425	2.0	37.09	1891.58	645.85
3.9	184,077	2.7	37.36	1371.63	650.50
5.9	334,420	4.1	37.85	914.07	659.14
7.8	408,831	4.8	38.09	790.94	663.25
9.8	428,303	5.0	38.17	757.13	664.63
11.8	462,249	5.5	38.34	693.14	667.62
13.7	523,579	6.5	38.68	595.74	673.48
15.7	551,947	7.0	38.84	557.69	676.36
17.6	594,838	7.7	39.11	506.10	681.01
19.6	625,715	8.3	39.31	472.78	684.59
21.6	677,615	9.3	39.67	425.21	690.77
23.5	751,578	10.7	40.16	374.36	699.30
25.5	894,198	13.1	40.98	313.32	713.64

will offset some of the power benefits. The values shown in Table 4 are only for the Idaho Power system. The value of this flow augmentation at dams downstream from the Idaho Power dams will also be discussed later in this report.

Even with fairly frequent intervention, the water that is actually delivered is quite valuable to the utility. It is important however to keep in mind the magnitude of this undertaking in mind. It would be necessary to organize a market and to get 625,715 acre-feet of water under a contract that assures delivery of the water with absolute certainty in order to accrue the power generation values shown in the 19.61 percent row of Table 4.

The amount of electricity that could be generated by this market water is determined by the developed head at the dams that the water would pass on its way to Hells Canyon, the Columbia River and the Pacific Ocean. Table 5 shows that an acre-foot of water in (or above) American Falls Reservoir could potentially generate 1882 KWH of electricity on its way to the ocean. Of this, 1264 KWH would be generated at Idaho Power Company dams along the Snake River, and 818 at the federal dams lower down on the Snake and Columbia Rivers.

Table 5. Potential Energy Lost by Consumption of an Acre-Foot of Water from Snake-Columbia System.

	Pool Height above Sea Level	Developed Gross Hd. at Dam	Undeveloped Hd. Below Dam	Cumulative Developed Gross Hd.	Cumulative Energy at .87 KWH/AF/ft.
	(feet)	(feet)	(feet)	(feet)	(feet)
Snake River (Idaho)					
American Falls	4,297	49	3	2,094	1,882
Minidoka	4,245	48	678	2,045	1,779
Twin Falls	3,519	147	10	1,997	1,737
Shoshone Falls	3,362	214	270	1,850	1,610
Upper Salmon Falls B	2,878	37	0	1,636	1,423
Upper Salmon Falls A	2,841	46	0	1,599	1,391
Lower Salmon Falls	2,799	59	86	1,553	1,351
Bliss	2,654	70	129	1,494	1,200
C.J. Strike	2,455	88	53	1,424	1,239
Swan Falls	2,314	24	213	1,336	1,162
Brownlee	2,077	272	0	1,312	1,141
Oxbow	1,805	120	0	1,040	905
Hells Canyon	1,688	210	742	920	800
Snake-Columbia River (Oregon-Washington)					
Lower Granite	736	98	0	710	618
Little Goose	638	98	0	612	532
Lower Monumental	540	100	0	514	447
Ice Harbor	440	98	2	414	360
McNary	340	74	1	316	275
John Day	265	100	5	242	211
The Dalles	160	83	22	142	124
Bonneville	74	59	17	59	51

CHAPTER III

OPTION LEASING OF WATER

In the Pacific Northwest, agriculture and other consumptive uses impose a major impact on regional power supplies by diverting water from hydroelectric generation in the Columbia River system. The basic phenomenon underlying this research project is the fluctuation of river flows from one year to the next. Agriculture operates with water rights granted under the appropriation doctrine. As long as water is available, the agricultural user will get his usual supply, regardless of how much remains for other uses in years of low stream flow. It has been traditionally assumed that hydropower can live with interruptible or fluctuating supplies of water more easily than agriculture. But this may not be true if the value of some power is downgraded in all years because it cannot be guaranteed in low flow periods.

This research examines the potential for exchanging water currently used by irrigated agriculture for use in generation of electricity in the Snake and Columbia River system during critical stream flow periods. Agriculture would use the water for crop production in most years, but during the dry periods agriculture would be asked to give up some or all of a committed portion of its irrigation water in order to raise stream flows to a predetermined level. Such a program might require that agriculture give up only 10 percent of its water one year and as much as 50 percent in some other year. This arrangement would allow some of the current nonfirm power to be treated as firm power and, consequently, raised in value in all years.

In reducing the diversions of water to agriculture, two types of gain can be obtained. Agriculture currently diverts from the stream of the Snake River a great deal more water than it consumptively uses. Some of these diversions return to the river at different points in time and at different locations on the river system. A change in the level of unused diversions of water may affect only the timing of the river system stream flow. However, in reducing the diversions to agriculture we also expect to reduce the consumptive use of water by crops in agriculture. This change in consumptive use will provide a greater quantity of water for instream uses, in particular, hydropower. The following analysis considers changes in consumptive use levels through the control of irrigation diversions under an option leasing program for an interruptible water market for the purpose of increasing hydropower production. The uncertainty of participating in such a market will be considered by showing the range of possible outcomes that can occur for a typical farm. The analysis considers several farm types in southeast and southcentral Idaho. Cropping patterns, irrigation systems, and sources of power for irrigation pumping are some of the variables that are considered in this analysis. The loss in net agricultural income from market participation is investigated for each typical farm. This net farm income loss should be a lower bound on the amount of compensation required by agriculture to justify participation in a water market. In this study the measure of net farm income is a return to land investment costs, irrigation system costs, machinery investment costs, management, and other fixed costs. Only variable production costs of crop production are deducted.

A. Procedure Used in Constructing Model

A linear programming analysis was used to investigate the expected response of irrigators to changing water supplies in years of water shortage and assess the costs to agriculture from participation in a water market. As the water supply to an irrigated farm is decreased in any given year the farmer can respond in several ways. The cropping system can be changed within some limits. The amount of water applied to a crop can be adjusted, irrigation efficiency can be increased by better irrigation management, and land can be left idle if insufficient water is available for production. The range of adjustments that can occur will depend upon the cropping pattern which is typical for a farm, the existing irrigation system and the level of irrigation management and irrigation efficiency which prevails. A farm with an abundant supply of water under normal conditions may be using the water to substitute for labor, management, and capital costs of irrigation systems. Such a farm may have more potential adjustments to changing water supplies than a high lift, center pivot irrigated farm which is already being squeezed by rising energy costs. The high lift farm will have already made many of the potential adjustments that are described above. Hence, as the water supply to such a farm is reduced, there may be fewer alternatives for additional adjustments in the farming system. These are some of the phenomena that are investigated in the following analysis.

1. Representative Farms

For this analysis, typical farms were developed for the southeast region and southcentral region of Southern Idaho as shown in Table 6. More details are provided in Appendix A. In the southeast region, a rill irrigated farm and a sideroll irrigated farm were chosen. The sideroll irrigated farm was further subdivided according to whether it received pumping power from the Idaho Power Company (IPC) or the Utah Power and Light (UPLC). Cropping patterns and relative weights of the farms are given in this table.

In the southcentral region four types of farms were delineated. A rill irrigated farm with a zero pump lift constitutes the majority of the acreage. A zero pump lift, sideroll irrigated farm and a sideroll irrigated farm requiring 200 feet of pump lift were considered. The last farm type was a center pivot irrigated farm with an assumed pump lift of 500 feet. In all cases the pump lift was in addition to the requirement for pressurization of sprinklers.

In choosing the crops to represent the farms in each region it was necessary to do some aggregation. Barley was used to represent spring wheat and spring seeded small grains. Potatoes were used to represent high value cash crops which include sugarbeets. Beans were assumed to also represent grain corn as a cash row crop of intermediate value. The production costs, water requirements, and productivity of these crops are shown in later tables.

2. Budget Data

A summary of crop budget information is shown in Table 7. Additional details are provided in Appendix A. It was assumed that a short-run fluctuation in water supply would not affect the fixed costs of a farm operation. Hence, only the variable costs of production were considered in this analysis. The net returns to

Table 6. Representative Farms and Rotations for Land Irrigated from Surface Water (Percent).[a]

SOUTHEAST REGION

	Rill	Sideroll	Region Total
Percent of Area	63	37	100.0
Winter Wheat	11	9	10.3
Spring Grain	38	36	37.3
Alfalfa	25	23	24.3
Potatoes	10	22	14.4
Pasture	16	10	13.8
Region Total	100	100	100.0

SOUTHCENTRAL REGION

	Rill	Sideroll Zero Lift	Sideroll 200' lift	Center Pivot 500' lift	Region Total
Percent of Area	67	17	8	8	100.0
Winter Wheat	8	9	12	12	8.8
Spring Grain	27	29	30	30	27.8
Alfalfa	25	25	25	25	25.0
Potatoes	5	10	18	18	7.9
Beans	15	15	15	15	15.0
Pasture	20	12	0	0	15.4
Region Total	100	100	100	100	100.0

[a] Of total irrigated land in southeast Idaho, 62.6% or 664,000 acres are served by water diverted from the Snake River. In southcentral Idaho 55.3% or 680,000 acres are irrigated with Snake River water. The balance in each region is irrigated with groundwater.

Table 7. Summary of Crop Budget Information.

		Winter Wheat	Barley	Alfalfa	Potatoes	Beans	Pasture
				Southeast Region			
Variable Cost[a]	$/A	65.00	70.00	20.00	550.00	--	10.00
Fertilizer	$/A	44.80	46.00	15.60	125.95		15.00
Harvest	$/A	13.41	24.03	63.74	83.05		
Irrigation:							
Rill	$/A	1.15	1.15	1.15	1.15		1.15
SR	$/A	10.15	10.15	10.15	10.15		10.15
Crop: Yield		90 bu	85 bu	4.3 T	260 cwt		8.5 AUM
Price	$/U	3.50	2.90	65.00	4.50		11.00
Gross Revenue	$/A	315.00	246.50	279.50	1170.00		93.50
				Southcentral Region			
Variable Cost	$/A	75.00	80.00	22.00	600.00	100.00	15.00
Fertilizer	$/A	44.80	38.40	9.60	132.00	7.50	15.00
Harvest	$/A	13.41	26.00	65.00	87.99	18.04	--
Irrigation:							
Rill	$/A	1.15	1.15	1.15	1.15	1.15	1.15
SR	$/A	10.15	10.15	10.15	10.15	10.15	10.15
CP	$/A	9.62	9.62	9.62	9.62	9.62	9.62
Crop: Yield		100 bu	95 bu	4.8 T	310 cwt	18 cwt	9.5 AUM
Price	$/U	3.50	2.90	65.00	4.50	17.00	11.00
Gross Revenue	$/A	350.00	275.50	312.00	1395.00	306.00	104.50

[a] Not including fertilizer, harvest, or irrigation costs.

irrigated farming were calculated as the return to all fixed resources including land, management, machinery and irrigation system costs.

Table 7 shows the estimated variable production costs for each crop. Changing water application levels was one way a farmer could adjust to a changing water supply, so the fertilizer, harvest, and irrigation labor costs were adjusted for the crop yield of each crop activity. The maximum expected yields and the expected prices used in this analysis are shown in Table 7.

Table 8 shows the net irrigation requirements for study crops in acre-inches per acre. Two sources of data were used for these estimates. The final two columns of Table 8 show the amounts of water used for this analysis. In general, southcentral Idaho crops have slightly higher levels of water consumptive use than do similar crops grown in southeastern Idaho.

Estimates of pumping energy used for the representative farms in this analysis are shown in Table 9. Pumping plant efficiencies, operating sprinkler pressures, total dynamic head, and energy use per acre-inch of water application are presented in this table.

The assumed baseline parameters for irrigation application systems are presented in Table 10. The labor efficiency and field application efficiency for irrigation in southcentral Idaho are slightly higher than for southeastern Idaho.

3. Irrigation Adjustments to Water Supply

This analysis required that the farmers´ response to a changing water supply in the short run be simulated as accurately as possible.

Table 8. Net Irrigation Requirements for Study Crops, Acre Inches per Acre.[a]

	Southeast	Southcentral
Winter wheat	17.23	19.00
Barley	14.05	14.05
Alfalfa	26.43	26.43
Beans	14.52	16.49
Pasture	22.80	23.62
Potatoes	20.50	21.60

[a]Water requirements were synthesized from information obtained from Sutter & Cory (1970) and Soil Conservation Data (1979).

Table 9. Pumping Energy Calculations.

		SR-SE 0' lift	SR-SC 0' lift	SR-SC 200' lift	CP-SC 500' lift
Pumping Plant eff.	%	58	58	58	60
Operating pressure	PSI	60	70	70	70
	ft	140	162	162	162
Total head	ft	140	162	362	662
Energy use[a]	KWH/AI	20.59	23.83	53.24	94.11

[a]$KWH/AI = \frac{.0853 \text{ (head ft.)}}{\text{Efficiency}}$

Table 10. Baseline Parameters for Irrigation Application Systems.

	Surface	Sideroll	Center Pivot
Labor Hours per Acre per Application			
Southeast	0.80	0.35	0.035
Southcentral	0.60	0.30	0.035
Field Application Efficiency			
Southeast	0.40	0.65	0.80
Southcentral	0.45	0.65	0.80

Source: John Busch, Department of Agricultural Engineering, University of Idaho.

Since it was not practical to develop a large multi-period irrigation simulation model to account for the optimum application of water over an irrigation season, an alternative approach was required. Previous experience with the SPAW-IRRIG simulator model (Bernardo and Whittlesey) has shown that there are many ways to irrigate a crop with a given irrigation system and water supply. Approximately 1,200 irrigation activities were generated for four different crops using the SPAW-IRRIG model for irrigation in the central Columbia Basin of Washington State. The information obtained from these 1,200 irrigation activities were then used to develop alternative ways of irrigating crops in southern Idaho to reflect the tradeoffs that can occur when irrigation water supplies are varied. Only these activities forming the envelope of water use efficiency at alternative water supply levels were used in this analysis, resulting in approximately 30 irrigation activities for each crop. In general, as water becomes more limiting it is practical for the irrigator to apply more frequent, smaller applications of water to raise the irrigation efficiency and consequent yield from a given quantity of water. To increase the number of irrigations for a given level of water application requires greater management and labor inputs.

An example of the alternative irrigation activities for rill irrigated spring grain in southeast Idaho is shown in Table 11. In the left margin of this table is shown an index of the net irrigation requirement and the acre-inches of consumptive water use that could be used to irrigate barley or spring wheat in southeastern Idaho at each level of water use. For each level of water consumptive use,

Table 11. Alternative Irrigation Activities for Rill Irrigated Spring Grain in Southeast Idaho.

NIR[a/] Index NIR I/A	Irr. Eff. %	Applied Water I/A	Yield Index %	Yield bu/A	Labor Index %	Labor hrs/acre	Total Variable Cost $/A
100.00	40.00	35.13	100.00	85.00	100.50	4.80	141.18
14.05	37.00	37.97	99.90	84.92	90.40	4.34	141.12
	33.00	42.58	99.40	84.49	80.40	3.86	140.83
	28.00	50.18	98.60	83.81	70.40	3.83	140.37
	24.00	58.54	97.40	82.79	60.30	2.89	139.67
92.90	44.00	29.66	98.00	83.30	104.60	5.02	140.02
13.05	40.00	32.63	97.00	82.45	94.20	4.52	139.44
	35.00	37.29	96.00	81.60	83.70	4.02	138.86
	31.00	42.10	95.00	80.75	73.30	3.52	138.28
	27.00	48.33	94.00	79.90	70.00	3.36	137.70
77.30	55.00	19.75	97.70	83.05	123.50	5.93	139.85
10.86	53.00	20.49	96.50	82.03	111.20	5.34	139.15
	48.00	22.63	95.80	81.43	98.80	4.74	138.74
	40.00	27.15	85.70	72.85	86.40	4.15	132.88
	38.00	28.58	76.20	64.77	69.30	3.33	127.37
74.80	60.00	17.52	91.90	78.12	178.10	8.55	136.48
10.51	58.00	18.12	91.60	77.86	160.30	7.69	136.31
	55.00	19.11	90.70	77.10	142.50	6.84	135.78
	54.00	19.46	89.10	75.74	124.60	5.98	134.86
	53.00	19.83	86.90	73.87	106.80	5.13	133.58
	50.00	21.02	84.20	71.57	89.00	4.27	132.01
52.80	54.00	13.74	81.80	69.53	93.60	4.49	130.62
7.42	52.00	14.27	81.40	69.19	84.30	4.05	130.39
	50.00	14.84	80.00	68.00	74.90	3.60	129.58
	47.00	15.79	77.70	66.05	65.60	3.14	128.24
	40.00	18.55	74.60	63.41	56.20	2.70	126.44
	38.00	19.53	70.40	59.84	46.80	2.25	124.01
42.10	54.00	10.96	73.80	62.73	83.10	3.99	125.98
5.92	53.00	11.17	73.40	62.39	74.80	3.59	125.75
	52.00	11.38	72.10	61.29	66.50	3.19	124.99
	48.00	12.33	70.00	59.50	58.20	2.79	123.78
	46.00	12.87	67.00	56.95	49.80	2.39	122.04
	39.00	15.18	63.10	53.64	59.95	1.99	119.77

[a/] Net irrigation requirement.

several alternative levels of irrigation efficiency may be used. Subsequent columns in this table then show the estimates of applied water, a yield index, and the estimated yield in bushels per acre for the alternative ways of irrigating this crop. Associated with each of the irrigation activities is an estimate of labor use and the total variable costs of production. The variable costs of production have been adjusted to account for that part of fertilizer and harvest costs that are proportionate to yield. A similar set of data were developed for each crop and irrigation system in each of southeast and southcentral Idaho. The inclusion of these alternative irrigation activities in a linear programming model allowed an assessment of the tradeoffs that can occur as water supplies are changed due to participation in a water market. In response to a change in the quantity of delivered water the farmer may change the level of irrigation efficiency, the consumptive use of water for any crop, or the acres of crops that are produced. As the irrigation efficiency and water application for any crop is changed, the labor requirements and energy pumping requirements will also change. The optimum response for a farmer to any given level of water supply will depend upon the price of energy, the price of labor, the prevailing irrigation technology, and the value of the crops that are produced. The responses derived in this analysis are based upon the assumed costs of production, yields, and crop returns which are shown in the previous tables.

Upper and lower bounds for individual crops were used to control the level of crop acreage adjustment to changing water supplies in this analysis. The crop acreage constraints are shown in Table 12. The assumptions used to develop these upper and lower bound constraints on crop acreages are based on the following rationale. Under the concept of an interruptible water market it was assumed that a farmer would always know what his water supply would be prior to planting spring crops of that year. Hence, it would be possible to reduce the acreage of any spring planted crop to zero if necessary and it was assumed that, except for potatoes, these crops could be increased by 20 percent over baseline levels. Alfalfa and rotation pasture were assumed to have a 5-year life after establishment and more than one-fifth of total acreage could not be allowed to die for lack of water without significantly affecting long-run costs of production. Hence, it was permitted that alfalfa or pasture acreage could be reduced as much as 20 percent in any given year due to a water shortage without significantly affecting the underlying production costs associated with that crop. It was not possible to increase the acreage of these crops in the short run.

Winter wheat was assumed to be established prior to having knowledge of the water supply for that year. Hence, it would not be possible to either increase or decrease the acreage of winter wheat produced due to a change in water supply. Only the level of water application for that crop could be adjusted to the actual water supply.

It was stated above that a farmer will always know what his total seasonal supply of water will be prior to investing in spring planted crops. An important part of this assumption is that the

Table 12. Crop Acreage Constraints, Base Value, Upper Bounds, and Lower Bounds.

	Percent Total Acreage					
	Southeast Idaho		Southcentral Idaho			
	Rill	Sideroll 0' lift	Rill	Sideroll 0' lift	Sideroll 200' lift	Center Pivot 500' lift
Alfalfa - base	25	23	25	25	25	25
UB	25	23	25	25	25	25
LB	20	18.4	20	20	20	20
Winter Wheat - base	11	9	8	9	12	12
UB	11	9	8	9	12	12
LB	11	9	8	9	12	12
Barley - base	38	36	27	29	30	30
UB	45.6	43.2	33.4	34.8	36	36
LB	0	0	0	0	0	0
Pasture - base	16	10	20	12	0	0
UB	16	10	20	12	0	0
LB	12.8	8	16	7.2	0	0
Potatoes - base	10	22	5	10	18	18
UB	10	22	5	10	18	18
LB	0	0	0	0	0	0
Beans - base	0	0	15	15	15	15
UB	0	0	18	18	18	18
LB	0	0	0	0	0	0
Total base	100	100	100	100	100	100

farmer can distribute that supply over the season in any way deemed most desirable. That is, there is assumed to be sufficient upstream storage capacity in a water deficit year to allow farmers to optimally shape water use to crop needs and produce the maximum value of crops from available water.

4. Water Market Assumptions

Under the conditions of an interruptible water market, a participating farmer would have his full water supply in most years. His normal water supply for irrigation would be interrupted or reduced only when certain stream flow conditions were met. Table 3 in this report has shown the historical river flow conditions for the Snake River for a 51-year period. This information was used to establish the level of participation for the assumed market and the probabilities and quantities of interruption that would be imposed on participating farmers. It was assumed that the interruptible water market would contribute a sufficient quantity of water to raise the level of stream flow in all years to a level presently achieved only 80 percent of the time (i.e., the market would be filling in the lowest 20 percent of the streamflow graph as shown in Figure 2). Such a market would be required to contribute approximately 600,000 acre-feet of water to the river flow under the most extreme low flow conditions. It would be expected that, on the average, a farmer's water supply would be interrupted in 8 years out of 51. The remaining 43 years of the 51 would require no interruption. In these 8 years of interruption the amount of water required to be given up by a participating farmer would vary from as little as 10 percent of his normal water supply to as much as 50 percent, under these assumptions. It was considered for a market to be politically feasible, no region of agriculture could be completely eliminated in any given water short year. Hence, it was assumed that no individual farmer or group of farms within a region could give up more than 50 percent of their total water in any given year. Actually, Table 3 shows that 10 years of 51 would not provide a natural average flow of 8,042 cfs. However, two of these years would provide deficits so small that less than 10 percent of a farmer´s water supply would be needed to meet streamflow requirements. It was assumed that it would not be practical to operate an option lease program to obtain such small quantities of water from a large number of farmers. The small deficits in those years could be obtained from a select few farmers willing to market larger quantities of water in those years or from water normally stored upstream. In this sense, this analysis understates the total cost of a water market to augment streamflows by 19.6 percent above critical flow levels. Alternatively, the program costs estimated by this analysis would augment critical streamflow levels by slightly less than 19.6 percent.

The estimated reduction in delivered water necessary to obtain a chosen decrease in consumptive use over a 51-year period is shown in Table 13. It is assumed that the 600,000 acre-feet of additional stream flow would be derived from changes in consumptive use only. The change in diversions required to obtain this reduction of consumptive use would exceed the required change in consumptive use. In Table 13 are shown the nine possible water supply levels that may

Table 13. Percent Reduction in Delivered Water to Obtain Chosen Deficit in Consumptive Use.[a]

Case No.	Percent Deficit in Consumptive Use	Percent Reduction in Delivered Water[b] RILL-SE	SR-SEI	SR-SEU	RILL-SC	SRL-SC	SRH-SC	CP-SC
1	0	0	0	0	0	0	0	0
2	10	31	12	12	25	12	14	13
3	13	35	15	15	29	15	17	17
4	15	39	18	18	31	18	20	18
5	18	42	21	21	35	22	23	21
6	25	50	29	29	43	30	29	28
7	35	60	40	38	54	40	38	37
8	40	63	43	41	58	42	42	43
9	50	69	53	51	64	52	52	51

[a] Eight years out of 51 would require some amount of supply reduction and the remaining years would require no supply reduction.

[b] Farm types are: Rill-Southeast Idaho (RILL-SE); Sideroll-Southeast Idaho-Idaho Power Company (SR-SEI); Sideroll-Southeast Idaho-Utah Power & Light (SR-SEU); Rill-Southcentral Idaho (RILL-SC); Sideroll-Zero Lift-Southcentral Idaho (SRL-SC); Sideroll-200 foot lift-Southcentral Idaho (SRH-SC); Centerpivot-500 foot lift-Southcentral Idaho (CP-SC).

be encountered by a farmer participating in this water market. The range in the percent of normal consumptive use available to the farmer would be from 0 to 50 percent. Farms using different irrigation systems operate at different levels of irrigation efficiency and will respond differently to a change in delivered water supply. Hence, to obtain the assumed levels of change in consumptive use shown in the second column of Table 13, the farms under each irrigation system would be required to give up the indicated percentages of delivered water. For example, in order to reduce consumptive use by 25 percent on the rill irrigated farm in southeast Idaho (RILL-SE) it would be necessary to reduce the delivered quantity of water by 50 percent. The sideroll irrigated farm in southeast Idaho (SR-SEI), operating at a higher level of irrigation efficiency, would be faced with a 29 percent reduction in delivered quantity of water to obtain a 25 percent reduction in consumptive use.

The values in Table 13 were obtained by establishing a base level quantity of water use for each of the farms without a restricted supply. This base level quantity of water was then parametrically varied downward to establish a relationship between the change in consumptive use and to the change in delivered water. The relationships between delivered water and consumptive use shown in Table 13 will vary some with the level of prices for crops and the climatic year. If farm income is high due to high crop prices a farmer will devote greater effort to irrigation management and will achieve higher levels of consumptive use from a given quantity of delivered water than if the potential for farm income is reduced by low farm commodity prices. Hence, in an operable water market it may be necessary to continually refine the relationships shown in Table 13 for application in a year of low streamflow.

The average consumptive use of water on the representative farms in southern Idaho is estimated to be approximately 18 to 20 inches per year. To obtain a 50 percent reduction in this level of consumptive use under the most extreme conditions would require a sacrifice of approximately 9 acre-inches of water per acre. Hence, to obtain the 600,000 acre-feet of water assumed to be required to operate the market underlying this analysis would require the market participation of approximately 800,000 acres of irrigable land.

It is important to note that change in consumptive use is the quantity of primary interest in this analysis. A unit of water that is diverted to irrigation but merely returned to the river at a later time is still available for hydropower production. Hence, to obtain real changes in the power output of the hydropower system requires a change in the consumptive use level of water by irrigation. However, it is assumed that a controlling agency operating a water market could not tell a farmer how he may irrigate his farm or what crops to grow in order to affect the consumptive use of water. It is only practical to control the level of water that is delivered to the farm. In this analysis it is assumed that changes in consumptive use will always be obtained by controlling the level of delivered water to farms. By anticipating the management response of farmers to changing water supplies, it does appear to be practical to operate a market in this manner. A farmer who responds less efficiently than is assumed in this analysis would necessarily give up a greater portion of his consumptive use than required by the market. Therefore, farmers would be expected to always respond with approximately the level of managerial efficiency assumed in this analysis.

It was assumed that, including the cost of management for irrigation, the labor cost per hour of irrigation would be $5, $6, and $7 per hour respectively for rill, sideroll, and center pivot irrigated farms. The basic energy cost for farms using electricity from Idaho Power Company (IPC) was estimated to be 30 mills per KWH. For the sideroll irrigated farm in southeastern Idaho using energy from Utah Power & Light (UPL) the cost was 51 mills per KWH. These were estimated to be the prices paid for electricity by irrigators in 1986.

Two different approaches were used to analyze the cost of power for participating farms using IPC electricity. In the first instance all farms were assumed to pay a constant energy cost of 30 mills per KWH (demand plus energy charge) regardless of the level of water interruption in any given year. In the second case, it was assumed that a farmer who committed 50 percent of his water to the market would receive a 25 percent reduction in the cost of power used for pumping that portion of the market committed water in the years the water is used for irrigation. That is, the farmer would pay 30 mills per KWH for 50 percent of his water not committed to the market and 22.5 mills per KWH for pumping water that is committed to the market.

Under these conditions, the participating farmer in a year in which no water supply interruption occurred would have a blend price for energy of 26.3 mills per KWH. In the extreme situation in which he gives up 50 percent of his water supply the amount paid for pumping the remaining portion would be 30 mills per KWH. As expected, this price break on energy costs had the greatest effect on the high pump lift farms. The assumption of a 25 percent cost reduction was based on the approximate difference between the current values of firm and nonfirm power. Further, the basis for this price break is the assumption that in years when streamflows were above the desired level (say, 8,042 CFS) there would be nonfirm power available for purchase. Since the farmer participating in the water market would have no need for the nonfirm power in years of deficit water supply, he is in a good position to use this nonfirm power. Actually, a more realistic approach might be to allow the use of nonfirm power only in years of no supply reduction.

B. Results from Model

1. Baseline Solutions

Individual farm response to an interruptible water market was obtained for seven representative farms in south Idaho. The baseline solution at a full water supply for each farm under the assumption that energy prices would be constant at 30 mills per KWH is shown in Table 14. The farms in southcentral Idaho are shown to have higher net farm income than those in southeastern Idaho. The primary reason for the differences in net farm income are due to the more profitable cropping patterns found in southcentral Idaho. Beans, not included

Table 14. Baseline Values for Farms with No Energy Price Adjustment. a/ b/

		SE Idaho			SC Idaho			
		Rill	Idaho Power Sideroll 0' lift	Utah Power Sideroll 0' lift	Rill	Sideroll 0' lift	Sideroll 200' lift	Center Pivot 500' lift
Net Revenue	$/A	133.82	153.43	140.79	160.22	166.96	185.07	168.78
Crop Acres								
Alfalfa	Percent	25	23	23	25	25	25	25
Pasture	Percent	12.8	8	8	16	9.6		
Barley	Percent	41.2	38	38	28	28.4	27	27
Wheat	Percent	11	9	9	8	9	12	12
Beans	Percent				18	18	18	18
Potatoes	Percent	10	22	22	5	10	18	18
Water Use	AI/A	58.31	30.10	27.11	46.74	28.98	27.72	19.48
Net Irr Req	AI/A	19.26	19.47	17.93	17.90	19.17	18.61	16.21
Irr. Eff.	%	33	65	66	38	66	67	83
Energy Use	KWH/A		620	558		691	1,476	1,834
	Hrs/A	4.62	2.84	3.38	3.55	2.61	2.90	1.55

a/ Labor cost $5, $6, and $7, respectively for Rill, Sideroll, and Center Pivot farms.

b/ Energy cost is $.03/KWH for all except the farm using power from Utah Power & Light which is $.051/KWH.

in the rotation for southeast Idaho farms, was a relatively profitable crop under the assumptions of this study.

Of course, changes in assumed production costs, yields, or commodity prices could change the profitability of any crop included in the study. Barley, for example, which was used to represent spring grain crops, was found to be a relatively unprofitable crop.

The net revenue figures shown for representative farms in Table 9 are an estimate of the return to all fixed resources including land, management, machinery, and irrigation equipment investments. It was assumed that these costs would not be affected by short-run variations in the water supply due to participation in a water market. The baseline values for typical farms shown in Table 14 are intended to be representative of those currently existing in southern Idaho. That is, a farm with no restriction in water supply would be expected to have a cropping pattern, resource use, and net farm income under current farming conditions as shown in this table.

A rather large difference between the net farm income figures for the two southeast Idaho sideroll farms is explained by the difference in the cost of power to these farms. The farm obtaining energy from IPC is paying 30 mills per KWH for electricity while the farm using UPL power energy is paying 51 mills per KWH for energy. The cropping pattern for these two farms is identical. However, the higher energy cost does result in lower levels of water use, and slightly higher levels of irrigation efficiency.

Though having different cropping patterns, the rill and sideroll irrigated farms in southcentral Idaho have approximately the same net farm income per acre. These levels of income, however, are obtained with significantly different levels of water use, irrigation efficiency, and labor use.

The center pivot farm currently uses much less water and more pumping energy than other farms in southern Idaho. It was found that the higher energy costs for this center pivot farm have already caused it to adopt many of the water saving measures which are options to other farms when water shortages occur. Therefore, the center pivot irrigated farm was quicker to reduce irrigated acreage in response to water shortages than other farm types.

2. Irrigation Management Under Water Shortage

The southern Idaho representative farms responded in different ways to water shortages when participating in the water market. If current water supply is abundant and the efficiency of irrigation relatively low, more options are available for adjustment in irrigation management when water shortages occur than if water scarcity has already been imposed on the farm. Irrigation management choices with limited water supply for the rill irrigated farm in southeast Idaho are shown in Table 15. The first column of this table shows the baseline condition where no water shortage exists. The percentage of cropland devoted to each crop is shown along with the level of consumptive use and irrigation efficiency for each crop. The values shown for the baseline condition are close to those currently existing for farms in this region. The rill irrigated farm is applying more than 58 acre-inches of water per acre. Of this, 19.26 acre-inches are consumptively used by crops to provide an irrigation efficiency of 33 percent. Irrigation labor used to derive this level of irrigation efficiency is 4.62 hours per acre of irrigated cropland.

Across the top of Table 15 are shown the percentage reductions in delivered water used for the rill irrigated farm. Each successive column represents a level of supply lower than the previous one. In order to observe the managerial responses to changing water supplies it is most instructive to move from left to right for a single crop to observe the adjustments in irrigation of that crop. For example, alfalfa is initially irrigated with 26 inches of consumptive use at an irrigation efficiency of 43 percent. Alfalfa was a relatively profitable crop in this scheme and consequently was changed from this level of application and irrigation efficiency only slightly until a 50 percent reduction in water supply was imposed. At this point, the irrigation efficiency was increased to 46 percent and the level of consumptive use dropped to 20 acre inches per acre. When the water supply had been reduced by 69 percent the level of consumptive use for alfalfa was reduced to 12 inches and the irrigation efficiency raised to 58 percent.

Pasture is relatively unprofitable in comparison to other crops. It was initially provided 22 inches per acre for consumptive use with an irrigation efficiency of 40 percent. The 31 percent supply reduction resulted in a decrease in the level of consumptive use to 10 acre-inches and an increase in irrigation efficiency to 58 percent, the most restrictive conditions available to the model

Table 15. Managerial Response to Changes in Delivered Water Supply for the Rill Irrigated Farm in Southeast Idaho.

		Percent Delivered Water Supply Reduction								
Item	Unit	0	31	35	39	42	50	60	63	69
Net Rev.[a]	$/A	133.82	128.99	127.51	126.00	124.63	120.15	110.58	104.74	92.13
Alfalfa	%	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
	NIR[b]	26	26	26	26	25	20	13	12	12
	IE[c]	43	45	45	45	45	46	59	58	58
Pasture	%	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8
	NIR	22	10	10	10	10	10	10	10	10
	IE	40	58	58	58	58	58	58	58	58
Barley	%	41.2	41.2	41.2	41.2	41.2	41.2	41.2	37.9	20.3
	NIR	14	13	11	10	10	10	10	10	10
	IE	24	41	45	48	53	55	55	55	55
Wheat	%	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0
	NIR	17	17	17	17	16	14	13	9	9
	IE	28	40	40	41	44	53	55	54	54
Potatoes	%	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	NIR	20	20	20	20	20	20	20	20	20
	IE	43	43	43	43	43	43	43	43	43
Idle Land	%								3.3	20.9
Water Use	AI/A[d]	58.31	40.23	37.90	35.57	33.82	29.15	23.32	22.31	22.86
Ave. NIR	AI/A[d]	19.26	17.27	16.79	16.31	16.07	14.47	12.51	11.89	12.11
Ave. IE	%	33	43	44	46	48	50	54	53	53
Labor	H/A[d]	4.62	5.33	5.39	5.46	5.69	5.73	5.55	5.31	5.16

a/ Based on total irrigable acreage.
b/ Net irrigation requirement in acre inches per acre.
c/ Irrigation efficiency in percent.
d/ Based on irrigated acreage only.

without allowing the pasture to die. Each crop except potatoes was adjusted in both level of water use and irrigation efficiency as water supplies became more restrictive. The higher levels of irrigation efficiency are normally obtained by more frequent smaller applications of water which also require higher levels of irrigation labor and management.

Potatoes are the only crop for which no adjustments in irrigation management occur due to changing water supplies. This was the most profitable of the crops available to this farm and the same consumptive use level and irrigation efficiency were used throughout. This phenomenon was true for all farm types under all energy pricing conditions. Due to the problems of maintaining potato quality under differing levels of water application and application efficiency, this model allowed only minor adjustments in irrigation efficiency and no adjustments in level of water application.

For the rill irrigated farm in southeast Idaho, the level of water use declined from more than 58 acre-inches per acre irrigated under an unlimited water supply to 23 acre-inches per acre irrigated when the water supply was reduced by 63 percent. Since barley acreage declined from this point onward, the average level of water application per irrigated acre increased again slightly. The average level of irrigation efficiency was raised from 33 percent to 53 percent by the irrigation options available to this farm. In part, this was achieved by increasing the level of irrigation labor and management per acre. The total irrigation labor per acre increased from 4.62 hours per acre irrigated to 5.73 hours per acre irrigated under the 50 percent supply reduction condition. The irrigation efficiency and labor use per acre declined slightly when barley acreage was reduced.

It is instructive to note that no land was idled on this farm until delivered water was reduced by 63 percent to provide approximately a 40 percent reduction in water consumptive use. This phenomenon was fairly consistent for all farm types, as shown by subsequent tables. Hence, if crop prices are at or above normal levels, this option lease program would very rarely take cropland completely out of production. However, a sensitivity analysis, not further described here, did indicate that the amount of labor and management devoted to irrigation is influenced by the level of expected farm profits. High crop prices will elicit higher levels of irrigation efficiency and water consumptive use from a given level of delivered water than will low crop prices.

Similar irrigation management choices under limited water supply conditions are shown for the 200 foot lift sideroll irrigated farm in southcentral Idaho in Table 16. The adjustments to changing water supplies for the sideroll irrigated farm are similar to those previously described for the rill irrigated farm. However, since this farm starts at a higher level of irrigation efficiency and lower levels of water application, there are fewer alternatives for adjusting to water deficit conditions. The average irrigation efficiency rose from 67 percent under an unlimited water supply to 72 percent when the water supply was reduced by 23 percent. Labor input for irrigation increased from 2.90 hours per acre to 3.33 hours per

Table 16. Managerial Response to Changes in Delivered Water Supply for the 200 Foot Lift Sideroll Irrigated Farm in Southcentral Idaho, No Energy Price Adjustment.

		Percent Delivered Water Supply Reduction								
Item	Unit	0	14	17	20	23	29	38	42	52
Net Rev.[a]	$/A	185.07	180.58	178.98	177.37	175.75	172.22	161.37	154.72	138.05
Alfalfa	%	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
	NIR[b]	23	23	21	19	17	13	12	12	12
	IE[c]	68	68	70	71	73	74	74	74	74
Barley	%	27.0	27.0	27.0	27.0	27.0	27.0	34.5	36.0	16.8
	NIR	13	10	10	10	10	10	7	7	7
	IE	65	76	76	76	76	76	71	71	71
Wheat	%	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
	NIR	19	14	14	14	14	14	10	10	10
	IE	65	76	76	76	76	76	71	71	71
Beans	%	18.0	18.0	18.0	18.0	18.0	18.0	10.5	4.0	--
	NIR	16	13	13	13	13	13	13	13	--
	IE	70	72	72	72	72	72	72	72	--
Potatoes	%	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
	NIR	21	21	21	21	21	21	21	21	21
	IE	67	67	67	67	67	67	67	67	67
Idle Land	%								5.0	28.2
Water Use	AI/A[d]	27.72	23.84	23.01	22.18	21.34	19.68	17.19	16.93	18.54
Ave. NIR	AI/A[d]	18.61	16.78	16.30	15.82	15.32	14.72	12.11	11.91	13.01
Ave. IE	%	67	70	71	71	72	72	70	70	70
Labor	H/A[d]	2.90	3.33	3.29	3.26	3.23	3.11	2.55	2.54	2.66
Energy Use	KWH/A	1476	1269	1225	1181	1136	1048	915	856	709

a/ Based on total irrigable acreage.
b/ Net irrigation requirement in acre inches per acre.
c/ Irrigation efficiency in percent.
d/ Based on irrigated acreage only.

acre when the water supply was reduced by 14 percent and then declined slightly thereafter as less water was available for irrigation. Again, all crops except potatoes were adjusted in application level and irrigation efficiency as water supplies became more restrictive. Land was idled only when the supply of delivered water had been reduced by more than 40 percent.

a. Short-run Responses to Water Shortage

The response of each remaining farm type to water supply changes is shown in Tables 17-27. For each pump irrigated farm there is a table showing the adjustments with no energy price change and a second table showing adjustments with an energy price adjustment for the use of nonfirm power for market committed water. The relationship between the quantity of delivered water and consumptive use for each farm is shown in Table 13.

The impacts of water shortage on the center pivot irrigated farm using only firm energy at a cost of 30 mills per KWH is shown in Table 17. The price of labor for irrigation was set at $7 per hour. Net revenue per acre, measured as a return to all fixed resources, was $168.78 per acre. The change in net revenue per acre is a measure of the cost of participating in an interruptible water market. A 28 percent reduction in the water supply also reduces total water consumptive use by approximately 25 percent. At this point the net income per acre has been decreased by approximately $13 per acre (8 percent) from the baseline condition. A further reduction of water supply to 51 percent of the full supply level reduces net farm income to $124.02 per acre, 27 percent below the baseline level.

Table 17. Response to Changes in Delivered Water Supply for the Center Pivot Irrigated Farm in Southcentral Idaho, No Energy Price Adjustment.

		Percent Delivered Water Supply Reduction								
Item	Unit	0	13	17	18	21	28	37	43	51
Net Rev.[b]	$/A	168.78	165.28	163.90	163.53	162.22	155.00	144.19	135.89	124.02
Crops										
Alfalfa	%	25.0	25.0	25.0	25.0	25.0	25.0	23.3	20.0	20.0
Barley	%	27.0	27.0	27.0	27.0	27.0	15.9			
Wheat	%	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Beans	%	18.0	18.0	18.0	18.0	18.0	18.0	18.0	13.0	2.2
Potatoes	%	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
Idle Land	%						11.1	28.7	37.0	47.8
Water Use[a]	AI/A	19.48	16.95	16.17	15.97	15.39	15.78	17.21	17.62	18.30
NIR[a]	AI/A	16.21	14.53	13.98	13.82	13.27	13.54	14.68	15.02	15.54
Irr. Eff.	%	83	86	86	87	86	86	85	85	85
Irr. Labor[a]	Hr./A	1.55	1.52	1.51	1.50	1.44	1.43	1.49	1.49	1.46
Energy Use	KWH/A	1834	1595	1522	1503	1448	1320	1154	1045	899

a/ For irrigated land only, not including idle land.
b/ Based on total irrigable acreage.

More of the adjustment for the center pivot farm to declining water supplies is accomplished through changes of irrigated acreage than for other farm types. Barley, being the least profitable crop, is reduced when the water supply is decreased by 28 percent. By the time the water supply has been reduced by 37 percent barley is no longer produced on the center pivot farm and some alfalfa acreage is reduced. Finally bean acreage is decreased as the water supply reaches 43 percent of the normal level. The pumping energy, expressed in kilowatt hours per acre (KWH), is an indication of the total water use by this farm. Since the center pivot farm is already operating at a relatively high level of irrigation efficiency and the lowest practical levels of water application to individual crops under current farming conditions, there are relatively few adjustments available to this farm as the water supply is diminished. Despite the more restrictive conditions on this farm, land would be idled in only about four years out of 51 (8 percent) by the option lease water market. The response to water supply changes for the center pivot irrigated farm using a combination of firm and nonfirm power is shown in Table 18. In this case the energy price was adjusted with the level of participation in the water market. For pumping the 50 percent of water committed to the market a 25 percent reduction in the cost of power was allowed to provide a blend price of 26.3 mills per KWH of energy with a full water supply. When total delivered water was reduced by 50 percent the average price of pumping energy was 30 mills per KWH. With no reduction in the water supply the baseline farm income level to this farm is $175.72 per

Table 18. Response to Changes in Delivered Water Supply for the Center Pivot Irrigated Farm in Southcentral Idaho, with Energy Price Adjustment.

Item	Unit	Percent Delivered Water Supply Reduction								
		0	13	17	18	21	28	37	43	51
Net Rev.[b/]	$/A	175.72	169.71	167.67	167.14	165.37	157.18	145.31	136.43	123.95
Crops										
Alfalfa	%	25.0	25.0	25.0	25.0	25.0	25.0	23.3	20.0	20.0
Barley	%	27.0	27.0	27.0	27.0	27.0	15.9			
Wheat	%	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Beans	%	18.0	18.0	18.0	18.0	18.0	18.0	18.0	13.0	2.2
Potatoes	%	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
Idle Land	%						11.1	28.7	37.0	47.8
Water Use[a/]	AI/A	19.80	16.95	16.17	15.97	15.39	15.78	17.21	17.62	18.30
NIR[a/]	AI/A	16.45	14.53	13.98	13.82	13.27	13.54	14.68	15.02	15.54
Irr. Eff.	%	83	86	86	87	86	86	85	85	85
Irr. Labor[a/]	Hr./A	1.56	1.52	1.51	1.50	1.44	1.43	1.48	1.49	1.46
Energy Use	KWH/A	1864	1595	1522	1503	1448	1320	1155	1045	899

a/ For irrigated land only, not including idle land.
b/ Based on total irrigable acreage.

acre which is about 4 percent greater than for the same farm using only firm power, Table 17. The result of the cheaper power for the center pivot irrigated farm is to use slightly higher levels of water and energy when the water supplies are not restricted. Otherwise, the cropping patterns associated with alternative water supplies are very similar to that for the farm using only firm power. At the 51 percent level of water supply reduction, both farms use power costing 30 mills per KWH and the net income, water use, and other resource input levels are nearly identical for both farms. The changes in net farm income associated with varying levels of water supply are a measure of the marginal value of water for irrigation in this region and an indication of the cost of participating in a water market. However, it is not possible to directly ascertain the participation costs from the information in these tables, since the farm income levels associated with water supplies are not weighted by the probability of interruption. Recall that in a 51-year period there was one each of the water supply conditions with some level of reduction and 43 years with no supply reduction. The results of water market participation for the rill irrigated farms are shown in Tables 19 and 20. The large difference in net farm income between the southeast Idaho farm and the southcentral Idaho farm is primarily due to differences in the allowable crops for production in each region. However, the southcentral rill irrigated farm was also assumed to operate with higher levels of irrigation efficiency and lower requirements for irrigation labor, plus having slightly higher crop yields. All of these factors combine to provide the

Table 19. Response to Changes in Delivered Water Supply for the Rill Irrigated Farm in Southeast Idaho.

		Percent Delivered Water Supply Reduction								
Item	Unit	0	31	35	39	42	50	60	63	69
Net Rev.[b]	$/A	133.82	128.99	127.51	126.00	124.63	120.15	110.58	104.74	92.13
Crops										
Alfalfa	%	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
Pasture	%	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8
Barley	%	41.2	41.2	41.2	41.2	41.2	41.2	41.2	37.9	20.3
Wheat	%	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0
Potatoes	%	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Idle land	%								3.3	20.9
Water Use[a]	AI/A	58.31	40.23	37.90	35.57	33.82	29.15	23.32	22.31	22.86
NIR[a]	AI/A	19.26	17.27	16.79	16.31	16.07	14.47	12.51	11.89	12.11
Irr. Eff.	%	33	43	44	46	48	50	54	53	53
Irr. Labor[a]	Hr./A	4.62	5.33	5.39	5.46	5.69	5.73	5.55	5.31	5.16

[a] For irrigated land only, not including idle land.
[b] Based on total irrigable acreage.

Table 20. Response to Changes in Delivered Water Supply for the Rill Irrigated Farm in Southcentral Idaho.

		Percent Delivered Water Supply Reduction								
Item	Unit	0	25	29	31	35	43	54	58	64
Net Rev.[b/]	$/A	160.22	155.91	154.49	153.76	151.83	146.69	136.21	128.23	112.32
Crops										
Alfalfa	%	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
Pasture	%	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
Barley	%	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	14.1
Wheat	%	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Beans	%	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
Potatoes	%	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Idle Land	%									13.9
Water Use[a/]	AI/A	46.74	35.05	33.19	32.25	30.38	26.64	21.50	19.63	19.55
NIR[a/]	AI/A	17.90	16.35	15.71	15.37	14.74	13.39	11.85	10.68	10.60
Irr. Eff.	%	38	47	47	48	49	50	55	54	54
Irr. Labor[a/]	Hr./A	3.55	4.16	4.09	4.05	3.98	3.92	3.96	3.62	3.42

[a/] For irrigated land only, not including idle land.
[b/] Based on total irrigable acreage.

southcentral Idaho rill irrigated farm with a substantially higher net farm income per acre than the rill irrigated farm in southeast Idaho.

In general, the response to changes in water supply are very similar for the two rill irrigated farms. Both farms substantially increase irrigation efficiency while also increasing the amount of irrigation labor used. The amount of land idled by the southcentral rill irrigated farm is less than that for the southeast Idaho farm though neither farm idles land until the water supply is reduced by more than 60 percent. The profitability of farming in the southeast Idaho region is lower, providing fewer incentives for adjusting to water supplies prior to idling land than for the farm in the southcentral region. Neither of these farms use energy for pumping irrigation water and are, therefore, not affected by assumptions about the cost of energy.

The impact of water supply changes on the sideroll irrigated farm in southeast Idaho using UPL energy is shown in Table 21. This farm, using energy costing $.051 per KWH, responds to changes in water supply very much like those for the sideroll irrigated farm using energy from IPC as shown in Table 22. However, due to the higher energy costs, this farm does have a substantially lower net farm revenue for all water supply levels. The higher energy costs on this farm also result in slightly lower levels of water and energy use than for the sideroll irrigated farm obtaining energy from IPC.

Comparing the information in Tables 22 and 23 provides a measure of the impact of selling nonfirm energy to the sideroll irrigated

Table 21. Response to Changes in Delivered Water Supply for the Zero Lift Sideroll Irrigated Farm in Southeast Idaho Using Utah Power and Light Energy, No Energy Price Adjustment.

		Percent Delivered Water Supply Reduction								
Item	Unit	0	12	15	18	21	29	38	41	51
Net Rev.[b/]	$/A	140.79	137.73	136.15	134.57	132.86	128.29	120.41	116.60	103.85
Crops										
Alfalfa	%	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Pasture	%	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Barley	%	38.0	38.0	38.0	38.0	38.0	38.0	36.0	28.3	2.4
Wheat	%	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Potatoes	%	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
Idle Land	%							2.0	9.7	35.6
Water Use[a/]	AI/A	27.11	23.87	23.05	22.24	21.42	19.26	17.15	17.72	20.64
NIR[a/]	AI/A	17.93	16.03	15.59	15.17	14.69	13.52	11.83	12.19	14.11
Irr. Eff.	%	66	67	68	68	69	70	69	69	68
Irr. Labor[a/]	Hr./A	3.38	3.33	3.33	3.35	3.39	3.61	3.09	3.16	3.51
Energy Use	KWH/A	558	491	475	458	441	397	346	329	274

[a/] For irrigated land only, not including idle land.
[b/] Based on total irrigable acreage.

Table 22. Response to Changes in Delivered Water Supply for the Zero Lift Sideroll Irrigated Farm in Southeast Idaho, Using Idaho Power Company Energy, No Energy Price Adjustment.

		Percent Delivered Water Supply Reduction								
Item	Unit	0	12	15	18	21	29	40	43	53
Net Rev.[b]	$/A	153.43	151.90	151.03	149.94	147.84	142.00	132.90	129.40	114.01
Crops										
Alfalfa	%	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Pasture	%	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Barley	%	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	10.6
Wheat	%	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Potatoes	%	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
Idle Land	%									27.4
Water Use[a]	AI/A	30.10	26.49	25.59	24.68	23.78	21.37	18.06	17.16	19.49
NIR[a]	AI/A	19.47	17.50	16.89	16.44	15.99	14.65	12.69	11.87	13.36
Irr. Eff.	%	65	66	66	67	67	69	70	69	69
Irr. Labor[a]	Hr./A	3.40	3.33	3.26	3.31	3.33	3.38	3.48	3.12	3.37
Energy Use	KWH/A	620	545	526	508	490	440	372	353	291

[a] For irrigated land only, not including idle land.
[b] Based on total irrigable acreage.

Table 23. Response to Changes in Delivered Water Supply for the Zero Lift Sideroll Irrigated Farm in Southeast Idaho Using Idaho Power Company Energy, With Energy Price Adjustment.

		Percent Delivered Water Supply Reduction								
Item	Unit	0	12	15	18	21	29	40	43	53
Net Rev.[b]	$/A	155.76	153.46	152.41	151.17	148.91	142.70	133.18	129.58	113.94
Crops										
Alfalfa	%	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Pasture	%	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Barley	%	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	10.6
Wheat	%	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Potatoes	%	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
Idle Land	%									27.4
Water Use[a]	AI/A	30.10	26.49	25.59	24.68	23.78	21.37	18.06	17.16	19.49
NIR[a]	AI/A	19.47	17.50	16.89	16.44	15.99	14.66	12.69	11.87	13.36
Irr. Eff.	%	65	66	66	67	67	69	70	69	69
Irr. Labor[a]	Hr./A	3.40	3.33	3.26	3.30	3.33	3.38	3.48	3.12	3.36
Energy Use	KWH/A	620	545	527	508	490	440	372	353	291

[a] For irrigated land only, not including idle land.
[b] Based on total irrigable acreage.

farm in southeast Idaho. Recall that this farm is not required to pump water other than for pressurizing the irrigation system. Hence, the advantages associated with lower cost power are relatively slight for this farm. While net farm income is increased slightly, the cropping patterns and resource use levels are nearly identical for these two farms at most water supply levels.

Impacts of delivered water supply changes on the zero lift-sideroll irrigated farm in southcentral Idaho are shown in Tables 24 and 25. Again, due to the low energy requirement for pumping water on this farm there is little advantage to the use of nonfirm power for pumping. There is a slightly higher net income level under the full water supply conditions, but all other values of resource use and cropping pattern are similar for both farms.

Results associated with the sideroll irrigated farm in southcentral Idaho with a 200 foot pump lift are shown in Tables 26 and 27. Due to the higher pump lift requirement for this farm, there is a greater advantage to the use of nonfirm power as shown by comparing the net farm income levels for these two situations. However, other than the net farm income effects there is little difference in the cropping patterns, water use levels, or irrigation efficiencies associated with these two farms.

While the cheaper power will provide a greater incentive for market participation, it affects water, energy, and other resource use only on the very high pump lift farms. It is not clear from this analysis whether the energy cost adjustment for market participation can be justified or is a socially desirable feature of the water

Table 24. Response to Changes in Delivered Water Supply for the Zero Lift Sideroll Irrigated Farm in Southcentral Idaho, No Energy Price Adjustment.

Item	Unit	Percent Delivered Water Supply Reduction								
		0	12	15	18	22	30	40	42	52
Net Rev.[b/]	$/A	166.96	165.07	163.50	161.27	158.14	151.63	141.33	138.44	114.43
Crops										
Alfalfa	%	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
Pasture	%	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
Barley	%	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.6
Wheat	%	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Beans	%	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	
Potatoes	%	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Idle Land	%									17.8
Water Use[a/]	AI/A	28.98	25.50	24.63	23.76	22.60	20.29	17.39	16.81	16.23
NIR[a/]	AI/A	19.17	17.03	16.71	16.32	15.77	14.42	12.27	11.74	11.23
Irr. Eff.	%	66	67	68	69	70	71	71	70	69
Irr. Labor[a/]	Hr./A	2.61	2.51	2.64	2.79	2.94	2.85	2.41	2.24	2.15
Energy Use	KWH/A	691	608	587	566	539	484	414	401	318

[a/] For irrigated land only, not including idle land.
[b/] Based on total irrigable acreage.

Table 25. Response to Changes in Delivered Water Supply for the Zero Lift Irrigated Farm in Southcentral Idaho, With Energy Price Adjustment.

		Percent Delivered Water Supply Reduction								
Item	Unit	0	12	15	18	22	30	40	42	52
Net Rev.[b/]	$/A	169.55	166.80	163.49	162.63	159.28	152.34	141.63	138.69	118.52
Crops										
Alfalfa	%	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
Pasture	%	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
Barley	%	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4	34.3
Wheat	%	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Beans	%	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	
Potatoes	%	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Idle Land	%									12.1
Water Use[a/]	AI/A	28.98	25.50	24.03	23.76	22.60	20.28	17.39	16.81	15.82
NIR[a/]	AI/A	19.17	17.03	16.44	16.32	15.77	14.41	12.27	11.74	10.97
Irr. Eff.	%	66	67	68	69	70	71	71	70	69
Irr. Labor[a/]	Hr./A	2.61	2.51	2.74	2.79	2.94	2.85	2.41	2.24	2.14
Energy Use	KWH/A	691	608	573	566	539	483	414	401	331

a/ For irrigated land only, not including idle land.
b/ Based on total irrigable acreage.

Table 26. Response to Changes in Delivered Water Supply for the 200 Foot Lift Sideroll Irrigated Farm in Southcentral Idaho, No Energy Price Adjustment.

		Percent Delivered Water Supply Reduction								
Item	Unit	0	14	14	20	23	29	38	42	52
Net Rev.[b]	$/A	185.07	180.58	178.98	177.37	175.75	172.22	161.37	154.72	138.05
Crops										
Alfalfa	%	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
Barley	%	27.0	27.0	27.0	27.0	27.0	27.0	34.5	36.0	16.8
Wheat	%	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Beans	%	18.0	18.0	18.0	18.0	18.0	18.0	10.5	4.0	
Potatoes	%	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
Idle Land	%								5.0	28.2
Water Use[a]	AI/A	27.72	23.84	23.01	22.18	21.34	19.68	17.19	16.93	18.54
NIR[a]	AI/A	18.61	16.78	16.30	15.82	15.32	14.22	12.11	11.91	13.01
Irr. Eff.	%	67	70	71	71	72	72	70	70	70
Irr. Labor[a]	Hr./A	2.90	3.33	3.29	3.26	3.23	3.11	2.55	2.54	2.66
Energy Use	KWH/A	1476	1269	1225	1181	1136	1048	915	856	709

[a] For irrigated land only, not including idle land.
[b] Based on total irrigable acreage.

Table 27. Response to Changes in Delivered Water Supply for the 200 Foot Lift Sideroll Irrigated Farm in Southcentral Idaho, With Energy Price Adjustment.

		Percent Delivered Water Supply Reduction								
Item	Unit	0	14	14	20	23	29	38	42	52
Net Rev.[b]	$/A	190.60	184.01	182.01	180.02	178.06	173.88	162.18	155.22	137.92
Crops										
Alfalfa	%	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
Barley	%	27.0	27.0	27.0	27.0	27.0	27.0	34.5	36.0	16.8
Wheat	%	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Beans	%	18.0	18.0	18.0	18.0	18.0	18.0	10.5	3.9	
Potatoes	%	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
Idle Land	%								5.1	28.2
Water Use[a]	AI/A	27.72	23.84	23.01	22.18	21.34	19.68	17.19	16.94	18.54
NIR[a]	AI/A	18.61	16.78	16.30	15.81	15.33	14.23	12.11	11.92	13.01
Irr. Eff.	%	67	70	71	71	72	72	70	70	70
Irr. Labor[a]	Hr./A	2.90	3.33	3.30	3.26	3.23	3.11	2.55	2.54	2.66
Energy Use	KWH/A	1476	1269	1225	1181	1136	1048	915	856	708

[a] For irrigated land only, not including idle land.
[b] Based on total irrigable acreage.

market. Further study will be required to resolve this matter. It is clear, however, that farms with high pump lift requirements will benefit from this reduction in energy costs. More detail on this matter will be provided later.

b. Effects of Long Term Market Participation

There are some conditions of participating in an option lease water market of this nature which need review at this point. It was assumed that no individual farm or group of farms would be asked to market more than 50 percent of current levels of consumptively used water. A farm currently consuming 18 to 20 inches of water per acre could market no more than 9 to 10 inches of water per acre under the most extreme drought conditions. This limitation on market participation is intended to be a protection for the integrity of irrigated agriculture during periods of low streamflow. Agriculture will remain intact over time and third party effects will be minimized under these conditions.

It is assumed that a farmer will always know the water supply for a given year prior to the planting of spring crops. The acreage of perennial crops and fall planted crops would already be committed at the time the water supply is known. However, most spring planted crops can be adjusted to any desirable acreage to accommodate the water supply expected that year. It is expected that a farm committed to the water market will be enrolled for some fixed period of time. In this case, it was assumed that a contract for market participation would prevail for 25 years and the estimated impact on participating farms was based upon that length of time. Given that water supplies can range from a full noninterruptible level to only 50 percent of current consumptive use levels, there is increased uncertainty about farm income under these conditions. While the probability of being interrupted in any given year may be known, the actual supply of water that may be available in any succeeding year is uncertain. The parties to a water market would have to develop an acceptable definition of the conditions under which a water supply would be interrupted for a participating farm. In southern Idaho these conditions are most likely to be defined in terms of snowpack and reservoir content. There could be mandatory predictions being made on, say, February 1, March 1, and April 1, each with increasing degrees of probability and the latter being the last date of decision. Using these defined trigger conditions, it is assumed that a farmer would always know his minimum water supply for a growing season prior to committing any resources to spring planted crops.

To illustrate the uncertainty associated with water market participation, the long run market simulator was run for a 25 year period 30 consecutive times. The results of market participation over the 25 year period are shown for the 30 different draws in Table 28. The numbers in this table indicate the level of reduction in the consumptive use water supply. A number 1 indicates no interruption of the water supply while a number 9 indicates a 50 percent level of reduction in the consumptive use water supply.The percentage reductions associated with these indices are only approximate because they are not exactly the same for each farm.

Table 28. Random Draws for Market Participation over a 25-Year Period.

Draw	Year																								
No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	5	1	1	2	1	1	1	2	1	1	1	7	1	1	1	1	5	1	1	1	1	1	1	5	1
2	1	7	1	5	1	1	1	1	1	2	1	6	1	1	1	1	1	1	1	1	1	1	1	1	1
3	6	1	1	1	1	1	1	1	8	1	1	8	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	6	9	1	7	1	1	1	1	1	1	3	1	6	1	4	4	1	1	1	1	4
5	1	1	1	1	1	1	6	1	1	1	9	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	3	1	6	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	4	9	1	8	1	1	1	4	1	1	1	1	1	1	1	1
8	1	8	1	1	1	7	1	1	1	8	1	1	8	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	5	1	1	1	1	1	5	6	1	1	1	7
10	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1	8	3	1	1	2	1	1	1	1	2
11	9	1	5	1	1	7	1	1	1	1	1	1	1	4	1	1	1	6	1	1	1	1	1	1	1
12	7	1	1	1	1	1	1	2	1	1	1	2	8	1	1	1	1	5	1	1	3	1	9	1	1
13	1	1	2	1	1	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	8	7	1	7	7	1	1	1	5	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	6	1	1	1	1	1	1	1	1	7	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	3	1	1	1	1	3	1	9
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	8
18	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	7	1	1
19	1	1	1	1	1	1	7	1	7	7	1	8	1	1	1	4	1	1	1	5	1	1	6	1	1
20	1	1	1	1	1	8	1	1	5	1	1	1	1	1	9	1	1	1	1	1	1	1	1	9	1
21	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	6	1	1	1	9	1	1	1	1
22	1	9	1	1	1	1	6	1	1	1	1	1	6	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	6	1	1	1	1	1	1	3	1	1	1	1	3	1
24	1	6	1	1	1	1	1	1	5	1	1	1	1	1	1	1	1	1	1	1	1	1	4	1	7
25	1	1	1	1	1	1	1	1	1	1	1	1	1	5	1	9	1	1	1	5	1	1	2	1	1
26	1	1	1	1	1	1	4	1	1	1	1	4	1	1	1	1	1	1	1	1	1	1	1	1	1
27	3	1	1	1	1	4	1	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	4	1	1	1	1	1	1	1	1	1	4	1	6	1	1	1	8	1	1	1	1
29	8	1	1	4	1	1	1	1	1	5	1	1	1	1	1	2	1	1	5	8	1	1	1	4	1
30	1	1	1	1	1	1	1	1	1	1	1	1	9	1	5	1	1	1	2	1	1	1	1	1	1

[a] Numbers represent reduction in water consumptive use. 1 = zero, 2 = 10%, 3 = 13%, 4 = 15%, 5 = 18%, 6 = 25%, 7 = 35%, 8 = 40%, and 9 = 50%.

While the expected value for the parameters associated with market participation would be the same under all conditions, the actual outcomes can vary widely. For the 30 different draws shown in this example, there are several possible levels of impact that could be imposed on a market participator. For example, in draw 17 a participant would have the first 24 years with no water supply interruption. Others, like draw number 14, begins with 4 consecutive years with no supply interruption followed by 4 out of the next 5 years with 35 percent and 40 percent supply reductions. Draw numbers 11 and 29 begin the first year with a 50 percent supply reduction. Using a concept of present value for income expectation over the period of market participation, the impact of the water supply condition in early years has a large effect on the long term desirability of participating in the market. Also, the range of outcomes that can be expected will partially determine the type and amount of compensation that would be required for farms in a water market.

Each farm was run through the 25 year participation period 30 different times as shown by the draws in Table 28. The stream of income over each 25 year period was discounted to a present value using two real discount rates (RDR), 3 percent and 6 percent. These discount rates are expected to bracket any real discount rates that could be used by borrowers or lenders in today´s world for determining the impacts of the long range planning program. Of course, the 3 percent discount rate will provide a higher present value estimate than will the 6 percent discount rate. The distribution of present value outcomes for each farm discounted at the two rates is shown in Table 29.

The first two columns of Table 29 are the present value incomes for the center pivot farm receiving IPC energy with no price adjustment for market participation. The first column represents the 3 percent discount rate and the second column represents the 6 percent discount rate. It may be noted that draw number 4, with no interruption until the fifth year but then interrupted three of the next four years and five more times before the end of the 25 year period, has the lowest present value income for any of the 30 random observations. Similarly, draw number 17, which begins with a 24 year grace period with no interruptions of water supply, has the highest present value of net farm income. The same random draws were used to calculate the income for every farm so that it is possible to compare the outcomes among farms. The same draw (number 4) will provide the lowest present value of net farm income for every farm under each discount rate. Similarly draw number 17 will provide the highest present value of net farm income for all farms.

Note in Table 29 that the range of present value outcomes for each farm is relatively small. This is illustrated more clearly in Table 30 where the minimum, maximum, and average outcomes for each farm are presented for the 30 replications shown in Table 29. The first set of data shown in the Table 30 summarizes the average annual net farm income for participating and nonparticipating farms. For example, the centerpivot farm in southcentral Idaho (CP-SC) would have an average net farm income of $169 per acre if not participating

Table 29. Distribution of Present Value Outcomes for each Farm for a 25 Year Period Discounted at 3 Percent and 6 Percent Rates.

Representative Farm and Discount Rate[a]

	CP-SC		CPE-SC		Rill-SE		Rill-SC		SR-SEU		SR-SEI		SRE-SEI		SRL-SC		SRLE-SC		SRH-SC		SRHE-SC	
	3%	6%	3%	6%	3%	6%	3%	6%	3%	6%	3%	6%	3%	6%	3%	6%	3%	6%	3%	6%	3%	6%
	(dollars per acre)																					
1	2902	2130	3007	2206	2287	1678	2749	2017	2416	1773	2643	1940	2678	1966	2868	2105	2907	2134	3179	2333	3262	2393
2	2898	2122	3005	2198	2287	1673	2747	2011	2414	1767	2638	1932	2674	1958	2863	2096	2903	2124	3180	2328	3264	2389
3	2877	2109	2984	2186	2274	1666	2730	2001	2404	1762	2625	1924	2661	1950	2851	2089	2890	2118	3166	2321	3251	2382
4	2850	2089	2946	2159	2240	1642	2697	1976	2373	1740	2599	1904	2631	1927	2809	2058	2847	2086	3129	2294	3205	2350
5	2895	2125	3007	2207	2289	1680	2744	2014	2415	1772	2634	1933	2671	1960	2857	2096	2902	2129	3178	2333	3267	2398
6	2911	2134	3021	2213	2301	1686	2762	2024	2426	1778	2650	1943	2687	1970	2878	2109	2918	2138	3195	2342	3283	2405
7	2877	2114	2984	2193	2270	1668	2725	2002	2400	1763	2622	1926	2658	1953	2842	2088	2885	2120	3158	2320	3243	2382
8	2841	2077	2941	2150	2242	1639	2694	1970	2377	1739	2598	1901	2631	1925	2818	2062	2856	2089	3131	2291	3211	2349
9	2912	2143	3023	2226	2301	1694	2761	2032	2426	1785	2649	1949	2686	1977	2876	2117	2917	2148	3193	2349	3281	2416
10	2907	2137	3017	2217	2297	1689	2757	2026	2426	1783	2651	1948	2688	1975	2882	2118	2921	2146	3190	2344	3277	2408
11	2857	2085	2958	2157	2249	1639	2703	1971	2380	1737	2602	1899	2636	1923	2814	2051	2855	2082	3136	2289	3216	2346
12	2858	2100	2958	2173	2251	1654	2706	1988	2385	1752	2609	1916	2642	1941	2827	2077	2865	2105	3140	2307	3219	2365
13	2924	2145	3039	2228	2314	1697	2775	2035	2438	1788	2661	1952	2699	1980	2893	2122	2935	2153	3208	2353	3299	2419
14	2847	2083	2946	2154	2243	1640	2699	1974	2377	1739	2598	1901	2631	1925	2815	2060	2852	2086	3133	2293	3212	2350
15	2915	2143	3030	2227	2307	1696	2767	2034	2431	1787	2652	1949	2690	1977	2882	2118	2925	2150	3200	2352	3291	2419
16	2909	2142	3021	2226	2299	1694	2757	2031	2426	1786	2649	1950	2686	1978	2876	2119	2917	2149	3190	2349	3279	2415
17	2937	2156	3056	2244	2327	1709	2787	2047	2449	1799	2671	1961	2711	1990	2906	2134	2949	2166	3220	2364	3315	2435
18	2922	2147	3037	2231	2312	1699	2772	2036	2437	1790	2659	1954	2698	1982	2891	2124	2932	2154	3205	2354	3296	2421
19	2845	2089	2941	2160	2239	1645	2696	1980	2373	1743	2596	1906	2628	1930	2812	2065	2847	2091	3130	2298	3206	2355
20	2856	2101	2960	2178	2252	1657	2702	1989	2383	1753	2603	1915	2638	1941	2817	2074	2861	2106	3137	2308	3220	2369
21	2904	2138	3017	2221	2296	1691	2753	2027	2422	1783	2643	1945	2680	1973	2868	2112	2913	2145	3186	2345	3276	2412
22	2876	2102	2983	2179	2271	1658	2725	1990	2398	1753	2617	1913	2653	1939	2835	2070	2879	2102	3159	2309	3244	2371
23	2924	2148	3038	2232	2314	1700	2774	2038	2438	1791	2661	1954	2699	1983	2893	2125	2934	2155	3207	2356	3298	2423
24	2907	2134	3016	2214	2295	1686	2756	2024	2421	1778	2645	1942	2682	1969	2871	2108	2911	2138	3188	2341	3275	2405
25	2901	2134	3012	2217	2291	1686	2748	2022	2417	1778	2640	1941	2677	1969	2863	2106	2907	2139	3180	2339	3268	2405
26	2931	2151	3047	2236	2318	1702	2780	2041	2442	1793	2666	1957	2705	1986	2899	2128	2942	2159	3211	2357	3303	2424
27	2925	2145	3037	2226	2310	1693	2772	2033	2436	1786	2662	1953	2700	1980	2892	2121	2933	2150	3203	2349	3292	2413
28	2905	2137	3015	2218	2295	1688	2755	2026	2422	1781	2647	1946	2683	1973	2874	2114	2915	2144	3187	2343	3274	2408
29	2871	2104	2971	2176	2260	1656	2719	1992	2394	1755	2622	1922	2656	1947	2843	2084	2881	2111	3151	2310	3230	2367
30	2902	2133	3015	2216	2293	1686	2749	2021	2420	1778	2640	1940	2678	1968	2865	2105	2909	2138	3182	2338	3271	2404

[a] Farm types are: Rill-Southeast Idaho (RILL-SE); Sideroll-Southeast Idaho-Idaho Power Company (SR-SEI); Sideroll-Southeast Idaho-Utah Power & Light (SR-SEU); Rill-Southcentral Idaho (RILL-SC); Sideroll-Zero Lift-Southcentral Idaho (SRL-SC); Sideroll-200 foot lift-Southcentral Idaho (SRH-SC); Centerpivot-500 foot lift-Southcentral Idaho (CP-SC).

Table 30. Effect of Water Option Market Participation on Income from Irrigated Farming

	Annual Income					Present Value of Farm Income[b] 3% RDR				Present Value of Farm Income[b] 6% RDR			
		With Program					With Program				With Program		
Farm[a]	W/O Program	Max	Min	Ave	Ave Loss	W/O Program	Ave	Max Loss	Ave Loss	W/O Program	Ave	Max Loss	Ave Loss
					(dollars per acre)[c]								
1. CP-SC	169	169	124	166	2.59	2939	2893	98	46	2158	2123	80	34
2. CPE-SC	169	176	124	172	(3.63)	2939	3001	(2)	(62)	2158	2202	8	(45)
3. Rill-SE	134	134	92	131	2.60	2330	2284	91	46	1711	1676	72	34
4. Rill-SC	160	160	112	158	2.70	2790	2742	96	48	2048	2012	78	36
5. SR-SEU	141	141	104	139	2.22	2452	2412	79	39	1800	1770	63	29
6. SR-SEI	153	153	114	151	2.06	2672	2635	76	37	1961	1934	62	27
7. SRE-SEI	153	156	114	153	(0.03)	2672	2671	44	0	1961	1960	38	1
8. SRL-SC	167	167	114	164	2.70	2907	2859	98	48	2134	2098	83	36
9. SRLE-SC	167	170	119	167	0.35	2907	2900	60	7	2134	2128	52	6
10.SRH-SC	185	185	138	182	2.69	3223	3175	93	48	2366	2330	77	36
11.SRHE-SC	185	191	138	187	(2.25)	3223	3261	17	(38)	2366	2393	20	(27)

[a] Farm types are: Rill-Southeast Idaho (RILL-SE); Sideroll-Southeast Idaho-Idaho Power Company (SR-SEI); Sideroll-Southeast Idaho-Utah Power & Light (SR-SEU); Rill-Southcentral Idaho (RILL-SC); Sideroll-Zero Lift-Southcentral Idaho (SRL-SC); Sideroll-200 foot lift-Southcentral Idaho (SRH-SC); Centerpivot-500 foot lift-Southcentral Idaho (CP-SC).

[b] Present value calculations at 3 percent and 6 percent real discount rates (RDR) are based on a 25 year period and averaged over 30 replications.

[c] Values in parenthesis represent a net gain in income over the base farm condition.

in a water market. The average net farm income for the participant farm over 25 years and 30 replications is $166 per acre, with an actual difference of $2.59 per acre. However, over this time period net income could range from $124 to $169 per acre. The water supply interruptions are infrequent, however, and agriculture is relatively undisturbed over time by participating in the water market.

Table 30 also shows the present value of net farm income for each representative participant and nonparticipant farm. It was assumed that a nonparticipating farm would have no reduction in energy cost like that of some participating farms. The average net loss for participating in the water market is calculated by subtracting the mean outcome for each farm from the estimated present value income for a counterpart nonparticipating farm. For a discount rate of 3 percent, the effects range from a present value average loss of $48 per acre for three farm types (RILL-SE, SRL-SC, and SRH-SC) to a present value average gain of $62 for the center pivot farm which receives a reduction in energy cost for market participation. The high-lift sideroll irrigated farm in southcentral Idaho also benefits from the energy price break associated with market participation. Such a farm would receive a long range benefit from the energy price reduction which exceeded the farm income losses from water supply reductions associated with the water market. These farms would be better off for market participation due to the energy price break even if they received no compensation for reductions in water loss. Of course, changes in the value of crops produced or the costs of other inputs could alter these results. In any case, the average necessary compensation scheme would require a present value in excess of the average net loss shown in this table.

Since many farmers would wish to be guaranteed of having no losses under the most extreme conditions of market participation, the maximum net loss that might be incurred is also shown in Table 30. Again, at the 3 percent discount rate, the center pivot farm would be a net beneficiary of the energy price break even if no compensation was paid. Representative farms would have maximum present value effects ranging from a net gain of $2 per acre for the center pivot irrigated farm benefiting from an energy price reduction to a loss of $98 per acre for the center pivot irrigated farm without an energy price reduction. The average and maximum losses in net farm income shown in Table 30 represent a range of possible values that would have to be covered by a minimum compensation scheme through the water market.

Perhaps the most meaningful information in Table 30 for a farmer considering market participation is the average annual loss in dollars per acre. While three farm types would actually have small net gains in annual returns to fixed factors, other farm types would experience average annual net farm income losses of about $2.50 per acre.

The distribution of possible present value outcomes for each farm discounted at the 6 percent rate are also shown in Table 30. The higher discount rate provides lower estimates of present value income in all cases and, therefore, lower estimates of net losses from market participation. The relative magnitudes of loss among farms is similar to that shown for the 3 percent discount rate.

c. Water Quantities for Market Exchange

Recall that the maximum quantity of water that can be marketed by any individual farm under the assumptions of this study is approximately 50 percent of present consumptive use level. The exact quantity and timing of water which would be sacrificed under this type of market is an unknown to all parties of the market exchange. The only parameters that are known are those associated with the distribution of long-run stream flow conditions and the level of water commitment to the market by an individual farm. The amount given up under each of the defined stream flow conditions determines the value of the power which may be produced by this water market.

The maximum changes in water delivery and consumptive use for market participants are shown in Table 31. The maximum changes in delivered water would be as low as approximately 10 acre-inches per acre for the center pivot irrigated farms and as high as 40 acre-inches per acre for the rill irrigated farm in southeastern Idaho. Each of the sideroll farms would sacrifice a maximum reduction in delivered water supply of 14 acre-inches per acre under the most extreme stream flow conditions. The maximum sacrifices of water consumptive use by each farm are much more similar than for the changes in water delivery. The maximum quantities of water consumptive use range from approximately 8 inches for the center pivot irrigated farms to nearly 9.8 inches per acre for the sideroll irrigated farms in southeast Idaho. These quantities represent approximately 50 percent of the present consumptive use levels for farms in this region. These quantities of change in consumptive use

Table 31. Effect of Water Option Market Participation on Water Use and Value of Hydropower Production

Farm[a]	Water Delivery Max	Water Delivery Min	Water Delivery Diff	Consumptive Use Max	Consumptive Use Min	Consumptive Use Diff	Consumptive Use Ave Reduc	Idaho Power kwh Per ac-ft	Value of Hydropower Production: Individual Year Max	Individual Year Min	Individual Year Ave	Pres Value 3% /acre	Pres Value 3% /ac ft	Pres Value 6% /acre	Pres Value 6% /ac ft
	(acre inches per acre)							(kwh)	(dollars per acre)			(dollars)			
1. CP-SC	19.48	9.55	9.93	16.21	8.11	8.10	0.662	1119	43	22	23	409	606	301	446
2. CPE-SC	19.80	9.55	10.25	16.45	8.11	8.34	0.700	1119	44	22	24	422	607	310	446
3. Rill-SE	58.31	18.08	40.23	19.26	9.58	9.68	0.769	1264	58	29	32	551	683	405	502
4. Rill-SC	46.74	16.83	29.91	17.90	9.13	8.77	0.702	1119	46	24	25	442	605	325	445
5. SR-SEU	27.11	13.29	13.82	17.93	9.09	8.84	0.716	1264	53	27	29	504	684	371	503
6. SR-SEI	30.10	14.15	15.95	19.47	9.70	9.77	0.779	1264	58	30	32	556	683	409	502
7. SRE-SEI	30.10	14.15	15.95	19.47	9.70	9.77	0.779	1264	58	30	32	556	683	409	502
8. SRL-SC	28.98	13.34	15.64	19.17	9.23	9.94	0.774	1119	52	27	29	500	604	368	444
9. SRLE-SC	28.98	13.91	15.07	19.17	9.64	9.53	0.770	1119	50	26	28	481	606	353	445
10.SRH-SC	27.72	13.31	14.41	18.61	9.34	9.27	0.733	1119	49	25	27	467	605	343	444
11.SRHE-SC	27.72	13.31	14.41	18.61	9.34	9.27	0.732	1119	49	25	27	467	605	343	444

[a] Farm types are: Rill-Southeast Idaho (RILL-SE); Sideroll-Southeast Idaho-Idaho Power Company (SR-SEI); Sideroll-Southeast Idaho-Utah Power & Light (SR-SEU); Rill-Southcentral Idaho (RILL-SC); Sideroll-Zero Lift-Southcentral Idaho (SRL-SC); Sideroll-200 foot lift-Southcentral Idaho (SRH-SC); Centerpivot-500 foot lift-Southcentral Idaho (CP-SC).

levels represent the amount of water which would be available to produce firm hydropower in the most extreme low stream flow condition.

It is instructive to note that while the maximum losses in water consumptive use range from 8 to 10 acre inches per acre for participating farms, the average loss over time is about 0.75 acre inches per acre. This average quantity of water loss is to be compared with the average annual net income losses shown in Table 30.

While the major focus of this study has been upon the changes in consumptive use and the value of this water, the much larger changes in stream diversion may have a value of their own. It is possible that operating this market in conjunction with a market for stored water could help to reshape stream flows in a beneficial manner and create values in addition to the stream flow changes caused by decreased consumptive use.

Given the hydrology of the upper Snake, there may even be some hydropower benefits from a transaction that only changes diversion quantity, leaving consumptive use unchanged. In an area where diversions approach 10 acre-feet per acre or more, much of the excess diversion percolates to the aquifer and returns to the river with a time lag of weeks or months. Reducing diversions would leave more water in the river in the irrigation season, and reduce streamflow later because of less aquifer to river springflow. This could allow IPC to better meet its summer peak loads. This study has not examined these questions, however.

C. Hydropower Value of Marketed Water

This analysis of an interruptible water market has shown the estimated direct agricultural losses that would be incurred by participating farms. Any compensation scheme for market participation would have to reward farmers at least as much as their average (expected) losses in net farm income. Many farmers would expect to be compensated for their maximum net losses in farm income. It probably will not be necessary to dispute this matter, however, since the increased value of power produced due to the existence of an interruptible water market generally exceeds the maximum net losses from participation. It is apparent that the sacrifice for market participation is greater for some farms than for others. Hence, it is not expected that all farm types will participate equally in a water market. Those with the greatest advantage (smallest revenue losses) should participate at a higher rate than farms with larger values for on-farm water use.

The purpose of an interruptible water market would be to convert nonfirm power to firm power. A previous section of this report has shown that the difference between the values of firm and nonfirm power contracted for a 25 year period from the present would be 14.6 mills/KWH and for power contracted 35 years into the future the difference would be 28.8 mills/KWH. The farther in the future the analysis goes, the greater is the value of the firm power relative to the nonfirm power.

In this analysis, the calculation of farm income losses are made for a 25 year period. However, since a water market is unlikely to be implemented for at least another 10 to 15 years, the 25 year planning period will extend well into the time period when the difference in value between firm and nonfirm power will be in the vicinity of 28.8M/KWH. Hence, the higher values of marketed water are probably most appropriate for comparison with the foregone values of water used in agriculture.

It was also shown that an acre-foot of water in southeast Idaho has the potential of producing 1,264 KWH in the IPC system or 1,882 KWH including the BPA system.

It was shown above that the maximum reduction in consumptive use per acre would be about 0.75 acre-feet per acre of cropland. Hence, each acre of irrigated land committed to a water market would create about 75 percent of the above values in increased energy production. Alternatively, about 1.3 acres of land would be required to provide one acre-foot of water for energy production under these assumptions.

The estimates of hydropower value created by water marketed from each farm is shown in Table 31. In any individual year there is a minimum and maximum value that can be created from this water. The minimum value is created in a year when no water supply deficit occurs. In such a year the increment of water committed to the market from one acre, say 8 acre inches for the centerpivot farms, will create a value equal to the difference between firm and nonfirm power, $23 in this case. This is the result of shifting the firm load power curve upward as shown in Figure 1.

The maximum value that can be created from the market committed water is in a year of maximum water supply deficit when the increment of power created has a firm load value. In the example of the centerpivot farm, this value is approximately $43 per acre. The value of power created by a unit of marketed water in southeast Idaho is a bit greater than in southcentral Idaho. This is best illustrated by the column showing KWH per acre-foot of water for each farm type.

The last set of data shown in Table 31 is the estimated present value of marketed water per acre-foot and per acre of land over a 25 year period for discount rates of 3 and 6 percent. The center pivot farm (CP-SC) would create a present value of energy over this period of $409 per acre or $606 per acre-foot of water committed to the market (3 percent discount rate). Estimates of value at the 6 percent discount rate are about 25 percent lower. But the estimates of farm income loss at the higher discount rate are also proportionately lower as shown in Table 30.

In any case, the estimates of the present value of farm income effects from market participation (3 percent discount rate) range from an actual net gain for some farms if electricity costs are reduced to an average loss of $48 per acre for three farms in southcentral Idaho as shown in Table 30. These average farm income losses are to be compared with the potential gains in power value shown in Table 31. For example, the center pivot farm without an energy price break will have an average present value loss (3 percent discount rate) in net farm income over 25 years of $46 per acre. The comparable gain in the present value of power created from this acre of cropland is $409, nearly a ten-fold difference. There is more than adequate value created from energy produced through the water market to compensate farmers for their farm income losses. It is not clear how this difference should be divided between participating farmers and energy consumers, but it should be possible to leave all parties to the water market better off with the market than without it.

In any case, it would appear that even under very conservative assumptions, the value of power created by an interruptible water market will far exceed the forgone costs to agriculture. By concentrating the water markets in those sectors of agriculture with the greatest advantage for participation, it should be possible to compensate agriculture considerably more than the amount of lost farm income. The exact level of compensation cannot be determined by this analysis. It is not clear how the difference between agricultural income losses and the value of power created by a water market should be divided among the participants. Definitely all market participants should be made better off by the existence of a market. That would appear to be possible from the evidence of this study.

D. A Land Retirement Plan

Questions have arisen about the possibility of having participating farmers reduce irrigated acreage proportionate to the change in water supply rather than allow other managerial adjustments in irrigation as suggested by the above analysis. An estimate of farm income losses under this scenario has been developed and presented in Table 32. In this case, it was assumed that farm income

Table 32. Effect of Water Option Market Participation on Income from Irrigated Farming Assuming Acreage Adjustment Only

	Annual Income					Present Value of Farm Income 3% RDR			Present Value of Farm Income 6% RDR		
		With Program					With Program			With Program	
Farm[a]	W/O Program	Max	Min	Ave	Ave Loss	W/O Program	Max Loss	Ave Loss	W/O Program	Max Loss	Ave Loss
	(dollars per acre)										
1. CP-SC	169	169	84	162	6.89	2939	243	122	2158	182	91
2. CPE-SC	169	176	87	168	0.54	2939	140	12	2158	106	10
3. Rill-SE	134	134	67	128	5.34	2330	189	95	1711	141	71
4. Rill-SC	160	160	82	154	6.28	2790	221	111	2048	166	83
5. SR-SEU	141	141	71	135	5.62	2452	199	100	1800	148	74
6. SR-SEI	153	153	76	147	6.14	2672	215	109	1961	160	81
7. SRE-SEI	153	156	78	150	3.90	2672	178	70	1961	133	53
8. SRL-SC	167	167	80	160	6.74	2907	238	120	2134	178	89
9. SRLE-SC	167	170	85	163	4.22	2907	196	76	2134	148	57
10.SRH-SC	185	185	93	178	7.29	3223	259	129	2366	194	96
11.SRHE-SC	185	191	96	183	1.97	3223	170	37	2366	129	28

[a] Farm types are: Rill-Southeast Idaho (RILL-SE); Sideroll-Southeast Idaho-Idaho Power Company (SR-SEI); Sideroll-Southeast Idaho-Utah Power & Light (SR-SEU); Rill-Southcentral Idaho (RILL-SC); Sideroll-Zero Lift-Southcentral Idaho (SRL-SC); Sideroll-200 foot lift-Southcentral Idaho (SRH-SC); Centerpivot-500 foot lift-Southcentral Idaho (CP-SC).

would be reduced proportionate to acreage reduction. Implicit in this approach is the assumption that the acreage of each crop would have to be reduced proportionately. Under these assumptions, the present value of farm income losses would be considerably greater than those presented in Table 30.

These estimates of income loss under an acreage reduction program are an upper limit of the farm income effects that should be expected. Actually, farmers would never reduce the acreage of all crops proportionately, but would first reduce the acreage of crops with the lowest marketing returns per unit of water, the scarce resource. This crop may require large amounts of water per acre (e.g., alfalfa) or small amounts of water per acre (e.g., barley) and the result would depend upon the relative profitability of such crops.

It should be emphasized that the authors of this report do not believe that a mandatory acreage reduction program would be a good option to follow. For reasons cited above, the administration of such a program would be at least as difficult as the one proposed in this report. To create rules for obtaining a specific quantity of water would be quite difficult. Moreover, the efficiency of water use in agriculture would be reduced due to the removal of some managerial options under a water shortage.

E. Some Cautions About Model Validity

The linear programming models developed for the representative farms in southern Idaho are believed to provide a good picture of how a farm would react to changing water supplies and how farm income would be affected in the long run by an interruptible water market. However, it is clear that there are many underlying assumptions associated with the input data used in this analysis that affect the results. Changes in assumptions regarding crop yields, cropping patterns, costs of production, prices received, and levels of irrigation management will each affect the outcome. However, the range in farm types, the alternative assumptions regarding energy cost, and the different discount rates used for estimating present values of net farm income do bracket a large range of possible outcomes. It is believed that a relatively accurate picture of the value of such a market can be obtained from these results. The most difficult problem associated with this analysis is anticipating the farm management response to changing water supplies. The approach used here provided a number of alternatives for applying different quantities of water at different levels of irrigation efficiency to obtain alternative yields for each crop. The accuracy of the data associated with these alternative irrigation schemes is relatively doubtful. This is an area in which agricultural engineers, agronomists, and economists should concentrate research in future years.

F. Compensation Schemes

The previous sections have established that sufficient value of energy may be created by a water market to adequately compensate the agricultural sector for any losses in net farm income. It was shown that the average present value of farm income impacts ranged from a net gain of $62 to a loss of $48 per acre at a 3% real discount rate.

The income losses can be incurred in many ways, however. The participating farmer may have no losses for several years after entering a market or the losses may be incurred in the early years of participation. Given the wide range of possible ways that the farm income losses may affect farmers, it is not clear what method of compensation is best. In fact, it is most likely that no single scheme is best for all farmers. The compensation methods could range from a lump sum payment provided at the very beginning of the market period to an annuity that is paid annually over the entire market period. The scheme most likely to be agreeable to all market participants is one that combines these extreme possibilities. A small annuity paid every year to farmers to offset average expected losses from market participation could be combined with lump sum payments in years of water supply interruption. In this way farmers would always be assured of adequate compensation but neither party to the market would be required to anticipate the number and severity of water interruptions over any market period.

A long term market period, say 25 or 35 years, would present many uncertainties to all parties. Inflation, crop prices, costs of agricultural production, farming technology, and the value of energy are examples of factors which could vary and affect the position of market participants. Hence, a long term contract would necessarily have to deal with these factors. The combination of an annuity with lump sum payments in years of water supply interruption would provide the maximum flexibility for dealing with these uncertainties. Research will have to be undertaken to discover the best ways to deal with these uncertainties.

Also, the characteristics of the farm itself would influence the choice of payment method. Age of the farmer, farm debt, family size, nonfarm income, size of farm, off-farm employment, method of irrigation, and crops produced would each affect the ability and desirability of the farm to deal with the uncertainties of a water market. Most farmers would desire for the market compensation scheme to reduce the risk of farming and the uncertainties of long-run net farm income.

In any case, it does appear that a water market developed under the conditions of this analysis would be feasible and financially rewarding. Since the market will not be needed until near the end of this century when its value will be increased over current levels, there is time to do the research and planning necessary for its proper implementation.

CHAPTER IV

MARKETING OF STORED WATER

The Water Bank has served as a market for surplus storage water for a number of years. Some observers argue that efforts to move in the direction of water markets should concentrate first on an expanded market for stored water, because such markets might be more familiar, simpler to operate, and less controversial than the kinds of markets discussed above. The hydrology of infrequently used storage water certainly makes it easier to manage than flow water. It is easily identified, quantified, and controlled. Since it is now rarely used, its use would involve few third party effects: no one is relying on wasteful use of this water to provide their own water supply.

A. How the Idaho Water Bank Works

The Water Bank serves as a clearinghouse, bringing together buyers and sellers of stored water. Early in the irrigation season, some water users decide that they have rights to more water than they will need. They then "deposit" this water with the Water Bank. Other users may decide that they will be short of water and arrange to "wthdraw" water to meet their needs. The water users that participate in the Water Bank may be water districts, municipalities, canal companies, or in some cases individuals.

The Water Bank is not a true free market. The price is set administratively at $2.50 per acre-foot, including a $.50 per acre-foot fee charged by the District 1 Watermaster to cover administrative costs. The $2.50 per acre-foot price is intended to cover the maintenance, operation and repayment obligations of the owners of the storage space rights. The "no profit" rule (which constrains spaceholder profits above operation, maintenance, and repayment costs) presently being imposed by the Bureau of Reclamation restricts the price to this low level, rather than a price determined by the market forces of water supply and demand. Only single-season water rental transactions are handled by the bank. Transactions are prioritized so that water goes to owners of storage rights first, then to other irrigators needing supplemental water, and only then to other beneficial users. Because they limit benefits received by a water depositor, these restrictions on prices appear to have held down participation in the Water Bank. There are proposals within the Bureau of Reclamation to relax the no-profit rule, a measure that could allow water prices to rise, and make storage water markets more attractive to sellers.

B. Possibility of Expanding the Market for Stored Water

Table 33 presents information on operation of the Water Bank in recent years. The bank has served as the intermediary for water transactions averaging 205,794 acre-feet over the period from 1979 to 1985. Activity peaked in 1985, when 362,169 acre-feet were sold by the bank. Some of the Water Bank water did go to farmers in need of supplemental irrigation water, but by far the largest purchaser from the Water Bank was IPC. The IPC purchases averaged 194,286 acre-feet for those seven years, and reached a maximum of 350,000 acre-feet in 1983 and 1985. In all years, some of the water deposited with the bank did not find a buyer, not surprising since none of these have been years of severe drought.

Table 33. Storage Carry-Over and Water Bank Activity for the Upper Snake, 1979-82.

Year	End of Season Carry-Over	Water Bank Space Yield	Water Bank Purchases	Purchase By Idaho Power	Price Per Acre-Foot
		(acre-feet)			(dollars)
1979	1,512,386	88,248	73,960	60,000	
1980	2,265,674	71,570	14,575	0	
1981	1,121,042	167,718	149,039	125,000	2.50
1982	3,097,684	288,702	210,385	200,000	2.30
1983		540,000	353,000	350,000	2.40
1984		781,065	277,433	275,000	2.50
1985		497,362	362,169	350,000	2.50
Average		347,809	205,794	176,446	

Source: District 1 Watermaster's Annual Reports.

How much bigger could the market for storage water grow? A principal impetus for the storage water market is the historic policy of the Bureau of Reclamation that encouraged many water users to acquire more storage water rights than they now need. In some cases additional storage water was acquired as additional insurance against shortage that might occur in an extremely dry year. In some cases improvements in irrigation systems reduced water requirements to a level that makes additional storage rights unnecessary. In some cases large blocks of storage water are rarely, if ever, used. End of season carryover averaged about 2 million acre-feet for the four years from 1979 through 1982. It is rare for carryover to go below 1 million acre-feet. Presently this water stays in storage as security against prolonged extreme drought, but if the reward were sufficient, more of this stored water might be marketed, benefitting both buyer and seller. Clearly, the amount of water regularly remaining in storage indicates that there may be a potential to expand the market for stored water several times beyond the scale of the present Water Bank. Quantifying how much expansion is possible would require a detailed river operations study, a task beyond the scope of this research project.

C. Value of this Stored Water for Power Generation

Water in storage in the upper Snake has potential value to both the water users that are potential sellers and to other irrigators and IPC who would be potential buyers. Because there are large blocks of storage water that are rarely used, it appears that the value to the farmers and irrigation districts that presently own this water must be very low.

There may, in some years, be irrigators with inadequate water supplies or junior water rights, who would be willing to pay a substantial price to augment their water. If a shortage occurs late in the year when much of the investment of growing the crop has already been made, supplemental water from a Water Bank may have a very high value. While such irrigators may buy some water from the Water Bank, the main purchaser has been and will likely continue to be IPC.

1. Power Values Based on Annual Water Bank Transactions

The present Idaho Water Bank is essentially a spot market for water. Transactions involve a commitment for one year only, rather than a long term contract. When IPC buys from the Water Bank, it is essentially buying the right to determine the short term timing of this water, so it can be released to flow down the Snake River at a time most advantageous for power generation. If some of this water committed to the Water Bank does not find a buyer, the water will still come down the river as spill before or during some subsequent spring runoff. What IPC should be willing to pay for Water Bank water depends on the benefits of shifting the timing of a block of nonfirm generation from spring (as dictated by reservoir operations and flood control) back to the previous summer (as dictated by power supply-demand conditions).

Most of the seldom used storage is located in or above American Falls Reservoir. When an acre-foot of stored water is released, it has the potential to generate 1264 KWH of electricity for IPC as it passes through the company's downstream turbines (Table 5). It may generate less if the riverflow already exceeds the hydraulic capacity of the turbines at some dams, making it necessary to spill some water, as is often true in early summer and in abundant water years.

The value of Water Bank water for hydropower generation can be estimated based on the avoided cost rates determined for IPC in the 1986 Idaho PUC proceedings (Table 5). If one thinks of the Water Bank transaction as occurred in most years, and ignores the constraints of dam hydraulic capacity, then this means shifting a block of nonfirm electricity supply from the March-May spring runoff period which has a 1.92 cents/kwh avoided cost, back into the the previous June-September period when avoided cost would be 2.77 cents/kwh. This would be an increase in value of 0.85 cents for each kwh of hydropower (or $10.74 per acre-foot of water) so shifted:

gain:	1264 KWH	X	2.77 cents =	$35.01
loss:	1264 KWH	X	1.92 cents =	$24.27
net gain:			0.85 cents	$10.74

This is a lower bound estimate of the value of Water Bank water for hydropower generation because in many years all of the March-May streamflow given up would not be usable for power generation, but some might be spilled because of either restricted turbine capacity or limited markets for nonfirm power. Moving the flow to June-September would make it much more likely that the water would be usable for power generation. For example, if one assumes that only half of the March-May streamflow, but all of the June-September, were usable for power generation, then the estimated market value of this water rises to $22.88 per acre-foot:

gain: 1264 KWH X 2.77 cents = $35.01

loss: 632 KWH X 1.92 cents = $12.13

net gain: $22.88

The actual power value of water from a Water Bank style market based on annual transactions depends on the regional electricity supply-demand situation and reservoir conditions in each year. This value would vary from year to year -- probably in the $10.74 to $22.88 per acre-foot interval suggested above, but well above the $2.50 price currently charged by the Idaho Water Bank.

Since these power values are dependent on annual conditions, that it might be beneficial to release the market from some of the bureaucratic constraints that presently restrict the Idaho Water Bank. The price could justifiably go higher than the $2.50 presently set. The price might be allowed to vary from year to year depending on conditions of storage water supply and demand.

2. Power Values for Long-term Stored Water Contracts

The above estimates of the value of water from the Water Bank are based on the rule that allows transactions only on an annual basis. Clearly, a market for stored water would be most useful to IPC in dry years when low power generation capability begins to jeopardize the company´s ability to meet firm sales commitments. IPC could supply some future load growth by taking blocks of power that presently are nonfirm because of uncertain summer streamflow, and firming them up using power generation flows from purchased stored water. However, using a storage water market to firm up nonfirm power requires some mechanism to assure that the water would be available in the very dry years when it would be needed. Obviously this would mean a fundamental change in the structure of the Idaho Water Bank to allow some sort of long-term contract.

A market for storage water based on long term contracts would have power values approaching those shown in Table 4. The stored water would be delivered under the contract only in very dry years, but would have very high values per acre-foot actually delivered. The average annual value of such long-term contract water for power generation would range between $37 and $40 per acre-foot at levels of intervention likely to be used in such a program.

The problem with this approach is the difficulty of determining the storage volume for which delivery could be assured in dry years, even if these dry years occur in sequence so that reservoirs become depleted. Failure to assure this absolute availability of storage water would greatly diminish the power value of water from such a market. It would take an operations study to give a definitive answer, but it is unlikely that this level of reliability could be assured for more than 300 to 400 thousand acre-feet of the infrequently used storage in the upper Snake. It is possible that one market for storage water and another market for option lease water from irrigation could be coordinated to assure higher levels of hydropower system reliability.

3. Impact of the One-Price Rule

The Idaho Water Bank presently charges the same price to all water purchasers. This practice is required under present Bureau of

Reclamation policies. This tends to hold down the price charged, because farmers argue that they are unable to pay more than the present $2.50 per acre-foot price. During periods of water shortage, farmers have the political clout and the public sympathy needed to effectively determine the administered water price. While it would violate the spirit of a free unregulated market, a two price system might possibly emerge from Bureau policy changes now being considered. It is not clear what guidelines could be used to set the prices that would apply to purchases for irrigation and hydropower uses.

It is important to note that Water Bank sales for irrigation purposes may have some effects on hydropower generation. If the water is used for irrigation, it obviously will not contribute to increased streamflow some subsequent spring, and thus some power generation potential will be lost. On the other hand, some part of any storage water purchased for irrigation will end up as return flow, and greater generation potential. If there were a free market for storage water with all potential buyers competing on an equal basis, IPC´s perception of these effects would affect its willingness to bid water away from purchase and consumptive use by irrigators.

CHAPTER V

CONCLUSIONS

Several conclusions can be drawn from the results of this study. Most important, it appears that in the future water markets will be economically feasible for water owned by agriculture in southern Idaho. Water markets of the type outlined in this report may not emerge immediately, but will probably build on the beginnings of the Idaho Water Bank. As the water and electricity supply-demand situations tighten in the 1990's the payoff to such markets will grow. However, many questions still remain about how best to structure these markets, in order to maximize their benefits, and minimize the costs and disruptions caused. It is not too early for the state to begin planning now to facilitate the emergence of these water markets as they are needed.

A. Option Leasing

The option lease program for marketing water currently used by agriculture would impose economic costs on agriculture that are far less than the potential economic value of the hydropower created by the water marketed. Agriculture's use of irrigation water would be changed very little while creating considerable amounts of increased value in the hydropower sector. The present value of costs imposed on agriculture over a 25 year participation period, being different for each type of farm, would range from near zero to a maximum of about $70 per acre of irrigated land when discounted at a rate of 3 percent. The value of power produced by this market would range from $200 to $700 per acre of irrigated land committed to the market. By the time this type of market could be implemented near the end of this century, the higher values would prevail.

Under the assumptions of this study, no farm or farming area would be permitted to market more than 50 percent of total water now being consumptively used in order to avoid third party effects by market participation. This constraint would allow about .75 acre-feet of water to be committed to the market by each participating irrigated acre. It was further assumed that levels of water consumption on participating farms would be controlled by affecting the amount of water delivered to the farm. This method of market management does appear to be feasible if delivered water can be measured and controlled.

It is clear from this analysis that some farm types would have much lower costs for market participation than others. Those with the greatest advantage in participation would be expected to enroll at the highest rate. If participating farms were to be given the opportunity to purchase pumping energy at nonfirm rates for the portion of their water committed to the market, some farms would gain a considerable advantage in the market. High pump lift farms would gain sufficiently from the energy price break to offset farm income losses from the market even if no compensation were paid for the water sold, under current farming conditions.

Crop mix was a very important determinant of costs imposed on agriculture by water market participation. Those farms with a high proportion of high value crops had the highest costs imposed by water shortages. Conversely, farms producing a low proportion of high value crops would incur relatively low costs from participation. This result implies that the value of crop production has a strong influence on the costs of market participation. Hence, commodity prices received by farmers would have a large effect on market costs. Such prices may very widely over time.

B. Stored Water

It was determined in this study that a market for stored water is economically feasible. The value that could be created by selling stored water for hydropower far exceeds its current value in storage, or agricultural uses. Even with annual market transactions, the power value of this water is in the $10 to $22 per acre-foot range, so price could justifiably go higher than the $2.50 presently set, and might be allowed to vary from year to year depending on conditions of storage water supply and demand.

To obtain maximum value for this water by allowing IPC to avoid investments in alternative energy sources, there would need to be long term agreements assuring the availability of this water for energy production. Under these conditions, the annual power values increase to $37 to $40 per acre-foot under contract, and delivery under the contract is necessary only in very dry years.

C. Other Legal, Institutional, Physical, and Economic Issues

This research raises a number of related issues and problems. We will discuss some of these topics briefly, more to acknowledge and explore the issues than to present definitive research results. Many of these topics are areas where more research is justified before the state makes a major commitment to using water markets.

1. Downstream Implications of Idaho Water Markets

Table 3 showed that each acre-foot of augmented flow originating in Idaho could generate one third of its potential power output, 618 KWH, at the Federal hydropower dams on the Snake and Columbia River below Hells Canyon. If water markets in Idaho in fact result in valuable power generation at these Federal dams, then it may make sense for the Federal power entity, Bonneville Power Authority, to play some role in the water market. BPA and Idaho Power could jointly buy or lease water to be used for power generation. Perhaps flow augmentation schemes of the type discussed above should be covered under PURPA mandated programs in a manner similar to the treatment now given energy conservation, small hydropower generation and cogeneration. Given that many Idaho citizens get their electricity from utilities served by BPA, it is in the best interest of Idaho's ratepayers to encourage a cooperative marketing strategy.

There are problems with expecting BPA and Idaho Power to cooperate in a water market. The time when Idaho Power needs more hydropower does not necessarily correspond to the critical periods on the BPA system. The rainfall and streamflow patterns of the upper Snake can be different from those on the Columbia. The electricity demand pattern is also different, with Idaho Power still experiencing a summer peak load, and BPA having a winter load peak. While the storage capacity in Brownlee Reservoir and in the upper Columbia would allow some flexibility to meet the separate needs of the two systems, their differences might make it difficult for them to agree on a joint water market strategy.

Despite these differences this water below Hells Canyon could have considerable value. IPC is not likely to be buying water at a time when the Federal dams are spilling water, so all of the increased flows would probably be usable at the federal dams. Even if the increased power could only be sold as surplus for 2.5 cents per KWH, this would mean a value of $15.45 per acre-foot, in addition to the value of the water to IPC. If some of this hydropower is generated in periods when BPA is short of power, the value of the water would be much higher. The only scenario where this water might have little value to BPA are the annual Water Bank transactions where the timing is such that flow at one time is being exactly traded off against flow at another time.

2. The Role of the Appropriation Doctrine

The appropriation doctrine has always been the foundation of water law in Idaho. Water is appropriated for beneficial use, and the priority of the water right dates from the date of first diversion and use. If water is not being beneficially used, this could be considered abandonment, and such water is subject to appropriation by someone else.

This complicates the creation of a water market. If storage water is infrequently (or never) used, then does the owner of record in fact have a valid title to the water to lease or sell? Can a farmer´s willingness to sell or lease water be taken as admission that he does not have a beneficial use for that water? Shouldn´t water "abandoned" in this manner go first to make more secure the remaining junior rights, and then be made available for junior appropriation, rather than being sold as a non-appurtenant senior right? Idaho law does now recognize the legitimacy of Water Bank "deposits", but it is unclear how far this precedent extends.

The strict interpretation of the appropriation doctrine would make most of the water markets discussed in this report infeasible. Farmers would have little incentive to conserve or efficiently use water. When the only value of water is appurtenant to the land, the only incentive a farmer has is to demonstrate the beneficial use of all of that water to which he has a right -- that is: "use it or lose it". This leads to wasteful and inefficient water use.

A parallel problem is that Idaho water rights are defined in terms of diversion quantities, but it is the amount of consumptive use that really counts in a water market. Idaho's "reasonable use" rules are not sufficiently stringent to have much impact. The Snake River adjudication now getting started will serve a very useful purpose if it successfully begins the quantification of water rights in terms of the consumptive use to which each right is entitled.

We have not surveyed the Idaho water law statutes to ascertain what changes might be necessary to make a functional and practical water market possible. Such legal research is essential if Idaho intends to move in this direction.

3. Tradeoffs Between Water Sources

A problem with water markets is that water comes in various forms: surface water flows, stored water, and groundwater. These forms of water are not equivalent, and are not all equally marketable. Most clearly, it would be inappropriate to propose a market for groundwater rights, because of the difficulty and severe third party effects of changing the location of diversion. However some farmers have the option of using water from more than one source to irrigate a given tract of land, and the state is unable to conclusively monitor how much water comes from each source. Farmers can be expected to make rational economic decisions, based on information available to them, when choosing among two or more water sources, and the existence of water markets is likely to alter these decisions.

If markets are created for flow water, but not for groundwater, then flow rights will have a cash value but groundwater will have no cash value. Under these conditions farmers can be expected to maximize their use of groundwater and conserve their flow rights in order to sell or lease their excess water. This could result in overdrafting of groundwater, and declining water tables.

The same tradeoff would be expected between storage and flow rights. If a market exists for one but not the other, the marketable type of right will get conserved at the expense of the nonmarketable one, possibly resulting in damaging third party effects. If the state chooses to move toward water markets, it will be necessary to monitor and perhaps to control these water source shifts.

4. Water Market Organization

Given willing buyers and sellers of water, the outcome of a water market will still depend on the relative bargaining strength of buyers and sellers, and on the nature of the market institutions. There are thousands of individual storage owners and water users in the upper Snake who are potential water sellers. While there may also may be a number of irrigation users who are potential purchasers, the dominant purchaser would undoubtedly be IPC. In this situation of many sellers and one major buyer, a completely free market might not lead to equitable results. For the existing Water Bank, the District 1 Watermaster's Office sets prices, functions as a clearinghouse, and charges a $.50 per acre-foot fee for these services. Presumably the Idaho Public Utilities Commission also has an interest in seeing that the Idaho Power Company's water market activities are in the interests of the customers of the utility.

A completely free and unregulated water market could probably exist with little government involvement. The state would only have to lay down the ground rules, and willing buyers and sellers would create the market. However such a free market is unlikely and probably undesirable. It appears that government has a legitimate role in a water market to help mediate between the many sellers and the dominant buyer, to look after the public interest, to define and standardize the short or long-term contracts traded, and to guard against third party effects. However, the price presently set by the state for Water Bank transactions is probably not equitable to the sellers, and a price closer to a market-clearing price would probably be in the long term interest of all parties. It seems obvious that the Department of Water Resources should play a major role in such a market. It may be necessary to develop bargaining units of farmer groups. Irrigation districts are probably the most practical units that could be used to represent farmer interests in a water market.

5. Impacts on Local Communities

It is argued that the use of water markets should lead to more efficient water use, and result in economic benefits to the state as a whole. However, the state should also legitimately be concerned with the effect that water market legislation has on local communities. If water markets should result in massive sales of irrigation water from one area, then this would damage the sectors of the local economy that depend on irrigated agriculture. There is a limit to how much inefficiency of water use the state should tolerate in order to sustain local communities and their economies, but the dislocations and adjustments caused by these water sales would also have costs. Whether these concerns are realistic depends on how water markets are structured.

However, a water market developed under the assumptions of this analysis with supply interruptions in perhaps one year out of five and with some of these interruptions taking as little as 10 percent of available water, it is expected that undesirable effects on local communities will be minimized. Since the overriding principle of a water market is that transactions are voluntary and make both parties better off, the market would be expected to raise local income. While local spending patterns with a water market will be somewhat different than without one, total local business spending should be increased by the existence of a water market.

If a relatively free water market were created that allowed outright sale of water rights between regions, then communities with lands poorly suited to irrigation would be expected to sell water and move out of irrigated farming. However, if a water market relies on the option leasing mechanism described above, or an expansion or modification of the present Water Bank, the local community effects will be less. The irrigated farming areas will experience a new form of supplemental income, and not be permanently driven out of business.

6. Recreation and Environmental Effects

The water markets proposed in this report could be expected to have a range of significant environmental effects. Since most market activity would occur in low flow periods of dry years, this should augment minimum stream flows. If the markets involve storage water, this could result in greater fluctuations in reservoir levels and lower average levels. If a water option leasing program affects land use, this would impact upland game habitat. If there is an effect on farming practices, this will influence soil erosion and water quality. All of these should be considered in future research.

A major concern of the Northwest Power Planning Council is finding sufficient and timely flows to support the passage of salmon and steelhead fish by the lower Snake and Columbia River dams. It is possible that an Idaho water market could be a component of that program in a way that would benefit all participants.

7. Structure of Compensation Schemes

The best method of payment for water purchased from agriculture is unclear. For currently used water that is purchased from irrigated agriculture, some combination of an annuity and lump sum payment would probably be the best method of compensating farmers for water committed to the market. The annuity could be paid every year for the term of the contract in an amount that might approximate the average long term expected losses of agricultural income from market participation. Then the lump sum payments could be provided in years of water supply interruption to offset the greater losses incurred in those years. The optimal combination of these payment methods needs further study, however.

8. Criteria for Water Market Interruption

The conditions under which water supplies would be interrupted must be defined to the satisfaction of all market participants. Such an agreement should include well defined trigger conditions for interruption and notification to farmers. An ideal program would always provide farmers with knowledge of their seasonal water supply prior to the planting of crops in the spring. However, variations on this scheme might allow for higher payments to be associated with interruption notification after, say, April 1.

9. Control of Water Consumptive Use

The option lease water market scheme requires that actual water consumptive use be reduced in order to deliver more water to IPC. Mechanisms to monitor and control consumptive use under actual farm conditions do not now exist in Idaho.

It appears that management of a practical water market would have to be through control of the quantity of water delivered to farms. However, the relationship between the delivered quantity of water and the consumptive use of water on farms is not known accurately at this time. Research will be required to establish this relationship with sufficient accuracy to operate a water market.

This report suggests that the payoffs from a water market could be sufficiently high to justify considerable expenditure by farmers and water delivery organizations in improving their ability to monitor and control water delivery and use.

10. Impact of Management for Water Deficit Irrigation

In this study the costs of crop production were adjusted for changes in expected crop yield as water quantities available to farm were varied. However, the optimal strategies for farming with limited water supplies are unknown because there has been little experience with farming under these conditions. Hence, the costs of production that should be used to represent crops produced under deficit irrigation is unknown. Further study is required to refine these data.

11. Participation in Federal Farm Programs

Many Idaho farmers are participants in Federal programs for land retirement. If irrigated land is retired under such a program, the water could be released for other purposes. It should be possible to coordinate water market participation with land retirement participation, to the benefit of the farmer. It might also be true in some cases that federal program provisions might restrict farmers´ ability to participate in a water market. This could be true if participation jeopardizes proven yields or base acreages.

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Appendix A

DATA USED IN OPTION LEASING MODEL

This appendix provides additional details on the sources of data used in constructing the model used to study farmer response to water shortage.

A. Representative farms:

The representative farms used for this study were based on available data. The US Census of Agriculture is a source for county data on acreage by crop. The southern Idaho Census data for 1982 is shown in Table A1. The regional totals of crop acreage were used as guidelines for constructing the representative farms.

Complete, consistent data for crop acreage by water source and application system and region are not available. Partial information is available from two sources, a 1977 study by King, Wensink, Wolfe, and Shearer, and a 1981 memorandum from the Pacific Northwest River Basins Commission. The representative farms used in this study result from our efforts to reconcile this occasionally inconsistent information. The crop mix differences between the representative farms are based partly on discussions with extension personnel at the University of Idaho.

These representative farms do not include farms obtaining water from wells. It was assumed that such farms would not participate in the proposed water markets.

B. Crop Yields and Prices:

Yield and price information is available from several sources. The annual Idaho Agricultural Statistics reports some detailed county level yield data, but price data only at the state level. The Bureau of Reclamation reports some price and yield data for its projects in southern Idaho for selected years. The UI Crop Budget reports include estimates of both yields and prices. In addition, recent studies by Hamilton and Lyman [1983] and Harris [1984] included estimates of yields and prices.

All of this information is reported in Tables A2 and A3. The prices and yields used in this report represent a synthesis from these diverse sources.

C. Crop Budget Cost Information:

The UI Crop Budgets were used as the source for crop production costs. The budgets used are included as Tables A5 through A12. The model required estimates of variable production costs exclusive of fertilizer, harvest and irrigation costs. These selected cost components were excluded because the model assumed that the level of these costs varied in response to the level of water application. The variable cost figures used as input to the model also incorporated some judgements about the likely differences in costs between the two study regions. Table A4 summarizes the computation of the variable cost components required by the model.

Cost data for pasture were not available from the UI Budgets. The figures presented in Table A4 represent our best estimates of reasonable variable costs for irrigated pasture yielding 8.5 to 9.5 AUM´s per acre.

TABLE A1.

ACREAGE OF IRRIGATED CROPS IN SOUTHEAST & SOUTHCENTRAL IDAHO REPORTED BY 1982 AG CENSUS

	BANNOCK	BINGHAM	BON-NEVILLE	FREMONT	JEF-FERSON	MADISON	POWER	TETON	SOUTHEAST REGION TOTAL	% OF AREA
CORN GRAIN & SEED	-	-	-	-	232	-	-	-	232	0.0
WHEAT GRAIN	8665	127536	33348	12000	27287	22368	43996	2409	277609	26.1
BARLEY GRAIN	7125	35609	42502	34897	51346	36807	6299	28445	243030	22.8
OATS GRAIN	536	979	1037	458	1667	301	131	85	5194	0.5
DRY PEAS	-	672	1063	2381	1846	-	643	-	6605	0.6
POTATOES	2537	54320	36516	30947	18978	33751	17839	10098	204986	19.2
SUGAR BEETS	-	7709	-	-	-	-	7719	-	15428	1.4
FIELD & GRASS SEED	-	1299	-	66	-	-	136	-	1501	0.1
ALFALFA HAY	13318	40307	26461	13780	71461	12145	8971	13820	200263	18.8
CORN SILAGE	-	1702	-	-	2750	280	190	-	4922	0.5
OTHER HAY & SILAGE	1875	4412	1075	1200	2317	844	651	3267	47917	4.5
VEGETABLES, SWEET CORN	13	59	10	-	-	-	-	-	82	0.0
PASTURE & OTHER	6328	20791	6401	14769	23172	5582	2098	10731	89872	8.4
TOTAL IRRIGATED CROPS	40397	295395	148413	110498	201056	112078	88673	68855	1065365	100.0

	BLAINE	BUTTE	CASSIA	CLARK	GOODING	JEROME	LINCOLN	MINI-DOKA	TWIN FALLS	S. CENTRAL REGION TOTAL	% OF AREA
CORN GRAIN & SEED	-	-	444	-	5303	3289	420	-	12441	21897	1.8
WHEAT GRAIN	3371	4343	83594	21741	15999	33124	14015	43127	45187	264501	21.4
BARLEY GRAIN	16336	21859	39938	5320	11068	17759	14260	35755	35166	197461	16.0
OATS GRAIN	602	1151	1188	365	1010	394	444	78	938	6170	0.5
DRY BEANS	-	-	15144	-	6758	21636	1034	7000	62912	114484	9.3
DRY PEAS	-	-	562	-	-	1221	-	664	5898	8345	0.7
POTATOES	362	2830	29766	1886	7199	12230	3794	10924	8994	77985	6.3
SUGAR BEETS	3044	-	20823	-	1434	5345	4727	28362	8179	71914	5.8
FIELD & GRASS SEED	-	-	225	-	374	1075	-	42	970	2686	0.2
ALFALFA HAY	20705	31008	43101	16487	30613	40126	22848	21456	55640	281984	22.8
CORN SILAGE	135	4616	-	-	4591	2176	2196	2597	5473	21784	1.8
OTHER HAY & SILAGE	2124	5284	9678	1035	2511	3306	2950	2060	4918	33866	2.7
VEGETABLES, SWEET CORN	-	-	2913	-	2891	935	410	675	9617	17441	1.4
PASTURE & OTHER	16202	11176	17598	4236	19451	8623	13778	5677	18732	115473	9.3
TOTAL IRRIGATED CROPS	62881	82267	264974	51070	109202	151239	80876	158417	275065	1235991	100.0

SOURCE: US CENSUS OF AGRICULTURE, 1982.

TABLE A2. SUMMARY OF YIELD INFORMATION ON IRRIGATED CROPS

	WINTER WHEAT	BARLEY	ALFALFA	POTATOES	BEANS	PASTURE
			SOUTHEASTERN REGION			
HARRIS ESTIMATE	82.2 *	64.1	3.1	257.8		
ID CROP & LIVEST	86.5			254.0		
UI BUDGETS		91.7	5.0	275.0		
USED IN THIS STUDY	90.0	85.0	4.3	260.0		8.5
			SOUTHCENTRAL REGION			
HARRIS ESTIMATE	88.2 *	93.3	3.1	323.6	17.8	
ID CROP & LIVEST	101.8			314.4		
UI BUDGETS	130.0	145.8	5.5	310.0	22.0	
USED IN THIS STUDY	100.0	95.0	4.8	310.0	18.0	9.5
		BOTH REGIONS				
HAMILTON-LYMAN	110.0 *	90.0	5.5	310.0	22.0	
BUREAU PROJECTS	86.2 *	86.7	4.5	276.8		8.9

* These studies did not distinguish between spring and winter wheat

TABLE A3. SUMMARY OF PRICE INFORMATION ON IRRIGATED CROPS

YEAR	WINTER WHEAT	BARLEY	ALFALFA	POTATOES	BEANS	PASTURE	PROD. PRICE INDEX
		IDAHO CROP & LIVEST. REPORT. SERVICE					
1980		2.92	62.00	5.65	28.30		268.80
1981		2.65	54.50	4.75	15.30		292.40
1982		2.48	69.00	3.50	11.70		299.30
1983		2.77	71.50	5.20	18.10		303.10
1984		2.50	68.50	5.15	15.80		310.30
INDEXED AVE	0.00	2.80	68.20	5.11	18.98		308.80
		REPORT ON BUREAU LANDS					
1982		2.10	57.89	3.28	12.94	11.15	299.30
1983		2.49	61.79	5.00	20.77	11.13	303.10
1984		2.32	66.80	4.69	16.23	9.59	310.30
INDEXED AVE		2.34	63.05	4.38	16.89	10.80	308.80
		HARRIS 1978-82 AVE					
AVERAGE	4.05 *	3.24	58.32	5.05	24.94		
HIGH	4.30 *	3.60	68.50	5.65	28.30		
		UI CROP BUDGETS					
1985, SE	3.30	2.40	65.00	4.75			
1985, SC	3.25	2.52	70.00	4.25	16.00		
		HAMILTON-LYMAN STUDY					
	3.70 *	2.20	65.00	4.50	13.00		
		USE IN THIS STUDY					
	3.50	2.90	65.00	4.50	17.00	11.00	

* These studies did not distinguish between spring and winter wheat

TABLE A4. SUMMARY OF CROP BUDGET INFORMATION ON IRRIGATED CROPS

	WINTER WHEAT	BARLEY	ALFALFA	POTATOES	BEANS	PASTURE
SOUTHEAST REGION						
UI BUDGET #	79-15	77-3	77-2	77-5		
UI BUDGET VAR. COSTS	179.51	197.99	172.64	891.65		
LESS:						
WATER ASSESS.	18.00	11.50	11.50	11.50		
IRRIG. MACH.	28.94	31.25	43.80	39.90		
IRRIG LABOR	8.54	14.96	17.95	44.89		
FERTILIZER	44.80	46.00	15.60	125.95		
HARVEST	13.41	24.03	63.74	83.05		
UI NET VAR. COSTS	65.82	70.25	20.05	586.36		
USED IN THIS STUDY	65.00	70.00	20.00	550.00		10.00

	WINTER WHEAT	BARLEY	ALFALFA	POTATOES	BEANS	PASTURE
SOUTHCENTRAL REGION						
UI BUDGET #	79-15	79-6	79-3	79-12	79-7	
UI BUDGET VAR. COSTS	179.51	190.82	157.12	843.78	153.50	
LESS:						
WATER ASSESS.	18.00	18.00	18.00	18.00	18.00	
IRRIG. MACH.	28.94	25.03	31.92	29.02	1.14	
IRRIG LABOR	8.54	6.18	13.55	9.13	11.40	
FERTILIZER	44.80	38.40	9.60	132.00	7.50	
HARVEST	13.41	26.00	65.00	87.99	18.04	
UI NET VAR. COSTS	65.82	77.21	19.05	567.64	97.42	
USED IN THIS STUDY	75.00	80.00	22.00	600.00	100.00	15.00

SOURCE: UI CROP BUDGETS, 1985.

District 3 MS 79-3

Crop Enterprise Budgets — 1985

Rob Brooks, Extension Associate
C. Wilson Gray, Extension Economist
University of Idaho Department of Agricultural Economics

Alfalfa Hay
Southcentral Idaho

BUDGET ID # -- 81 302200 142 1
ANNUAL CAPITAL MONTH 8

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST	YOUR VALUE
1. GROSS RECEIPTS FROM PRODUCTION				$	
ALFALFA HAY	TONS	70.00	5.50	385.00	________
TOTAL				$ 385.00	________
2. VARIABLE COSTS					
PREHARVEST				$	
PHOSPHATE	LB.	0.24	40.00	9.60	________
APPLY FERTILIZER	ACRE	5.00	0.25	1.25	________
WATER ASSESSMENT	ACRE	18.00	1.00	18.00	________
SENCOR	LB.	13.75	1.50	20.63	________
MACHINERY	ACRE	0.09	1.00	0.09	________
TRACTORS	ACRE	1.71	1.00	1.71	________
IRRIGATION MACHINERY	ACRE	31.92	1.00	31.92	________
LABOR(TRACTOR & MACHINERY)	HOUR	5.50	0.49	2.69	________
LABOR(IRRIGATION)	HOUR	4.75	2.85	13.55	________
INTEREST ON OP. CAP.	DOL	0.13	35.65	4.63	________
SUBTOTAL, PRE-HARVEST				$ 104.07	________
HARVEST COSTS				$	
MACHINERY	ACRE	31.22	1.00	31.22	________
TRACTORS	ACRE	6.24	1.00	6.24	________
LABOR(TRACTOR & MACHINERY)	HOUR	5.50	2.83	15.59	________
SUBTOTAL, HARVEST				$ 53.05	________
TOTAL VARIABLE COST				$ 157.12	________
3. INCOME ABOVE VARIABLE COSTS				$ 227.88	________
4. FIXED COSTS				$	
MACHINERY	ACRE	70.01	1.00	70.01	________
TRACTORS	ACRE	21.11	1.00	21.11	________
LAND (NET RENT)	ACRE	70.00	1.00	70.00	________
OVERHEAD	ACRE	6.08	1.00	6.08	________
TOTAL FIXED COSTS				$ 167.20	________
5. TOTAL COSTS				$ 324.32	________
6. NET RETURNS TO RISK				$ 60.68	________

IRRIGATED-CENTER PIVOT
LAND CHARGE-CASH RENT
ACTUAL NET RETURNS ARE LESS BY THE AMOUNT OF ESTABLISHMENT CHARGE

BREAKEVEN PRICES
IF 5.50 TONS ALFALFA HAY ARE PRODUCED:

TO COVER PREHARVEST VARIABLE INPUTS	18.923
TO COVER HARVEST VARIABLE INPUTS	9.645
TO COVER FIXED INPUTS	30.399
TO COVER ALL COSTS EXCEPT RISK	58.967

District 3 MS 79-7

Crop Enterprise Budgets — 1985

Rob Brooks, Extension Associate
C. Wilson Gray, Extension Economist
University of Idaho Department of Agricultural Economics

Commercial Beans
Southcentral Idaho

BUDGET ID # -- 73 302200 152 1
ANNUAL CAPITAL MONTH 9

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST	YOUR VALUE
1. GROSS RECEIPTS FROM PRODUCTION				$	
COMMERCIAL BEANS	CWT.	16.00	22.00	352.00	________
TOTAL				$ 352.00	________
2. VARIABLE COSTS					
PREHARVEST				$	
BEAN SEED	LB.	0.18	100.00	18.00	________
ZINC	LB.	1.00	5.00	5.00	________
PHOSPHATE	LB.	0.24	30.00	7.20	________
EPTAM/TREFLAN	ACRE	17.75	1.00	17.75	________
CYGON	QT.	6.70	0.50	3.35	________
WATER ASSESSMENT	ACRE	18.00	1.00	18.00	________
APPLY FERTILIZER	ACRE	5.00	1.00	5.00	________
MACHINERY	ACRE	10.40	1.00	10.40	________
TRACTORS	ACRE	14.79	1.00	14.79	________
IRRIGATION MACHINERY	ACRE	1.14	1.00	1.14	________
LABOR(TRACTOR & MACHINERY)	HOUR	5.50	3.47	19.07	________
LABOR(IRRIGATION)	HOUR	4.75	2.40	11.40	________
INTEREST ON OP. CAP.	DOL.	0.13	33.58	4.37	________
SUBTOTAL, PRE-HARVEST				$ 135.46	________
HARVEST COSTS				$	
MACHINERY	ACRE	5.22	1.00	5.22	________
TRACTORS	ACRE	5.48	1.00	5.48	________
LABOR(TRACTOR & MACHINERY)	HOUR	5.50	1.33	7.33	________
SUBTOTAL, HARVEST				$ 18.04	________
TOTAL VARIABLE COST				$ 153.50	________
3. INCOME ABOVE VARIABLE COSTS				$ 198.50	________
4. FIXED COSTS				$	
MACHINERY	ACRE	78.43	1.00	78.43	________
TRACTORS	ACRE	43.53	1.00	43.53	________
LAND (NET RENT)	ACRE	70.00	1.00	70.00	________
OVERHEAD	ACRE	6.50	1.00	6.50	________
TOTAL FIXED COSTS				$ 198.46	________
5. TOTAL COSTS				$ 351.96	________
6. NET RETURNS TO RISK				$ 0.04	________

IRRIGATED-SURFACE
LAND CHARGE-CASH RENT

BREAKEVEN PRICES

IF 22.00 CWT. COMMERCIAL BEANS ARE PRODUCED:

TO COVER PREHARVEST VARIABLE INPUTS	6.157
TO COVER HARVEST VARIABLE INPUTS	0.820
TO COVER FIXED INPUTS	9.021
TO COVER ALL COSTS EXCEPT RISK	15.998

District 4 MS 77-3

Crop Enterprise Budgets — 1985

Rob Brooks, Extension Associate
Paul Patterson, Extension Economist
University of Idaho Department of Agricultural Economics

Spring Barley
Southeastern Idaho

BUDGET ID # -- 79 401200 114 1
ANNUAL CAPITAL MONTH 8

x 2.05 = 91.7 bu

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST	YOUR VALUE
1. GROSS RECEIPTS FROM PRODUCTION				$	
BARLEY	CWT.	5.00	44.00	220.00	______
STRAW	TONS	30.00	0.75	22.50	______
TOTAL				$ 242.50	______
2. VARIABLE COSTS					
PREHARVEST				$	
BARLEY SEED	LB.	0.13	90.00	11.70	______
NITROGEN	LB.	0.33	100.00	33.00	______
PHOSPHATE	LB.	0.26	50.00	13.00	______
APPLY FERTILIZER	ACRE	5.00	1.00	5.00	______
2-4-D AMINE	QT.	2.25	1.00	2.25	______
AIR SPRAY	ACRE	4.50	1.00	4.50	______
WATER ASSESSMENT	ACRE	11.50	1.00	11.50	______
MACHINERY	ACRE	14.66	1.00	14.66	______
TRACTORS	ACRE	13.25	1.00	13.25	______
IRRIGATION MACHINERY	ACRE	31.25	1.00	31.25	______
LABOR(TRACTOR & MACHINERY)	HOUR	5.50	2.50	13.76	______
LABOR(IRRIGATION)	HOUR	4.75	3.15	14.96	______
INTEREST ON OP. CAP.	DOL.	0.13	39.40	5.12	______
SUBTOTAL, PRE-HARVEST				$ 173.95	______
HARVEST COSTS				$	
CUSTOM STACK	TONS	7.00	0.75	5.25	______
MACHINERY	ACRE	13.44	1.00	13.44	______
LABOR(TRACTOR & MACHINERY)	HOUR	5.50	0.97	5.35	______
SUBTOTAL, HARVEST				$ 24.03	______
TOTAL VARIABLE COST				$ 197.99	______
3. INCOME ABOVE VARIABLE COSTS				$ 44.51	______
4. FIXED COSTS				$	
MACHINERY	ACRE	64.92	1.00	64.92	______
TRACTORS	ACRE	26.52	1.00	26.52	______
IRRIGATION MACHINERY	ACRE	50.35	1.00	50.35	______
LAND (NET RENT)	ACRE	105.00	1.00	105.00	______
OVERHEAD	ACRE	8.26	1.00	8.26	______
TOTAL FIXED COSTS				$ 255.04	______
5. TOTAL COSTS				$ 453.03	______
6. NET RETURNS TO RISK				$-210.53	______

LAND CHARGE-CASH RENT
IRRIGATED-HAND LINE

District 4 MS 77-2

Crop Enterprise Budgets — 1985

Rob Brooks, Extension Associate
Paul Patterson, Extension Economist
University of Idaho Department of Agricultural Economics

Alfalfa Hay
Southeastern Idaho

BUDGET ID # -- 81 401200 114 4
ANNUAL CAPITAL MONTH 6

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST	YOUR VALUE
1. GROSS RECEIPTS FROM PRODUCTION				$	
ALFALFA HAY	TONS	65.00	5.00	325.00	________
TOTAL				$ 325.00	________
2. VARIABLE COSTS					
PREHARVEST				$	
PHOSPHATE	LB.	0.26	60.00	15.60	________
APPLY FERTILIZER	ACRE	5.00	1.00	5.00	________
FURADAN	QT.	13.25	0.50	6.63	________
AIR SPRAY	ACRE	4.50	0.50	2.25	________
WATER ASSESSMENT	ACRE	11.50	1.00	11.50	________
IRRIGATION MACHINERY	ACRE	43.80	1.00	43.80	________
LABOR(IRRIGATION)	HOUR	4.75	3.78	17.95	________
INTEREST ON OP. CAP.	DOL.	0.13	47.39	6.16	________
SUBTOTAL, PRE-HARVEST				$ 108.89	________
HARVEST COSTS				$	
CUSTOM STACK	TONS	7.00	5.00	35.00	________
MACHINERY	ACRE	7.18	1.00	7.18	________
TRACTORS	ACRE	8.69	1.00	8.69	________
LABOR(TRACTOR & MACHINERY)	HOUR	5.50	2.34	12.87	________
SUBTOTAL, HARVEST				$ 63.74	________
TOTAL VARIABLE COST				$ 172.64	________
3. INCOME ABOVE VARIABLE COSTS				$ 152.36	________
4. FIXED COSTS				$	
MACHINERY	ACRE	53.16	1.00	53.16	________
TRACTORS	ACRE	22.86	1.00	22.86	________
IRRIGATION MACHINERY	ACRE	50.40	1.00	50.40	________
LAND (NET RENT)	ACRE	105.00	1.00	105.00	________
OVERHEAD	ACRE	7.26	1.00	7.26	________
TOTAL FIXED COSTS				$ 238.68	________
5. TOTAL COSTS				$ 411.31	________
6. NET RETURNS TO RISK				$ -86.31	________

LAND CHARGE-CASH RENT
IRRIGATED-HAND LINE
NOTE FURADAN IS ONLY APPLIED ON 50% OF THE ACRES.

BREAKEVEN PRICES
IF 5.00 TONS ALFALFA HAY ARE PRODUCED:

TO COVER PREHARVEST VARIABLE INPUTS	21.778
TO COVER HARVEST VARIABLE INPUTS	12.749
TO COVER FIXED INPUTS	47.735
TO COVER ALL COSTS EXCEPT RISK	82.262

District 3 MS 79-6

Crop Enterprise Budgets — 1985

Rob Brooks, Extension Associate
C. Wilson Gray, Extension Economist
University of Idaho Department of Agricultural Economics

Spring Barley
Southcentral Idaho

BUDGET ID # -- 79 303100 142 1
ANNUAL CAPITAL MONTH 9

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST	YOUR VALUE
1. GROSS RECEIPTS FROM PRODUCTION				$	
BARLEY	CWT.	5.25	70.00	367.50	______
TOTAL				$ 367.50	______
2. VARIABLE COSTS					
PREHARVEST				$	
BARLEY SEED	LB.	0.12	110.00	13.20	______
NITROGEN	LB.	0.32	120.00	38.40	______
AVENGE	PT.	5.30	3.16	16.75	______
2-4-D AMINE	QT.	2.25	1.00	2.25	______
SPRAYER	ACRE	1.00	2.00	2.00	______
WATER ASSESSMENT	ACRE	18.00	1.00	18.00	______
MACHINERY	ACRE	9.34	1.00	9.34	______
TRACTORS	ACRE	11.72	1.00	11.72	______
IRRIGATION MACHINERY	ACRE	25.03	1.00	25.03	______
LABOR(TRACTOR & MACHINERY)	HOUR	5.50	2.54	13.96	______
LABOR(IRRIGATION)	HOUR	4.75	1.30	6.18	______
INTEREST ON OP. CAP.	DOL.	0.13	54.32	7.06	______
SUBTOTAL, PRE-HARVEST				$ 163.89	______
HARVEST COSTS				$	
MACHINERY	ACRE	12.98	1.00	12.98	______
LABOR(TRACTOR & MACHINERY)	HOUR	5.50	1.08	5.94	______
SUBTOTAL, HARVEST				$ 18.92	______
TOTAL VARIABLE COST				$ 182.82	______
3. INCOME ABOVE VARIABLE COSTS				$ 184.68	______
4. FIXED COSTS				$	
MACHINERY	ACRE	102.91	1.00	102.91	______
TRACTORS	ACRE	33.17	1.00	33.17	______
LAND (NET RENT)	ACRE	70.00	1.00	70.00	______
OVERHEAD	ACRE	7.55	1.00	7.55	______
TOTAL FIXED COSTS				$ 213.64	______
5. TOTAL COSTS				$ 396.45	______
6. NET RETURNS TO RISK				$ -28.95	______

IRRIGATED-CENTER PIVOT
LAND CHARGE-CASH RENT

BREAKEVEN PRICES
IF 70.00 CWT. BARLEY ARE PRODUCED:

TO COVER PREHARVEST VARIABLE INPUTS	2.341
TO COVER HARVEST VARIABLE INPUTS	0.270
TO COVER FIXED INPUTS	3.052
TO COVER ALL COSTS EXCEPT RISK	5.664

District 4 MS 77-5

Crop Enterprise Budgets — 1985

Rob Brooks, Extension Associate
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University of Idaho Department of Agricultural Economics

Commercial Potatoes
Southeastern Idaho

BUDGET ID # -- 77 401900 114 1
ANNUAL CAPITAL MONTH 10

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST	YOUR VALUE
1. GROSS RECEIPTS FROM PRODUCTION				$	
COMM.POTATOES	CWT.	4.75	275.00	1306.25	______
TOTAL				$1306.25	______
2. VARIABLE COSTS					
PREHARVEST				$	
SEED POTATOES	CWT.	7.50	20.00	150.00	______
NITROGEN	LB.	0.33	215.00	70.95	______
PHOSPHATE	LB.	0.26	150.00	39.00	______
POTASH	LB.	0.16	100.00	16.00	______
APPLY FERTILIZER	ACRE	5.00	1.00	5.00	______
TEMIK	LB.	2.40	20.00	48.00	______
SENCOR	QT.	23.00	0.50	11.50	______
BRAVO	QT.	7.00	1.00	7.00	______
AIR SPRAY	ACRE	4.50	2.00	9.00	______
POTATO STORAGE	CWT.	0.75	275.00	206.25	______
WATER ASSESSMENT	ACRE	11.50	1.00	11.50	______
SEED CUT & TREAT	CWT.	0.50	20.00	10.00	______
DINITRO	QT.	2.70	1.50	4.05	______
PROMOTION TAX	CWT.	0.04	275.00	9.90	______
SOIL/PET. TEST	ACRE	2.00	1.00	2.00	______
MICRO NUTRIENTS	ACRE	11.00	1.00	11.00	______
MACHINERY	ACRE	30.11	1.00	30.11	______
TRACTORS	ACRE	21.03	1.00	21.03	______
IRRIGATION MACHINERY	ACRE	39.90	1.00	39.90	______
LABOR(TRACTOR & MACHINERY)	HOUR	5.50	3.39	18.63	______
LABOR(IRRIGATION)	HOUR	4.75	9.45	44.89	______
OTHER LABOR	HOUR	5.25	3.50	18.38	______
INTEREST ON OP. CAP.	DOL.	0.13	188.57	24.51	______
SUBTOTAL, PRE-HARVEST				$ 808.60	______
HARVEST COSTS				$	
MACHINERY	ACRE	49.03	1.00	49.03	______
TRACTORS	ACRE	13.40	1.00	13.40	______
LABOR(TRACTOR & MACHINERY)	HOUR	5.50	3.75	20.62	______
SUBTOTAL, HARVEST				$ 83.05	______
TOTAL VARIABLE COST				$ 891.65	______
3. INCOME ABOVE VARIABLE COSTS				$ 414.60	______
4. FIXED COSTS				$	
MACHINERY	ACRE	91.03	1.00	91.03	______
TRACTORS	ACRE	59.58	1.00	59.58	______
IRRIGATION MACHINERY	ACRE	50.40	1.00	50.40	______
LAND (NET RENT)	ACRE	250.00	1.00	250.00	______
OVERHEAD	ACRE	29.99	1.00	29.99	______
TOTAL FIXED COSTS				$ 481.01	______
5. TOTAL COSTS				$1372.66	______
6. NET RETURNS TO RISK				$ -66.41	______

LAND CHARGE-CASH RENT
IRRIGATED-HAND LINE
ADD. HARVEST LABOR IS ACCOUNTED FOR IN PREHARVEST "OTHER LABOR"

BREAKEVEN PRICES

IF 275.00 CWT. COMM.POTATOES ARE PRODUCED:

TO COVER PREHARVEST VARIABLE INPUTS	2.940
TO COVER HARVEST VARIABLE INPUTS	0.302
TO COVER FIXED INPUTS	1.749
TO COVER ALL COSTS EXCEPT RISK	4.991

District 3 MS 79-12

Crop Enterprise Budgets — 1985

Rob Brooks, Extension Associate
C. Wilson Gray, Extension Economist
University of Idaho Department of Agricultural Economics

Potatoes
Southcentral Idaho

BUDGET ID # -- 77 305900 142 1
ANNUAL CAPITAL MONTH 10

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST	YOUR VALUE
1. GROSS RECEIPTS FROM PRODUCTION				$	
COMM.POTATOES	CWT.	4.25	310.00	1317.50	______
TOTAL				$1317.50	______
2. VARIABLE COSTS					
PREHARVEST				$	
SEED POTATOES	CWT.	7.50	25.00	187.50	______
NITROGEN	LB.	0.32	220.00	70.40	______
PHOSPHATE	LB.	0.24	110.00	26.40	______
POTASH	LB.	0.16	80.00	12.80	______
SENCOR	LB.	26.25	1.00	26.25	______
TEMIK	LB.	2.50	3.00	7.50	______
BRAVO	QT.	6.50	0.75	4.88	______
SIDEDRESS	ACRE	8.00	1.00	8.00	______
AIR SPRAY	ACRE	6.25	2.00	12.50	______
FERT. SPREADER	ACRE	1.00	1.00	1.00	______
POTATO STORAGE	CWT.	0.60	310.00	186.00	______
WATER ASSESSMENT	ACRE	18.00	1.00	18.00	______
SEED TREATMENT	CWT.	0.50	25.00	12.50	______
SOIL/PET. TEST	ACRE	2.00	1.00	2.00	______
MACHINERY	ACRE	50.88	1.00	50.88	______
TRACTORS	ACRE	14.18	1.00	14.18	______
IRRIGATION MACHINERY	ACRE	29.02	1.00	29.02	______
LABOR(TRACTOR & MACHINERY)	HOUR	5.50	4.17	22.94	______
LABOR(IRRIGATION)	HOUR	4.75	1.92	9.13	______
OTHER LABOR	HOUR	5.25	5.00	26.25	______
INTEREST ON OP. CAP.	DOL.	0.13	212.85	27.67	______
SUBTOTAL, PRE-HARVEST				$ 755.79	______
HARVEST COSTS				$	
DINITRO	PT.	2.75	1.50	4.13	______
MACHINERY	ACRE	52.12	1.00	52.12	______
TRACTORS	ACRE	10.86	1.00	10.86	______
LABOR(TRACTOR & MACHINERY)	HOUR	5.50	3.80	20.88	______
SUBTOTAL, HARVEST				$ 87.99	______
TOTAL VARIABLE COST				$ 843.78	______
3. INCOME ABOVE VARIABLE COSTS				$ 473.72	______
4. FIXED COSTS				$	
MACHINERY	ACRE	146.94	1.00	146.94	______
TRACTORS	ACRE	57.93	1.00	57.93	______
LAND (NET RENT)	ACRE	190.00	1.00	190.00	______
OVERHEAD	ACRE	28.41	1.00	28.41	______
TOTAL FIXED COSTS				$ 423.28	______
5. TOTAL COSTS				$1267.06	______
6. NET RETURNS TO RISK				$ 50.44	______

IRRIGATED-CENTER PIVOT
LAND CHARGE-CASH RENT

BREAKEVEN PRICES
IF 310.00 CWT. COMM.POTATOES ARE PRODUCED:

TO COVER PREHARVEST VARIABLE INPUTS	2.439
TO COVER HARVEST VARIABLE INPUTS	0.285
TO COVER FIXED INPUTS	1.367
TO COVER ALL COSTS EXCEPT RISK	4.090

Appendix B

COMPUTATION OF HYDROPOWER VALUES

This appendix provides additional details on how the hydropower values shown in Table 4 were computed. These computations are shown in Table B1. Table B1 is based on streamflow data from Tables 2 and avoided cost data from Table 3.

Each row of Table B1 represents one year from the historic record. These years are ordered as they were in Table 2; from driest to wettest. Each pair of columns refers to an alternative possible level of intervention and assured streamflow. For example, the column pair headed 19.61 refers to an intervention probability of 19.61 percent. Table 2 showed that this would be sufficient to assure a flow of 8042 cfs at Murphy, and would require a contractual commitment to 625,715 acre-feet of water. Using the historic streamflow record, all of this contract water would have been needed in 1935, 82 percent would have been needed in 1934, and so on.

In each year the hydropower value per acre-foot of contract water can be computed as:

$$\text{Value} = 1264\ [(5.65 * P) + (2.88\ (1-P))]$$

where P is the portion of the contract water that must be delivered in that year. The 1264 is the number of kwh that can be generated at Idaho Power Company dam by water in or above American Falls Reservoir. The term (5.65 * P) is the value of the power actually generated by the delivered water, while the term (2.88 (1-P)) represents the value of the additional power which can now be considered firm because the contract assures its availability.

Table B1. Quantity, Probability of Intervention and Hydropower Value of Market Water

YEAR OF RECORD	PROBABILITY OF INTERVENTION: 1.96		3.92		5.88		7.84		9.80		11.76		13.73		15.69		17.65		19.61		21.57		23.53		25.49	
	REQUIRED CONTRACT SIZE: 112,425		184,077		334,420		408,831		428,303		462,249		523,579		551,947		594,838		625,715		677,615		751,578		894,198	
	PART	VALUE	PART	VALUE	PART	VALUE	PART	VALUE	PART	VALUE	PART	VALUE	PART	VALUE	PART	VALUE	PART	VALUE	PART	VALUE	PART	VALUE	PART	VALUE	PART	VALUE
1935	1.00	71.42	1.00	71.42	1.00	71.42	1.00	71.42	1.00	71.42	1.00	71.42	1.00	71.42	1.00	71.42	1.00	71.42	1.00	71.42	1.00	71.42	1.00	71.42	1.00	71.42
1934	0.00	36.40	0.39	50.02	0.66	59.62	0.73	61.79	0.74	62.21	0.76	62.87	0.79	63.89	0.80	64.27	0.81	64.76	0.82	65.11	0.83	65.60	0.85	66.16	0.87	67.00
1961	0.00	36.40	0.00	36.40	0.45	52.12	0.55	55.63	0.57	56.36	0.60	57.45	0.65	59.09	0.67	59.72	0.69	60.56	0.71	61.09	0.73	61.89	0.76	62.84	0.79	64.20
1931	0.00	36.40	0.00	36.40	0.00	36.40	0.18	42.78	0.22	44.07	0.28	46.07	0.36	49.04	0.39	50.20	0.44	51.70	0.47	52.68	0.51	54.12	0.56	55.84	0.63	58.32
1941	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.05	37.98	0.12	40.43	0.22	44.07	0.26	45.47	0.31	47.33	0.35	48.52	0.40	50.27	0.46	52.37	0.54	55.38
1937	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.07	38.96	0.18	42.74	0.22	44.25	0.28	46.17	0.32	47.43	0.37	49.25	0.43	51.46	0.52	54.64
1932	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.12	40.50	0.16	42.08	0.22	44.18	0.26	45.54	0.32	47.50	0.38	49.85	0.48	53.31
1933	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.05	38.19	0.12	40.57	0.16	42.11	0.23	44.35	0.30	47.01	0.41	50.90
1936	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.07	38.92	0.12	40.50	0.19	42.88	0.27	45.68	0.38	49.78
1940	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.05	38.12	0.12	40.67	0.21	43.69	0.33	48.10
1942	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.08	39.06	0.17	42.25	0.30	46.91
1959	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.10	39.83	0.24	44.88
1955	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.16	41.97
1930	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1938	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1960	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1978	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1977	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1945	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1939	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1929	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1967	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1963	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1962	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1953	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1968	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1944	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1954	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1948	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1964	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1947	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1958	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1949	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1966	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1970	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1950	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1956	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1946	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1943	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1973	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1957	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1928	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1969	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1965	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1952	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1974	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1975	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1951	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1976	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1971	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
1972	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40	0.00	36.40
AVE	0.02	37.09	0.03	37.36	0.04	37.85	0.05	38.09	0.05	38.17	0.06	38.34	0.06	38.68	0.07	38.84	0.08	39.11	0.08	39.31	0.09	39.67	0.11	40.16	0.13	40.98
PRES VAL		645.85		650.50		659.14		663.25		664.63		667.62		673.48		676.36		681.01		684.59		690.77		699.30		713.64
AVE/AF		1891.58		1371.63		914.07		790.94		757.13		693.14		595.74		557.69		506.10		472.78		425.21		374.36		313.32