AN ECONOMIC ANALYSIS OF THE EFFECTS OF A DECLINING GROUND WATER LEVEL IN THE RAFT RIVER BASIN, CASSIA COUNTY, IDAHO

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HENRY LEE SCHATZ

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ABSTRACT

Ground water decline has become a serious problem in may semi-arid areas of the western United States. Idaho has designated five areas in which ground water decline has become critical. This study examined the effects of a declining ground water level in the Raft River Basin, the largest of the critical ground water areas. Dissimilar crop possibilities to climate differences in the basin necessitated its division into a northern and a southern portion.

Linear programming analysis was applied to farm plans developed for the two areas to estimate returns to operator labor and management for the farm plans. The effects on returns of 1,2,3,4,5, and 10 feet of yearly decline for a 20 year period were examined to evaluate the seriousness of decline in the study area.

Decline does affect farm returns, but not as seriously as had been anticipated. The location of the farm within the study area and the crop mix chosen for production on a farm have far more serious effects on returns than decline or depth to water. Administration of the ground water resource by examining the rate of ground water decline along ignores more important factors affecting farm returns.

CHAPTER I

Ground Water Irrigation In Idaho

Introduction

Agriculture has historically held an important position in the development of the American West. Early agricultural development occurred in the areas, usually the fertile valley bottoms, where adequate rainfall or surface water was available to produce crops.

The diversion of surface water was the only method of irrigation available to early farmers. Irrigated land was limited to level or nearly level land near streams and rivers which could be flooded by diverting water from the streams or river channels onto the land. In Idaho only small tracts of land in several river valleys were initially irrigated. As the demand for agricultural products increased and the technology of irrigation systems grew, more acreages of land were brought into production. The irrigation water used to obtain this increased production was obtained primarily from surface water diversions, but pumping from shallow ground water aquifers also began to provide significant amounts of irrigation water.

Since the early 1950's ground water pumping has played an increasingly important role in irrigated agriculture and other water uses in Idaho. The introduction of deep well turbine pumps which lift water from hundreds of feet below the land surface has made it possible to irrigate additional farmland in the state.

The total acreage of land in Idaho irrigated by ground water was estimated in 1966 to be approximately one million acres. The importance of ground water in irrigation is easily seen when this one million acre figure is compared to the estimated total of irrigated cropland in Idaho, 3,750,000 acres (1). In addition to providing over ¼ of the irrigation water in the state, ground water also provides much of the water used for domestic purposes. This increased use of ground water, however, has not been without accompanying problems for management and administration of the resource.

Administration

Ground water in Idaho is administered along with surface water under the appropriation doctrine of water law. Three important and basic portions of the Idaho Code relating to ground water are:

> ..., while the doctrine of "first in time is first in right" is recognized, a reasonable exercise of this right shall not block full economic development of underground resources, but early appropriators of underground water shall be protected in the maintenance of reasonable ground water pumping levels as may be established by the Director of the Department of Water Administration as herein provided. (Section 42-226)
>
> "Critical ground water area" is defined as any ground water basin or designated part thereof, not having sufficient ground water to provide

> a reasonably safe supply for irrigation of cultivated lands, or other uses in the basin at the then current rates of withdrawal, or rates of withdrawal projected by consideration of valid and outstanding application and permits....(Section 42-233a).
>
> .... Water in a well shall not be deemed available to fill a water right therein if withdrawal therefrom of the amount called for by such right would affect, contrary to the declared policy of this act, the present or future use of any prior surface or ground water right or result in the withdrawing of the ground water supply at a rate beyond the reasonably anticipated average rate of future natural recharge....(Section 42-237a-g).

To date, administration of ground water has been limited, with one exception, to the designation of five critical ground water areas in the state. All five closure decisions have been based on the belief that unappropriated ground water was no longer available within the areas.

The administrative case which is an exception to the simple designation of a critical ground water area is the Cottonwood critical ground water area. This critical ground water area in western Cassia County (northwest of Oakley) has been closed to additional development as the other areas have, but in addition, pumping from several wells in the area have been curtailed by court order. A recent Idaho Supreme Court decision, Baker vs Ore-Ida Foods, Inc., upheld the critical ground water designation and curtailment of pumping order on the grounds that Idaho does not allow mining (permanent depletion of the resource) of ground water and that mining had been occurring in the area.

Two important points of the Idaho Code concerning ground water administration, which were not considered when the critical ground water areas were designated, were "full economic development" of the resource and "maintenance of reasonable ground water pumping levels". Both of these phrases are difficult to define. The intent of the language was to protect individual rights and provide full development of the resource. However, the two phrases are in conflict. "Full economic development" of the resource could take on many meanings for various groups interested in ground water administration. The Idaho Department of Water Administration defines reasonable pumping lift to be the "distance water can be lifted by a typical irrigator for an economically-sized cropping unit. The quantity of water pumped, the payment capacity, and cost per unit of water are those assumed to be typical of the area" (2). In attempted to clearly define the point of "reasonable pumping lift", the vagueness of the phrase is compounded by the introduction of "a typical irrigator" and "an economically-sized cropping unit".

When the above two points are considered, administration of the ground water resources is not an easy task, but it is a problem which must be met. The resource management problems in Idaho are not unique, but are faced by most arid-land states.

The options of ground water resource management can be described by the following alternative strategies put forth by Butcher, _et al_.. 1971, (3):

- preserve the resource in its entirety for future use
- restrict withdrawal to no more than recharge
- limit depletion of the resource to a predetermined rate or amount
- allow uncontrolled depletion of the resource

These alternatives involve serious issues which must be examined in the determination of a management plan for the ground water resources in Idaho.

Purpose

In 1971 Dale Ralston of the Idaho Bureau of Mines and Geology proposed a study to analyze the impact of legal constraints on ground water resource development in Idaho. The study included the construction of a mathematical model of a ground water system, legal analysis of ground water administration and application of legal constraints to the mathematical model. The Raft River Basin was chosen as the study area because it is the largest of the five critical ground water areas in Idaho and the only one that may be considered as a hydrologic unit. An economic analysis was deemed necessary in the study to determine the value of irrigation water in the basin. This paper presents an examination and interpretation of the economic impacts on various types of agricultural enterprises in the Raft River Basin from various water management alternatives.

Objectives

Numerous alternatives exist for possible management of the basin. These alternatives and their associated consequences should be examined if wise management decisions are to be made. This economic analysis of the alternatives is presented as an input to that examination.

The objectives of this study are as follows:

1. To find, refine and apply a suitable method for estimating the economic value of water pumped from the aquifer system in the Raft River Basin.
2. To estimate the benefits and costs associated with varying rates of ground water decline in the basin.
3. To estimate the opportunity cost or value foregone by not pumping the ground water.

Area Description

The Raft River Basin, approximately 1,510 square miles in size, is located primarily in southcentral Idaho (Figure 1) in the eastern half of Cassia County. The southern most portion of the basin is in Utah.

The basin when studied by Walker and others (1970) was divided into the three subdivisions of the Raft River Valley, Yost-Almo and Elba. This study is limited to the Raft River Valley portion of the basin, the area where the greatest ground water decline has occurred

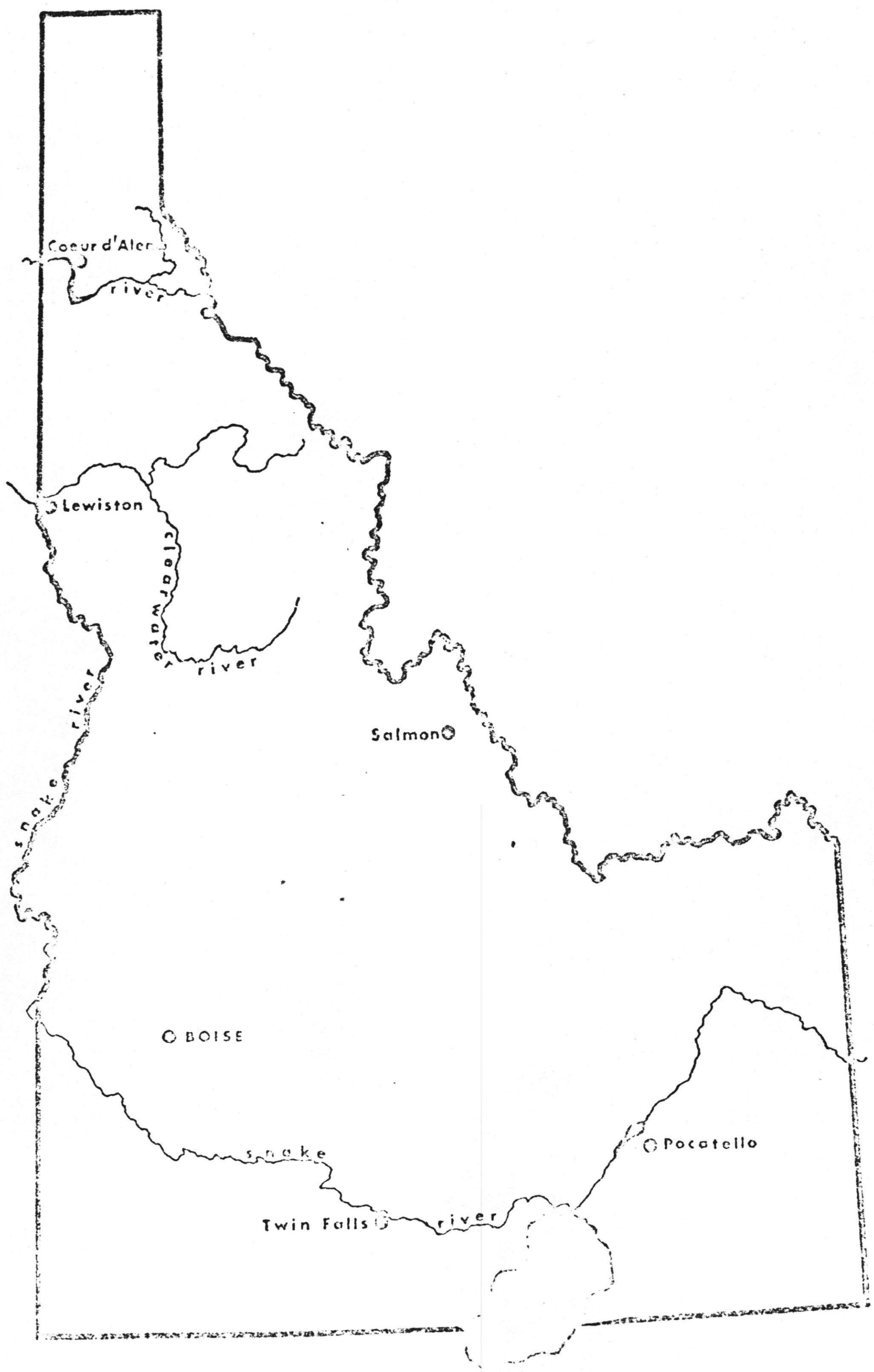


Figure 1: Index Map of the Raft River Basin, Idaho, and Utah.

(Figure 2). Ground water decline has been of little or no importance in the Yost-Almo and Elba areas to date.

The floor of the Raft River Valley is an alluvial plain 10 to 15 miles wide and 40 to 50 miles long. The land surface rises gently from the Raft River in the central part of the valley with steepening slopes near the mountains. The altitude of the valley floor is about 4,200 feet at Malta, and between 5,000 and 5,200 feet along the south end of the valley (4).

The rugged mountains surrounding three sides of the Raft River Basin form the hydrologic boundary of the basin. The Albion Range forms the western boundary of the basin. Another range in the western portion of the basin, the Cotterell Range, separates the Raft River Valley sub-basin from the Yost-Almo and Elba sub-basins. The Goose Creek Range and the Raft River Mountains form the southern boundary of the basin. The eastern boundary of the basin is formed by the Black Pine and Sublett Mountain Ranges. (Hereinafter the word "basin" will be used in reference to the Raft River Basin as a whole and the word "valley" will be used in reference to the main Raft River Valley.)

Average annual precipitation in the basin varies from less than 10 inches on the valley floor to more than 30 inches in the surrounding mountains. The majority of this precipitation falls during the winter with only small amounts falling during infrequent summer storms (4).

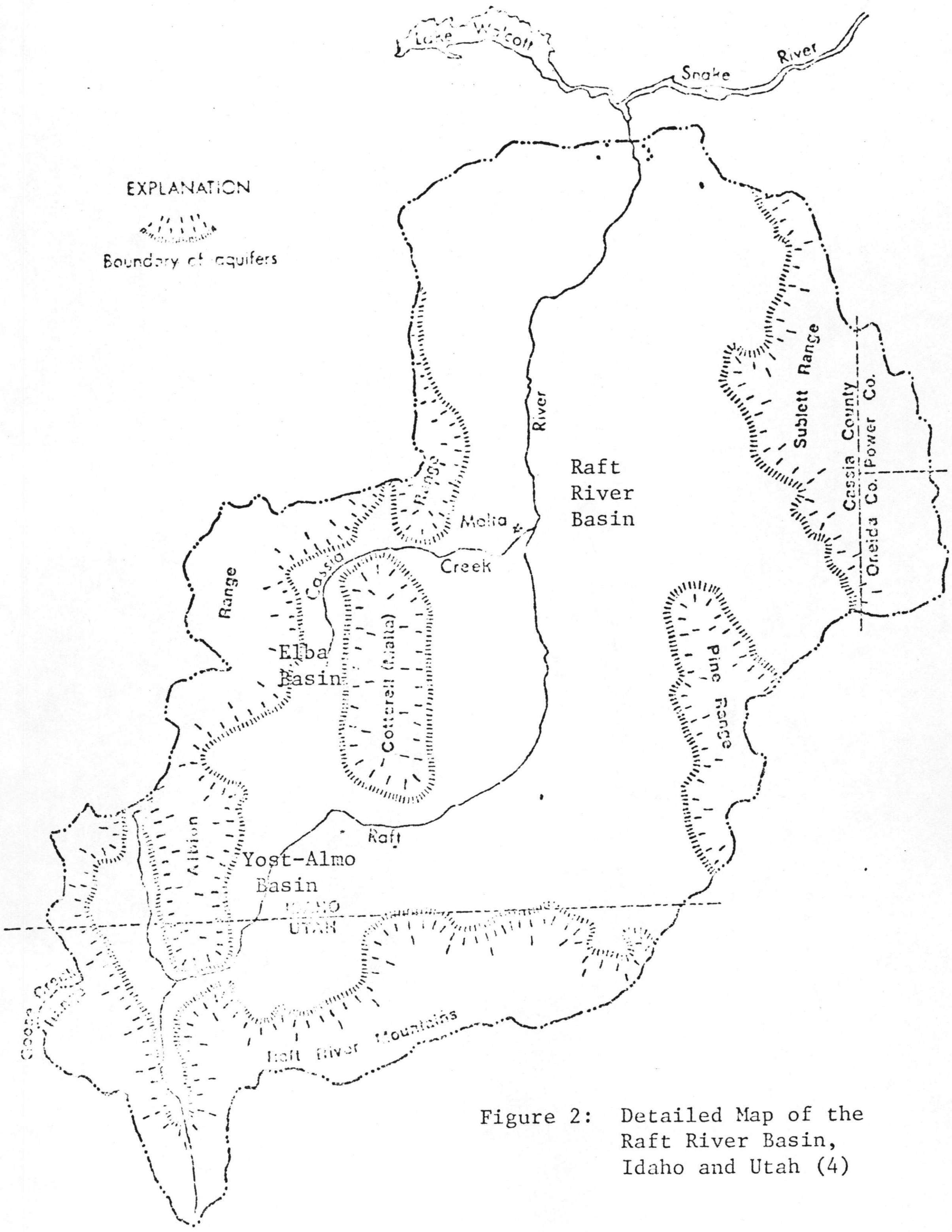


Figure 2: Detailed Map of the Raft River Basin, Idaho and Utah (4)

In 1966 the irrigated land in the Idaho portion of the Raft River Basin totaled about 83,000 acres. Total irrigated area in both Idaho and Utah was about 87,000 acres. At that time approximately 80%, or 69,000 acres, was irrigated partially or wholly with ground water (4). The location of land presently irrigated closely correlates with the land designated by the Idaho Water Resources Board as Class 1 potential for irrigation. Class 1 lands are defined as soils with slight irrigation limitations where gravity type systems are feasible (5). The board further defines the eastern portion of the valley as having only a slightly restricted potential for irrigation (Class 2) if water were available. Gravity type irrigation is deemed feasible (5). With the majority of the valley having a slope of 12% or less, much of the remaining undeveloped lowland area of the valley, about 345,000 acres, could probably be irrigated if water were available.

Pertinent Literature

Since the problems associated with a declining ground water level are not unique to Idaho, there is a considerable volume of literature available relating to the problems. Examination of this literature provides insight into the specific problems found in other areas which have experienced declining ground water levels, presents various alternatives which have or can be applied to Idaho's problems, and points out weaknesses in many studies undertaken.

States in the south and southwest have experienced ground water decline problems for a number of years because of the relatively small available surface water supplies. Their problems are in many cases more serious than Idaho's, but often their research does not examine all the elements associated with the problem of a declining ground water level. Few studies involving ground water have been undertaken using an interdisciplinary approach. Reports dealing with ground water problems are usualy quite thorough in one area, usually economics, geology, hydrology, or engineering, but most fail to examine all facets of the problem.

A 1966 study by Harold M. Stults in Pinal County, Arizona, attempted to predict the farmer response to a falling ground water level. The summary of the results of the study suggest that:

> Pinal County farmers...will continue to face declining net returns as the cost of tapping the stock of water increases. Various adjustments will have to be made as the stock of water decreases. Some of these adjustments will occur in land values, net income to farmers, and the number of farmers.

The study does a thorough job of examining the economics of ground water decline, but doesn't relate the economics of ground water decline to other factors , i.e., geology, hydrology, law, etc., that affect the rate of decline. Stults reaches obvious conclusions and makes slight mention of how the problems of decline may be overcome or at least minimized.

A State of Washington Water Research Center publication, "Long-Run Costs and Policy Implications of Adjusting to a Declining Water Supply in Eastern Washington" (3) was one of the first publications in the water resource field covering a study dealing with the problems of ground water decline from an interdisciplinary approach. The study examined the geohydrology of the area, the engineering aspects of deep well pumping in a declining water level situation, the economics of various underground water supply conditions, and the consequences of various ground water policies.

Conclusions of the study state that:

> If pumping depths reach 700-1000 feet...irrigation will be unprofitable. However, depth to water is not the only concern as rate of decline in water level has at least as serious an impact on returns. A rapid drawdown more than 20 feet per year, causes rapid obsolesence of well and pump equipment.... A preferred approach (of management)...provides for early protection (of appropriators) so that maximum economic returns can be gained....

Lindeborg (1970) used linear programming techniques in his study to determine the economic values of irrigation water in four areas of Idaho. The study's main objective was to determine the MVP (Marginal Value Product) of water as a factor of production on irrigated farms. (MVP of water was defined as the value of the increase in output obtained by adding an additional acre-foot of water to a fixed amount of other production factors.) The study dealt with surface water irrigation and a fixed water supply to determine what the value (price a farmer would be willing to pay) was for the last acre-foot of water used on the farm. Lindeborg concluded that the value of water was dependent on the crops irrigated on the farm. His results also showed an increased ability to pay for water with increased farm size.

Previous studies in the Raft River Basin have been basically geological or hydrological in nature. R.L. Nace in his 1961 study for the United States Geological Survey compiled the first comprehensive overview of the water resources of the Raft River Basin. The purpose of the study

> was to estimate the total water yield of the basin, the parts of that yield that are available as surface water and ground water, the amount of ground water that might be recovered for beneficial use and the effects of such use on downstream water supplies.

The study examined the geography, geology, and water resources of the basin to provide a basis for formulation of the water budget for the basin.

In August, 1970, the Idaho Department of Water Administration issued Water Information Bulletin No. 19, "The Raft River Basin, Idaho-Utah, as of 1966: A Reappraisal of the Water Resources and Effects of Ground Water Development" (4). New and additional information on well drilling, mapping of irrigated acreage, precipitation, streamflow, pumpage and ground water levels of the basin was used in the study to re-evaluate the elements of the basin's hydrologic budget and refine quantitative estimates made during earlier studies (4).

Information in Walker's study referring to the hydrologic budget and other ground water associated activities in the basin provided the information base for this study.

CHAPTER II

Development in the Raft River Basin

The Move to Irrigated Agriculture

The Raft River Valley was settled by stockmen before 1870. Early settlement occurred in the meadowland adjacent to the river and streams in the valley. Summer range for the cattle herds was available in the mountain ranges surrounding the Raft River Basin, however, herds were wintered in the valley bottom near the meadowland areas. Development and change from "cattle country" to farmland came slowly in the valley. Early crop farming in the valley mainly provided feed for the cattle in the area. The greatest surge of agricultural development in the basin began during the period following World War II. From 1948 through 1955 ground water pumpage for the irrigation of crops increased in the valley from about 8,700 acre-feet per season to 64,000 acre-feet per season (6). Development continued into the early 60's, but at a slower rate.

The early development of agriculture was largely the result of people taking advantage of the Desert Land Act of 1877. The original intention of the act was to make semi-arid lands in the West available at little cost to individuals who were willing to irrigate and farm the land. The act as it was originally written, however, was greatly abused by land developers and speculators. Complaints concerning fraudulant entries made under the act prompted Congrees in

1891 to pass the General Revision Act, an act designed to minimize the misuse of the Desert Land Act of 1877 (7).

Persons filing entries were, after 1891, required to show their plans for irrigating the land, including the canals and ditches projected and source of water. They were required to expend $1 per acre in each of the first 3 years constructing irrigation works and leveling the land. They were permitted to associate together in planning the construction of irrigation works, but had to affirm that they were not making the entries for others, either corporate or individual. The acreage that could be entered was reduced from 640 acres to 320 acres. Entrymen were required to be residents of the state in which they were filing and were allowed 4 years to prove up and pay their dollar an acre (7).

The Desert Land Act made it possible for many people to obtain inexpensive farmland in the Raft River Basin. The initial investment costs of farming, however, were more than many individuals could cope with. Much of the land in the area has changed ownerships many times since it was originally settled. Today, large tracts of land in the valley are owned by corporate-type enterprises, several of which are controlled by out-of-state interests.

Problems Accompanying Development

After 1948 much of the development in the Raft River Basin occurred in the northern portion of the Raft River Valley on the west side of the river and along a narrow strip on either side of the river in the southern portion of the valley. Well construction on these new acreages resulted in a heavy concentration of wells along the Raft River in the south and in several areas in the north (Figure 3). Between 1952 and 1965, several areas in the valley experienced ground water declines of up to 50 feet (4).

In addition to the problem of ground water decline, development of new farm lands under the Desert Land Act brought about another important problem in the basin -- the feeling early settlers, primarily cattlemen, held toward new development in the basin. Individuals in the valley who feared continued development and/or depletion of the ground water resource sought closure of the valley to further development.

Regardless of whether closure was sought for personal feelings against development or legitimate fears of continued depletion of the ground water resource, Carl E. Tappin, State Reclamation Engineer, on July 23, 1963, issued the "Raft River Critical Ground Water Area Order". The order prohibited approval of new permits for ground water rights in the area. But it did not stop the decline of the ground water level. From 1965 to 1972, several areas in the valley still experienced up to 20 feet of decline (10); although, some wells close

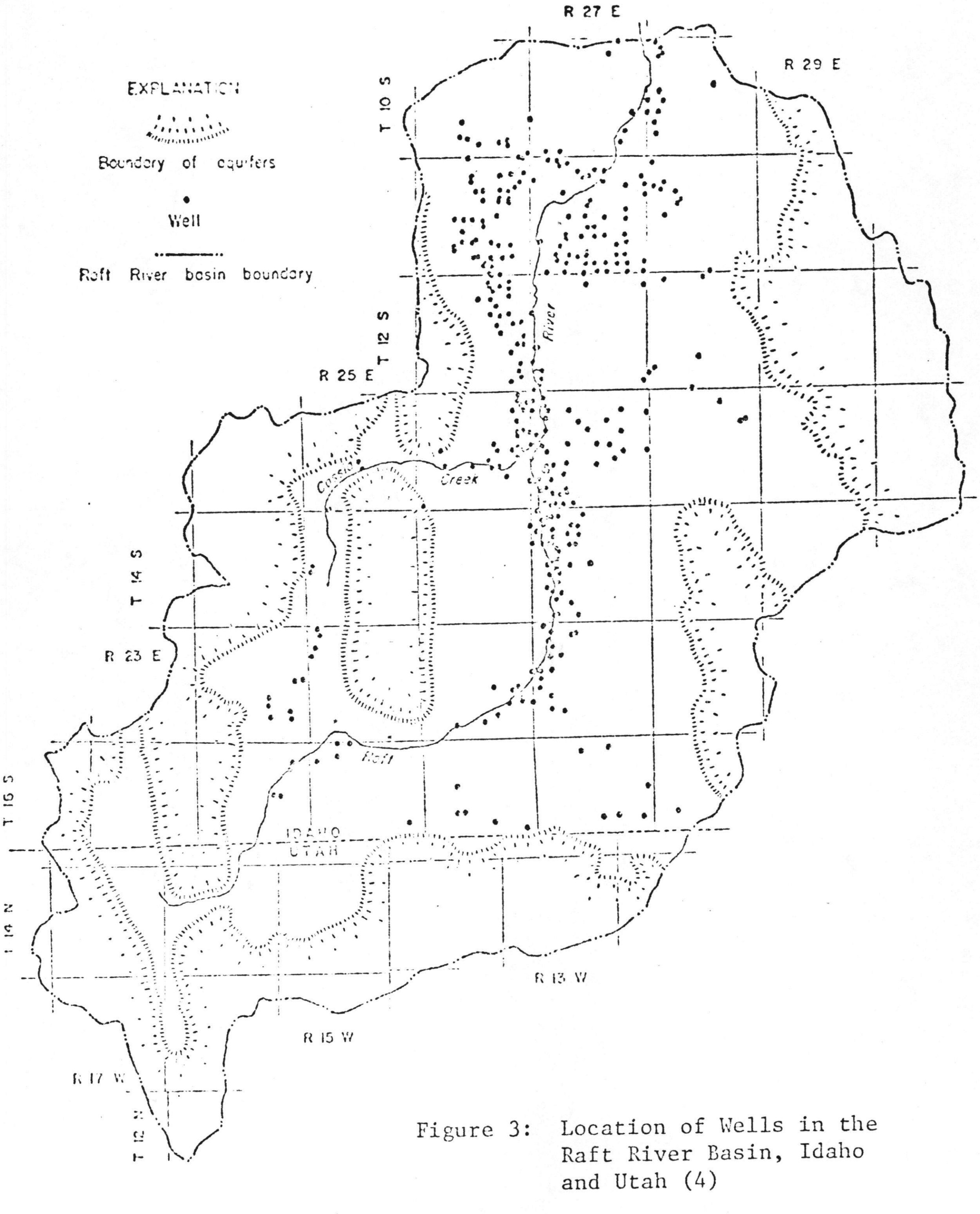


Figure 3: Location of Wells in the Raft River Basin, Idaho and Utah (4)

to the Raft River showed increases in water level for the time period, which may be attributable to the above average runoff in the Raft River Basin during that time.

CHAPTER III

Examining Farm Enterprises in the Raft River Basin

The first objective of this study was to find, refine and apply a suitable method for estimating the economic value of water pumped from the Raft River Basin aquifer. In this study the value of irrigation water on a farm is the value of the crops grown and irrigated with water pumped from the aquifer. This was assumed to be an appropriate method of valuation since land without irrigation water could only be used as a desert grazing area of little value. To find the irrigation water value, an examination of each farm in the area might have been conducted to determine the value of the farm's outputs, but realizing that time and money would not allow such an intensive study another suitable method was found.

The method chosen for use in this study was Linear Programming (LP) analysis. When LP is used in a study such as this, information collected from a sample of farm enterprises can be examined and extrapolated to determine the potential incomes to other similar farms. Linear programming is an empirical tool used by agricultural economists and others to specify the optimum organization of resources and enterprises. This optimum may be either a profit maximization or cost minimization soulution. Linear programming can be applied to any problem for which an objective can be expressed in quantitative terms. To apply LP analysis to a farming enterprise, certain information regarding resources available, i.e., land, labor, water for irrigation, etc., costs of production and returns from farm products produced must be available. Once this information is gathered and brought together to form activity budgets for farms, LP analysis can be applied.

Data Collection

Data collection for this study began in the Raft River Basin with personal interviews with the local Rural Electric Association representatives who provided a brief history of the area and pointed out changes which had taken place in the basin over the past 20 years. They provided initial information concerning farmers and farm practices, wells and pumping, and in general provided an information base from which to work. During the months of July and August, 1972, interviews with local farm operators, farm supply co-ops, well drillers, pumping equipment suppliers, SCS and ASCS officials and various financial institutions were undertaken to gather information on agricultural activities in the Raft River Basin.

The local ASCS office was helpful in providing information concerning crop yields and acreages of various farms in the study area. The SCS office in Burley, Idaho, provided information concerning irrigation practices in the Raft River Valley. In addition, they furnished the names of farmers who were cooperating with their agency. Co-ops in the area provided information concerning farm input costs and practices.

Financial institutions in the area were contacted to determine lending practices in the area and to determine land values for the study area. The Federal Land Bank was very helpful in this respect.

Several well drillers in the area were contacted, but the information presented in this study is primarily from one driller who has been operating in the area for the past 20 years. His only job is well drilling, whereas others contacted were periodically in and out of the business. Information was gathered on the size of wells drilled in the area, costs of drilling and problems found in the study area, i.e., water level decline, water quality differences of wells, and sand problems in wells.

Pumping equipment suppliers provided information concerning system design, complexity of that design for any given well, and cost estimates of various pumping equipment.

Interviews with farm operators were conducted using a questionnaire developed to obtain an overview of the entire farm operation. Farm operator cooperation in completing the questionnaire was low. The number of interviews and questionnaires completed concerning farm practices in the basin was of inadequate size to be of statistical value in this study. Therefore, the farm budgets used in this study are a mixture of actual primary data gathered from farmers and secondary information from various other sources which was assumed to be reasonably representative of the costs and returns experienced by farmers in the study area.

Study Area Division

It was noted early in the study that the agricultural activities in the Raft River Basin varied greatly from the northern end of the study area to the southern end. The basin was thus divided into two portions for study purposes. The line chosen to divide these two areas is drawn east-west across the Raft River valley floor. It is located two miles south of the township line between townships 11 and 12 south (Figure 4).

From this line south, early fall frosts prohibit the growing of sugar beets and potatoes. The growth of these crops has been attempted, but with unsatisfactory results. Field crops found in the southern area of the valley are alfalfa hay, pasture, silage corn, and various grain crops. The northern portion of the valley with its longer growing season has these crop possibilities, plus the additional high cash value crops of potatoes and sugar beets.

The division of the valley into two areas is also based on differences in pump sizes found in the basin. Pumps are, on the average, of greater horsepower and yield in the northern section than those found in the southern portion of the basin. A distribution of the pumps in the northern and southern sections of valley, presented in a later section, clearly shows the difference in pump sizes in the two areas. The major reasons for the larger pumps in the northern section of the study area are (1) greater average depths to water in that area; (2) increased yields required from these pumps to provide the necessary irri-

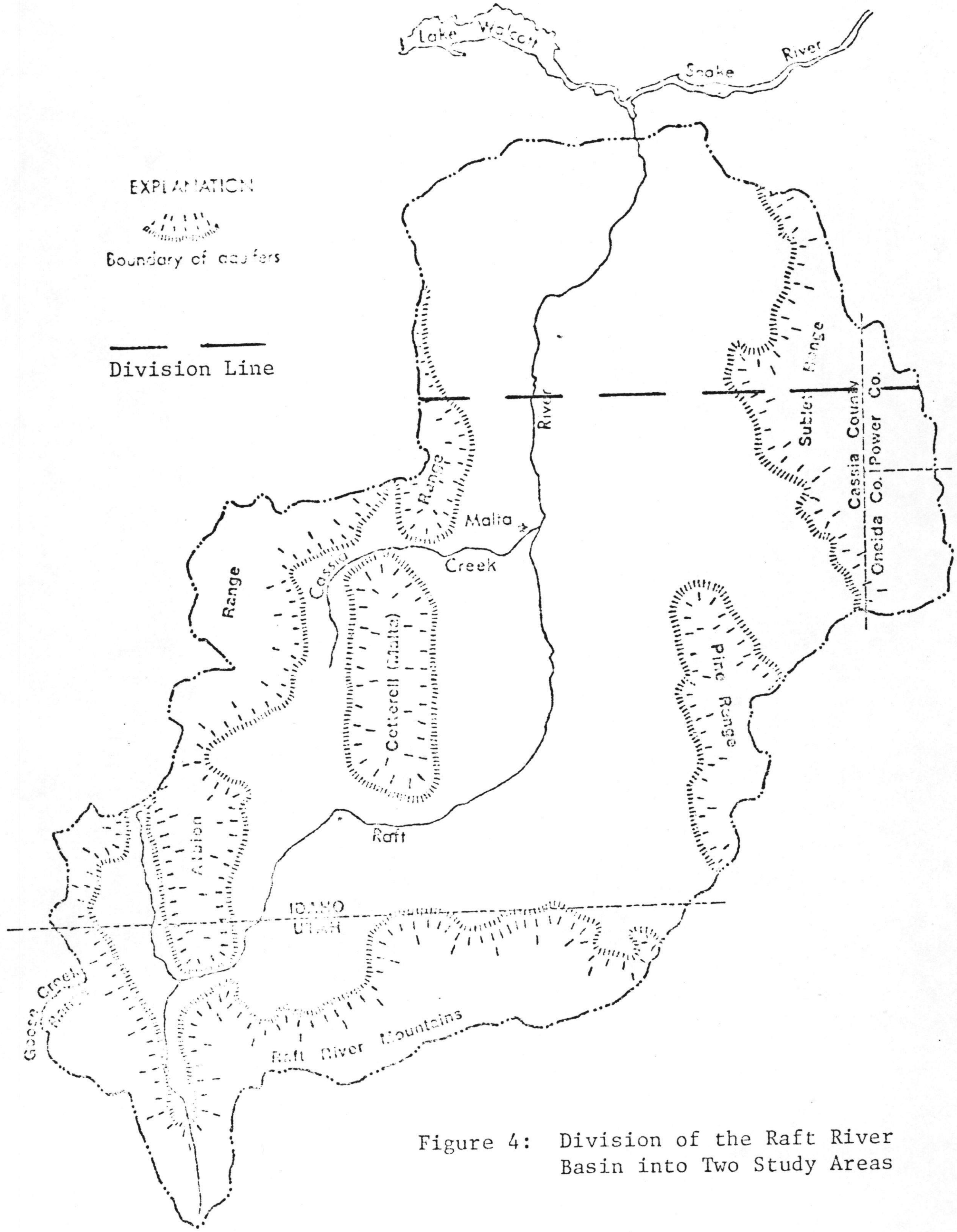


Figure 4: Division of the Raft River Basin into Two Study Areas

gation water for the growing of potatoes and sugar beets (high water using crops); and (3) wells in the northern section are capable of greater water yield than those in the south.

Budget Formulation

There is a wide range of agricultural activities within each section of the study area. Both sections contain cattle feeding operations, but information supplied for these enterprises was insufficient for inclusion and examination here. Field crop farms in the basin vary from 160 acre farms to others over 1000 acres in size. Farm sizes in the south are generally smaller than those in the north.

It was necessary to designate what sizes and types of agricultural enterprises to examine in this study. Once the representative farming enterprises were defined, activity budgets for these farms were developed. The activity budgets used in this study are presented in Appendix A. Farm sizes examined were 320 and 640 acre field crop farms in the southern portion of the valley and 640 and 960 acre field crop farms in the northern portion. In addition, 320 and 640 acre dairy operations were examined in the south. For each size field crop farm, several crop possibilities were examined to provide various total revenues possible from the same farm.

A sample farm budget, Table 1 (an activity budget for irrigated barley on a 320 acre field crop farm in the south), presents most of the estimated costs and returns for producing one acre of irrigated barley. Costs not presented in this or other budgets included in the appendix are those associated with the irrigation systems on the farms. Depreciation of the irrigation system, interest on the irrigation system investment and power costs were determined in the linear programming analysis of the farm. The analysis selected which wells were needed on a farm to provide the irrigation water required by the crop mix chosen to be optimum. How this choice was made will be further explained in a later section.

The budget in Table 1 is a mixture of primary and secondary data - primary data being data gathered directly from farmers and suppliers; secondary data being data gathered from other sources and applied to the budgets, i.e., the method used to calculate depreciation and repairs on farm equipment.

Machinery operating expenses were synthesized from actual costs reported by farm operators, performance figures derived from "Agricultural Machinery Management Data" in the 1971 Agricultural Engineers Yearbook, and information reported in various other farm studies. The synthesis of this information was necessary in order to standardize performances and costs of equipment useage in the study area. Information provided by farm operators often consisted of estimates or guesses concerning the use of equipment to do a par-

Table 1: Sample Farm Budget Presenting Estimated Costs and Returns for Irrigated Grain on a 320 Acre Farm, Southern End of Raft River Valley, 1972.

Variable Costs	
Seed, barley (100#/acre)	$ 5.00
Custom harvest	7.00
Machinery	
Repairs	5.36
Fuel & lubricants	1.14
Labor	
Irrigation (1.5 hrs. @ $2.25/hr)	3.38
All other (1.15 hrs. @ $2.25/hr)	2.59
Interest on working capitol	.89
Fixed Costs	
Depreciation on machinery	4.07
Interest on land	18.12
Taxes	3.06

Gross Returns

	50 Bu	60 Bu	70 Bu	75 Bu	80 Bu	90 Bu
Feed barley @ $.98/Bu	$49.00	58.80	68.60	73.50	78.40	88.20
Malting barley @ $1.73/Bu	86.50	103.80	121.10	129.75	138.40	155.70

ticular job on a farm. The Agricultural Engineers Yearbook provided estimated rates for various types of equipment as well as data upon which to base depreciation and repair expenses.

Labor requirements found in the budgets were divided into labor expended in machinery operation and labor required to irrigate the crops selected in the LP analysis.

Gravity flow irrigation using both flood and corrigation or furrow methods is the most common method of irrigation in the study area. Sprinkler irrigation, however, is gaining in popularity. Hand lines, side rolls systems and center pivot systems are all found in the basin. Most farm operators contacted indicated that they had either considered or had already changed to sprinkler irrigation to better utilize their irrigation water. The change to sprinkler systems has been slow in the area due to the high investment costs of installing the irrigation equipment.

The interest charge against land was calculated by using a 7¼% interest rate on the estimated value of land. This was appropriate since the money invested in land could have been alternatively invested elsewhere to obtain a return. (The 7¼% rate was chosen because it was the interest rate charged to borrowers in 1972 by financial institutions in the study area.) Land value in the south of the basin was estimated at $250 per acre. In the north, it was estimated at $350 per acre. Both land value estimates were provided by the Burley, Idaho, Federal Land Bank.

Interest on capitol investment was calculated on the total of seed, repair, fuel and lubricants, labor, spray, fertilizer, and custom harvest costs. A 7¼% interest rate was charged for a 6 month time period.

The total of costs presented in the budgets is the total cost (TC) of producing an acre of the crop in question except for the expenses of depreciation of the irrigation system, power costs for the water pumped for the crop, and the interest expense of the machinery and irrigation inventory on the farm. These items are deleted and calculated later because their values change when various constraints are examined in the linear programming analysis.

The returns presented in the sample budget are those for feed barley and malting barley. The $.98 per bushel selling price for feed barley is the 10 year (1963-1972) average selling price for the crop in Idaho. The $1.73 per bushel selling price for malting barley was the 1972 buying price, less shipping charges, quoted by the Adolph Coors Co. elevator manager in Burley, Idaho. An average price for malting barley is not available because it is a relatively new crop in the area.

Yields for malting barley were less than those for feed barley, but this was more than offset by the difference in selling prices. Seventy-five bushels per acre was a common yield figure in the south end of the basin for irrigated feed barley. Sixty bushels per acre was a common yield figure for malting barley in the southern end of the area.

A wide range of possible returns for each crop is presented on the budgets to show the different returns possible from the same crop. Yield differences are the result of soil difference, farming and irrigation practices, and management capability. The programming analysis examines the net returns for only one yield level. This was done to simplify programming and standarize returns at an average level.

Pumping Units in the Study

There are an estimated 330 existing irrigation wells in the Raft River Basin. Some of these wells are not used each season. The majority of the wells in the basin were drilled in the 1950's and early 1960's. The local Rural Electric Association provided specific information on when each well in the basin was first pumped. From this information the mean age of the wells in the two sections of the study area was determined. Wells in the south have a mean installation date of 1958. Those in the north are slightly newer with a mean installation date of 1960.

The estimated costs of drilling wells in the study area were assumed to increase between the southern and the northern end of the basin. The main reason for this increase is the intrusion of Snake River Plain basalts into the northern portion of the valley. The average cost for drilling a 16 inch diameter well in the south is $11 per foot. In the north this cost increases to an average of $13 per foot. The cost of drilling a 20 inch diameter well varies from $13 per foot in the south to $15 per foot in the north. (Estimates provided by an established well driller in the area.)

Casing costs average $5.50 per foot for 16 inch casing and $6.50 per foot for 20 inch casing. A common procedure in many wells in the basin is to case only a portion of the depth of the well, a procedure which often leads to added problems during the pumping life of the well. More productive wells with longer life expectancies might be obtained in the basin if entire wells were cased, and if the perforations of casings were more carefully planned.

Well depths in the basin, as shown in Figure 5, range from 70 feet deep near the Raft River to one well over 2,200 feet deep. More than 25 percent of the wells fall in the 200 to 299 feet deep range. Sixty-four percent of the wells in the basin are less than 400 feet deep.

The static depth to water in over one-half (157) of the wells was less than 50 feet (Figure 6). Drawdown at up to 100 feet occurs in some wells during the pumping season.

The sizes of pumps in operation in the basin vary greatly. This variation is primarily due to the variation in depths to water in the basin and the variation in yield capabilities of the wells. Since it was not feasible to examine all pump sizes in the study area, representa-

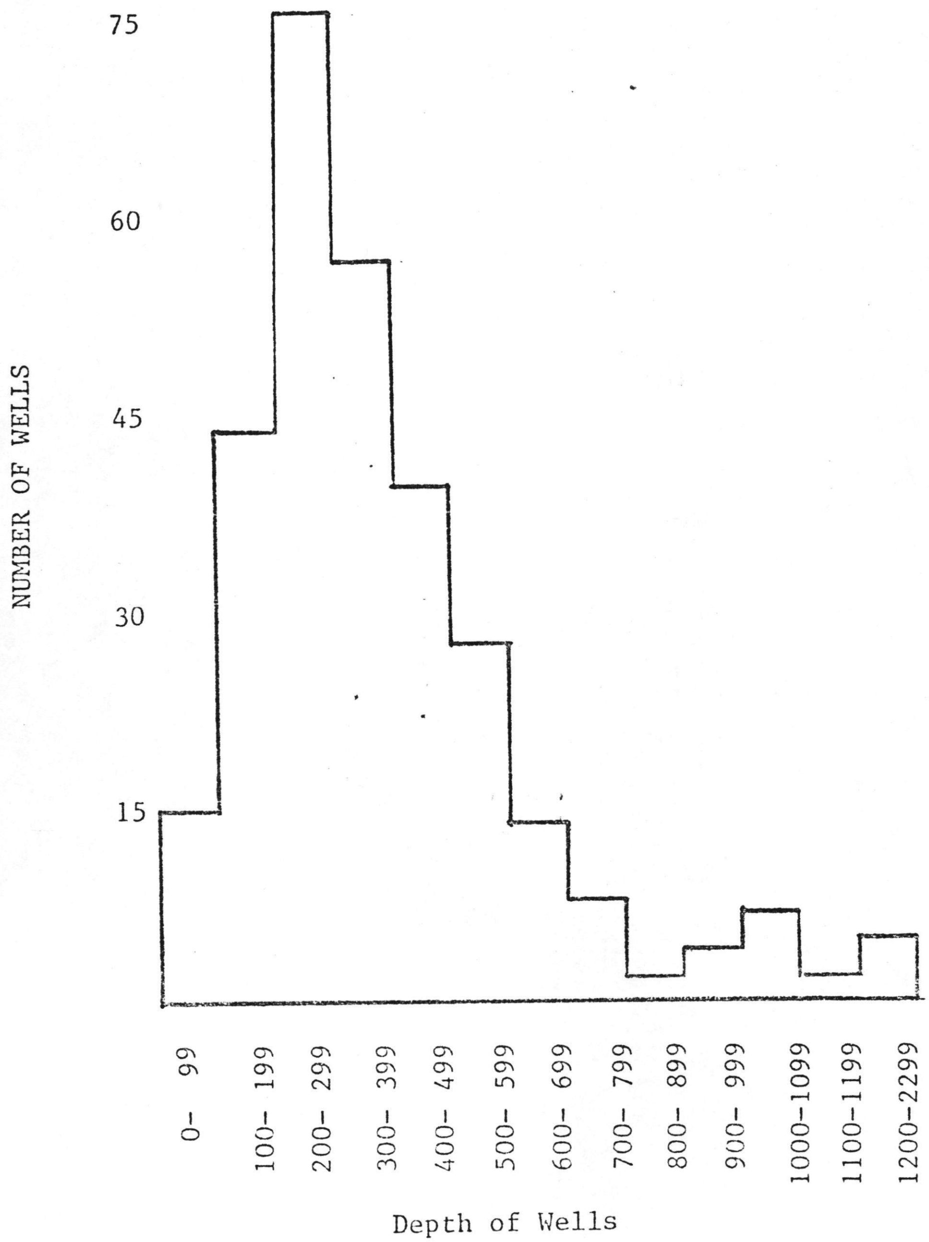


Figure 5: Depth of Wells in the Raft River Basin

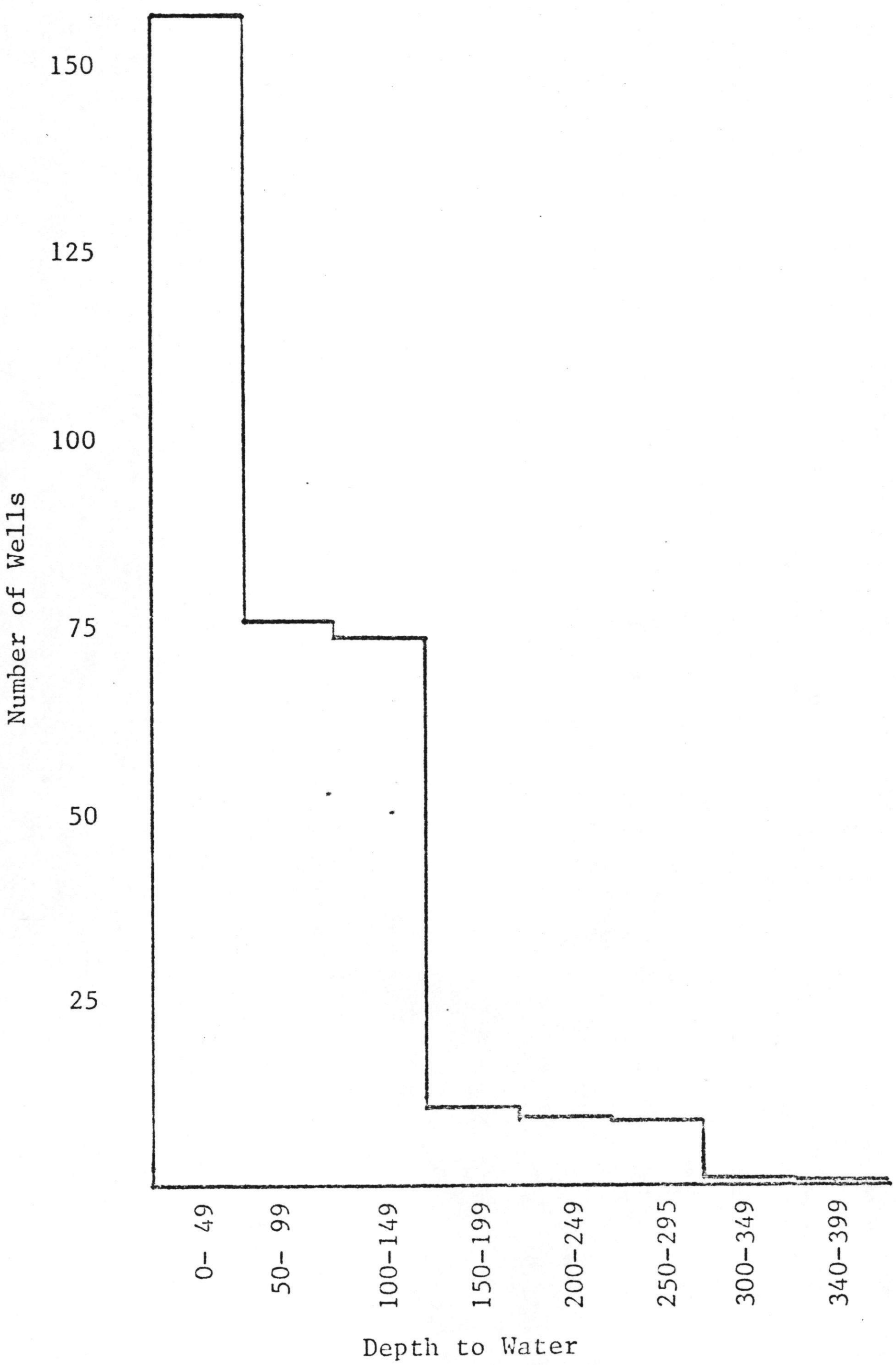


Figure 6: Static Water Levels of Wells in the Raft River Basin

tive pumps and wells were chosen for examination in this study. Data for determining the representative pumps and wells were compiled from interviews with individual farm operators, data from well drillers, an inventory of wells in the Raft River Valley, and manufacturer's pump information.

Tables 2 and 3 were compiled from an inventory of wells in the Raft River Basin. Pumps presented are those of various horsepower present which had had their output measured. The number of pumps in each size class and their average output in gallons per minute are presented for both portions of the study area. The distribution of pump sizes, as mentioned earlier, was significantly different in the two portions of the study area. Pumps in the southern portion of the valley were of smaller horsepower and yield than those found in the northern section of the study area.

A worksheet which presents horsepower (HP) and bowl requirements necessary to provide a given output of water from a given depth was next developed from information provided by Layne and Bowler, Inc. An example of how the worksheet was developed follows:

Problem: Provide an output of 950 GPM (gallons per mintue) from a well with 80 feet of lift.

Solution: Bowls designated by Layne and Bowler, Inc., as 12" THC are at near maximum efficiency when providing 950 GPM. Since each bowl stage will lift 950 GPM a distance of approximately 27 feet, three bowls are necessary to lift 950 GPM a distance of 80 feet. Each

Table 2: Pump Sizes (HP) and Yields (GPM) for Irrigation Pumps in the Raft River Valley, Northern Portion

HP	15	20	25	30	40	50	60	75	100	125	150	200	250
Measured Yields (GPM)			280	900	1,010	720	1,375	1,100	575	2,700	1,800	4,000	
			180	370	880	1,220	1,440	1,170	790	1,170	2,150	2,880	
			250	2,050	900	1,440	1,260	540	1,060	1,940	2,250	2,750	
			890		1,440	886	1,100	2,120	1,575	1,800	2,700	1,960	
					1,125	855	1,090	1,180	1,890	1,620	3,150	2,400	
					675	1,450	1,170	1,485	1,560	1,760	1,600	2,880	
						1,325	1,650	1,170	585	2,000	1,990	3,820	
							1,800	1,460	3,050	1,890	2,810	2,710	
							1,405			1,305	1,710	1,720	
											1,935		
											2,530		
											1,290		
											1,940		
											2,050		
											2,300		
											1,665		
											1,395		
											1,900		
No. Meas.			5	3	6	7	9	8	8	9	20	10	
Avg. Yield			508	1,107	1,015	1,128	1,366	1,278	1,386	1,798	2,029	2,679	

Table 3: Pump Sizes (HP) and Yields (GPM) for Irrigation Pumps in the Raft River Valley, Southern Portion.

HP	15	20	25	30	40	50	60	75	100	125	150	200	250
Measured Yields (GPM)	650	340	100	1,350	1,160	1,530	780	1,280	2,480	1,100	2,625	2,040	2,130
	570	650	540	1,200	990	1,080	520	1,395	2,340	1,160	990	2,360	
	495	1,350	790	1,150	1,110	1,440	1,080	1,760	3,360		2,430		
	315	760	730	540	260	1,160	2,270	540	690	2,480		2,770	
		284	480	1,120	1,830	1,440	1,975	1,410	900	3,060			
		880	1,960	2,180	780	640	1,800	1,980	1,800				
		337		660	1,250	880	1,550	1,410	1,530				
				1,220	1,430	940	850	1,475					
				965	830	1,860	715	1,170					
				450	900	1,810	900	950					
				920	980	830	1,295	1,180					
				1,060	1,080		1,350	1,840					
				630	1,475			1,230					
				870	710			930					
				1,250	1,470								
				450	900								
				1,440	1,180								
				270									
				360									
				1,125									
				1,035									
No. Meas.	4	7	6	22	17	11	12	15	7	5	2	4	1
Avg. Yield	508	657	767	948	1,076	1,207	1,287	1,275	1,643	2,232	1,808	1,400	2,130

> bowl requires 10 HP to operate it. Therefore, to provide an output of 950 GPM from 80 feet, a 30 HP pump motor and three 12" THC bowls are necessary.

This process was repeated for various combinations of GPM yield and lift to complete the worksheet (Appendix B).

From the distributions in Tables 2 and 3, pumps in the south providing 950, 1100, 1250 and 1900 GPM and pumps in the north providing 1100, 1300, 1800, 2000, and 2700 GPM were chosen as representative for the areas. Matching these yield requirements with the associated horsepowers in the northern and southern areas and comparing the two, HP and yield, with figures from the worksheet, the representative pumping units (including wells) presented in Table 4 were chosen.

The various characteristics presented on the eleven representative pumping units, 5 in the south and 6 in the north, form the basis for the examination of the effects of a decreasing ground water level. An explanation of these characteristics follows.

Yields of the representative pumping units are expressed in three forms of measurement to facilitate reader recognition. A miners inch of water equals approximately 9 GPM. An acre-foot (AF) of water equals approximately 325,900 gallons of water.

Table 4: Representative Pumping Units and Wells for the Northern And Southern Sections of the Raft River Basin

North End HP	GPM Yield	MI Yield	Lift	AF/ Season	AF/ Month	KWH/AF	Well Depth and Diam.	$6/KW Seasonal Demand Cost	Power Cost/ AF	Well Cost($)	Pumping Equipment Cost($)	TOTAL Yearly Depre-ciation
40	1100	115	100	1021	146	205	300'x16"	$ 240	1.16	$ 5500	$ 7000	$ 833
75	1300	135	150	1206	172	307	300x16	450	1.76	5500	11000	1100
100	1300	135	250	1206	172	512	400x20	600	2.81	8600	16000	1640
125	1800	188	200	1670	239	409	400x20	750	2.29	8600	16000	1640
150	2000	208	200	1856	265	409	500x20	900	2.33	10750	16000	1783
200	2700	281	200	2505	358	409	600x20	1200	2.32	12900	18000	2060
South End												
30	950	99	80	881	126	164	100x16	180	.96	1650	6000	510
40	1100	115	100	1021	146	205	200x16	240	1.16	3300	7000	687
60	1900	198	100	1763	252	205	300x30	360	1.13	5850	9000	990
60	1250	130	150	1160	166	307	400x20	360	1.69	6000	10000	1107
100	1900	198	150	1763	252	307	500x20	600	1.73	8250	12000	1350

Kilowatt-hours per acre-foot (KWH/AF) is an expression denoting the number of KWH needed to pump one AF of water from the particular well. The equation used to derive the figure is (8):

$$\text{KWH/AF} = 325.9 \frac{\text{Field head X .00314}}{\text{Wire to water efficiency}}$$

(The .00314 and 325.9 figures are constants in the formula.)

Field head is the well lift (depth to water) plus the above ground head (pressure desired at the point of discharge expressed in feet of lift). In this study field head is only well lift. Pressure at point of discharge is not necessary for a gravity irrigation system. Wire to water efficiency was chosen to be 50 percent (.5) for this study. The figure conforms to the average efficiency found in a 1968 Texas Technological College Agricultural Engineering study dealing with "Power Requirements and Efficiency Studies of Irrigation Pumps and Power Units".

The figures for well depths were selected to approximate the depths of actual wells in the study area.

Power cost per AF of water pumped was a combination of the $6 per KW seasonal demand charge (demand being nearly equal to the HP of most pumps), $.0085 per KW for the first 250 KW used per month, and $.0045 per KW for all additional power used (Raft River Electric Schedule, 1972). The figure presented was the cost per acre foot of water if the pumping unit operated at full capacity for the entire irrigation season.

Well costs and pumping equipment costs were estimated costs of drilling and fully casing the unit wells (provided by an area well driller) and estimated costs of pumping equipment necessary to provide the output of the well in question (provided by a Spokane, Washington, pump supplier.) The price of equipment from one area to another varies only in freight charges.

Total yearly depreciation on the pumping unit was calculated using the straight line depreciation method. The time period selected for depreciation was 15 years. At the end of the time period the equipment was assumed to have no salvage value.

Linear Programming Analysis

Linear programming analysis is a mathematical technique used in agricultural and other types of analysis to best allocate scarce resources among various alternative uses.

A linear programming problem has three quantitative components: an objective, alternative methods or processes for obtaining the objectives, and resource or other restrictions (9). In the general use of linear programming analysis, the objective is either to minimize costs or, as in this study, to maximize returns.

The profit maximizing LP solution is the most desirable when attempting to determine incomes from farming enterprises. A farmer attempts to minimize his costs, but his primary interest is in maximizing his return. A cost minimizing LP problem is more appropriate when the least cost of doing a job is desired, i.e., the least cost feedmix for a dairy, the least cost transportation route, etc.

A typical linear programming problem can be expressed be a set of equations taking the following form:

$$a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + \cdots a_{1n}x_n = b_1$$

$$a_{21}x_1 + a_{22}x_2 + a_{23}x_2 + \cdots a_{2n}x_n = b_2$$

$$\begin{matrix} \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \end{matrix}$$

$$a_{m1}x_1 + a_{m2}x_2 + a_{m3}x_3 + \cdots a_{mn}x_n = b_m$$

$$Z = C_1X_1 + C_2X_2 + C_3X_3 + \cdots + C_rX_r$$

Mathematically the problem is stated:

$$Z = \sum_{j=1}^{n} C_jX_j \qquad (i = 1,2,\ldots n)$$

Subject to restraints in the form:

$$\sum_{j=1}^{n} a_{ij}X_j \begin{pmatrix} \leq \\ = \\ \geq \end{pmatrix} b_i \qquad (i = 1,2,\ldots m)$$

and $X_j \geq 0$

where

X_j = the quantity of the jth variable of interest to the decision-maker, where there are n variables being considered;

C_j = the per unit contribution to the objective function (profit or cost) of the jth variable, where there are n variables;

Z = the objective function to be maximized or minimized;

a_{ij} = the exchange coefficient of the jth variable in the ith restraint where there are m restraints and n variables;

b_i = the ith requirement where there are m requirements in all.

The programming routine selected for use in this study was the IBM MPS-360 Linear Programming Routine. One of the major reasons for its selection over other linear programming routines was the relative ease with which a basic program may be revised and modified to reflect selected changes.

Figure 7 presents the basic matrix format developed in this study. The format of the matrix is that found on the computer output. The same matrix when presented in numerical format takes on the more easily understood form of Figure 8. The symbols on the printout matrix, A, T, U, etc., with the exception of the negative and positive ones which are actually ones, merely symbolize the range within which the numbers in the numerical format fall. A separate page on the printout (Figure 9) provides an explanation of these ranges and lists the number of elements within each range. An A when presented in the printout matrix symbolizes a real number between 1.000001 and 10.00000, a T symbolizes a number between .10000 and .99999, etc.

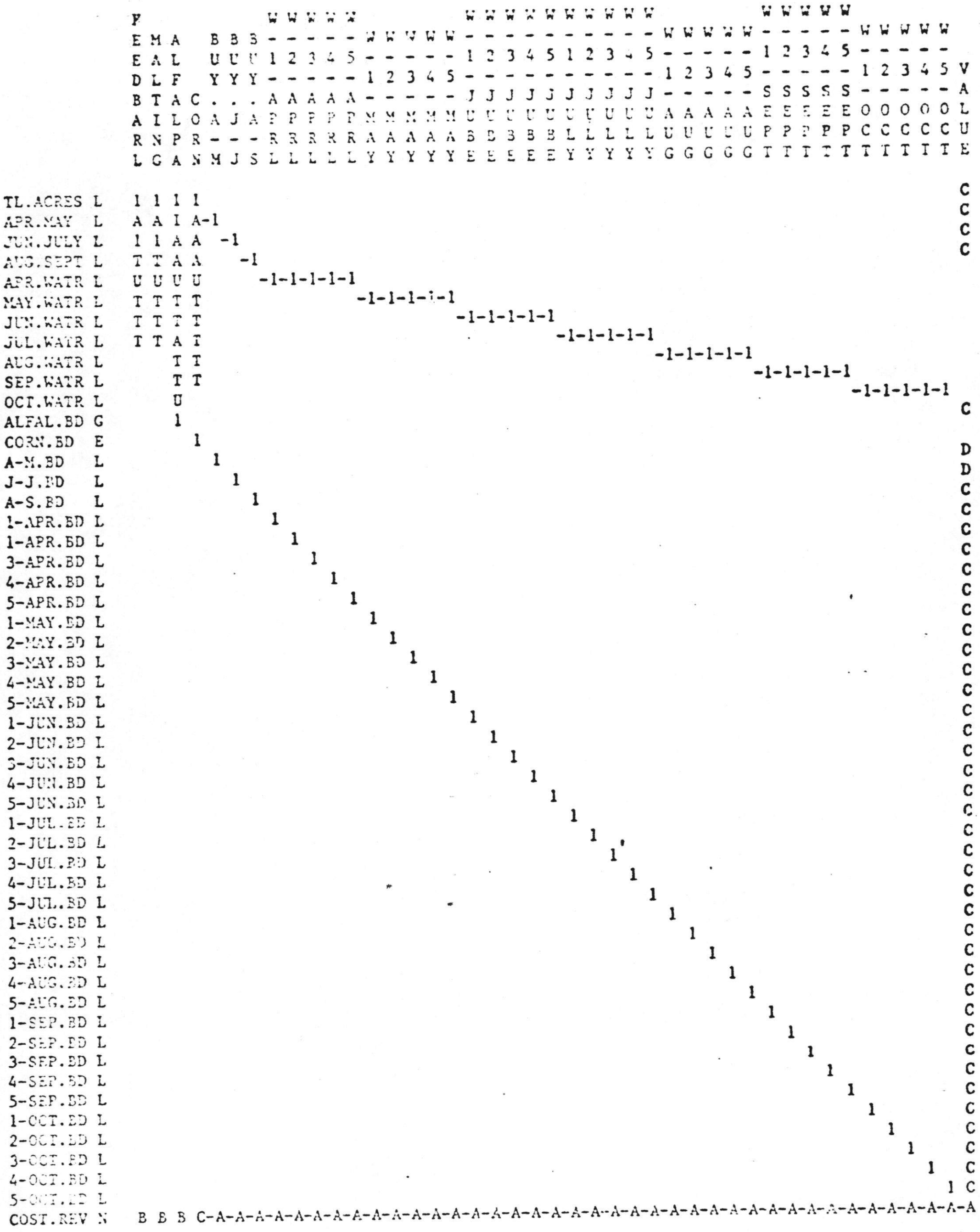


Figure 7: Example of Typical Linear Programming Matrix Used in This Analysis (Printout form)

	F.B.	M.B.	ALFA.	CORN	BUY A-M	BUY J-J	BUY A-S	W-1 APRL	W-2 APRL	W-3 APRL	W-4 APRL	W-5 APRL	W-1 MAY	W-2 MAY	W-3 MAY	W-4 MAY	W-5 MAY	W-1 JUNE	W-2 JUNE	W-3 JUNE	W-4 JUNE	W-5 JUNE	W-1 JULY	W-2 JULY	W-3 JULY	W-4 JULY	W-5 JULY	W-1 AUG	W-2 AUG	W-3 AUG	W-4 AUG	W-5 AUG	W-1 SEPT	W-2 SEPT	W-3 SEPT	W-4 SEPT	W-5 SEPT	W-1 OCT	W-2 OCT	W-3 OCT	VALUE
TL.ACRES	1.0	1.0	1.0	1.0																																					≤ 640
APR.MAY	1.5	1.5	.94	1.6	-1.0																																				≤ 600
JUN.JULY	1.0	1.0	2.2	2.4		-1.0																																			≤ 600
AUG.SEPT	.62	.62	2.2	2.5			-1.0																																		≤ 500
APR.WATR	.064	.064	.075	.028				-1.0	-1.0	-1.0	-1.0	-1.0																													
MAY.WATR	.446	.446	.331	.11									-1.0	-1.0	-1.0	-1.0	-1.0																								
JUN.WATR	.793	.793	.702	.348														-1.0	-1.0	-1.0	-1.0	-1.0																			
JULY.WATR	.46	.46	1.073	.946																			-1.0	-1.0	-1.0	-1.0	-1.0														
AUG.WATR			.854	.86																								-1.0	-1.0	-1.0	-1.0	-1.0									
SEP.WATR			.429	.248																													-1.0	-1.0	-1.0	-1.0	-1.0				
OCT.WATR			.078																																			-1.0	-1.0	-1.0	
ALFAL.BD			1.0																																						≥ 250
CORN.BD				1.0																																					
A-M.BD					1.0																																				≤ 3,000
J-J.BD						1.0																																			≤ 3,000
A-S.BD							1.0																																		≤ 3,000
1-APR.BD								1.0																																	≤ 126
2-APR.BD									1.0																																≤ 146
3-APR.BD										1.0																															≤ 252
4-APR.BD											1.0																														≤ 166
5-APR.BD												1.0																													≤ 252
1-MAY.BD													1.0																												≤ 126
2-MAY.BD														1.0																											≤ 146
3-MAY.BD															1.0																										≤ 252
4-MAY.BD																1.0																									≤ 166
5-MAY.BD																	1.0																								≤ 252
1-JUN.BD																		1.0																							≤ 126
2-JUN.BD																			1.0																						≤ 146
3-JUN.BD																				1.0																					≤ 252
4-JUN.BD																					1.0																				≤ 166
5-JUN.BD																						1.0																			≤ 252
1-JUL.BD																							1.0																		≤ 126
2-JUL.BD																								1.0																	≤ 146
3-JUL.BD																									1.0																≤ 252
4-JUL.BD																										1.0															≤ 166
5-JUL.BD																											1.0														≤ 252
1-AUG.BD																												1.0													≤ 126
2-AUG.BD																													1.0												≤ 146
3-AUG.BD																														1.0											≤ 252
4-AUG.BD																															1.0										≤ 166
5-AUG.BD																																1.0									≤ 252
1-SEP.BD																																	1.0								≤ 126
2-SEP.BD																																		1.0							≤ 146
3-SEP.BD																																			1.0						≤ 252
4-SEP.BD																																				1.0					≤ 166
5-SEP.BD																																					1.0				≤ 252
1-OCT.BD																																						1.0			≤ 126
2-OCT.BD																																							1.0		≤ 146
3-OCT.BD																																								1.0	≤ 252
4-OCT.BD																																									≤ 166
5-OCT.BD																																									≤ 262
COST.REVENUE	35.12	65.42	53.70	109.62	-2.25	-2.25	-2.25	-1.16	-1.39	-1.33	-2.00	-2.07	-1.16	-1.39	-1.33	-2.00	-2.07	-1,16	-1.39	-1.33	-2.00	-2.07	-1.16	-1.39	-1.33	-2.00	-2.07	-1.16	-1.39	-1.33	-2.00	-2.07	-1.16	-1.39	-1.33	-2.00	-2.07	-1.16	-1.39	-1.33	

Figure 8: Example of a Typical Linear Programming Matrix Used in This Analysis (Numerical form)

SUMMARY OF MATRIX

SYMBOL	RANGE		COUNT (INCL.RHS)
Z	Less Than	.000001	
Y	.000001 THRU	.000009	
X	.000010	.000099	
W	.000100	.000999	
V	.001000	.009999	
U	.010000	.099999	5
T	.100000	.999999	29
1	1.000000	1.000000	97
A	1.000001	10.000000	65
B	10.000001	100.000000	5
C	100.000001	1,000.000000	49
D	1,000.000001	10,000.000000	4
E	10,000.000001	100,000.000000	
F	100,000.000001	1,000,000.000000	
G	Greater Than	1,000,000.000000	

Figure 9: Example of a Typical Printout Matrix Summary

Since this matrix forms the basis for the analysis in this study, it is important to understand what the elements forming the matrix represent. The columnar section of the programming matrix represents the activities involved in the programming problem. The rows section represents the resources and restrictions involved in the problem. Negatives (-) within the matrix represent sources of a resource and postitives (+) represent uses of the resource. In the objective function of the matrix, negatives represent costs and positives represent returns.

The rows of the matrix represent equalities and/or inequalities which express the problem in equation form. Thus, the first row of Figure 10 becomes: 1 X_1 (feed barley) + 1 X_2 (malting barley) + 1 X_3 (alfalfa) + 1 X_4 (corn) $\leq$ 640 (total acres). What the equation expresses is that each unit (acre) of feed barley requires one unit (acre) of land, each unit of malting barley requires one unit of land, etc., and that the total land that can be used for the crops is less than or equal to 640 acres.

The rows designated APR.MAY, JUN.JULY, and AUG.SEPT express labor requirements and availabilities in the respective time periods. The uses of the labor for the four crops listed in the column (activity) section of the matrix are expressed in the same manner as the land requirements for crops. An example is that alfalfa requires .94 hours of April and May labor. This requirement is a total of the labor required for tillage, planting, irrigation, etc., for one unit of alfalfa during the time period in question. These requirements are derived from the representative farm budgets for the size of the farm being examined.

A new element which enters into these three rows is the negative one (-1) found in the columns marked BUY AM, BUY JJ, and BUY AS. This negative shows an availability of labor to fill the requirements in the time period. The availability is from the activity of "buying" labor to supplement the operator labor available in the time period.

The equation which expresses the labor conditions in the problem was initially in the general form: use of labor for crops ≤ operator labor + buying labor. In linear programming analysis only a single right hand member is permitted. Therefore the equation for labor is rearranged to take the form shown in the matrix: use of labor for crops - buying labor ≤ operator labor.

The rows designated APR.WATR through OCT.WATR are the irrigation requirements expressed in acre feet for the four crops in the various time periods. These requirements are the consumptive use requirements (consumptive use being the amount of water transpired in the process of plant growth plus the water evaporated from soil and foliage in the area occupied by the growing plant) for crops grown in the Rupert, Idaho, area. These requirements, as derived by Sutter and Corey (1970) in "Consumptive Irrigation Requirements for Crops in Idaho", were adjusted to reflect a 60 percent efficiency of irrigation. The equation for obtaining this adjusted consumptive use figure is:

$$\text{Adjusted C.U.} = \frac{\text{Consumptive Use}}{.60 \text{ (efficiency factor)}}$$

In each time period (rows section) there are five different sources of water to meet the consumptive use requirements of the crops. Each of these sources represents one of the five representative wells in the southern portion of the study area. These are "buy" activities of the same type as the "buy" labor activities explained earlier. There are five "buy" activities instead of one in any single time period because each well can only produce a certain maximum amount of water in a single given time period. The diagonal row of 1's across the bottom portion of the matrix expresses the maximum bounds of each well's production in a given time period. Well I can produce at most 146 acre-feet of water in one month; Well II can produce at most 146 acre-feet per month; Well III, 252 acre-feet per month; Well IV, 166 acre-feet per month; and Well V, 252 acre-feet per month.

Which wells operate in a time period is dependent on the water requirement of the crop mix selected by the computer in the linear programming analysis and the cost per acre-foot for pumping from a particular well. The least expensive water is used first, then the next most expensive, etc., until the water requirement is met or there is no more water available to buy. (The term "use" actually refers to the buying process in the programming analysis. The least expensive water is in reference to the least costly well being pumped first, then the next most expensive, etc.) If there is not enough water available to meet the irrigation requirement for utilization of all 640 acres of land, the number of acres of crops entering into the solution would be restricted by the availability of water for irrigation. (An assumption basic to the analysis at this point is that the irrigation system on a farm was such that any well selected to pump water in a given time period could provide water to any point on the farm. In reality this is seldom, if ever, the case, but the assumption was necessary to simplify the programming model for analysis.)

Water availability could have been examined on a seasonal basis, but it would have given a distorted view of what actually happens in a farm situation. Studies using the seasonal approach would reach significantly different results than a study using a monthly water requirement approach. If a seasonal approach was used in this study, Wells I and II could provide the necessary amount of irrigation water during the season to raise the crops on a 640 acre farm. The key word here is season. If crops required equal amounts of water throughout the season, this approach would be valid. However, there are peak water requirement periods within the season. An irrigation system must be large enough to provide enough water during the peak use periods rather than enough to meet average seasonal requirements. An examination on a monthly time period basis shows that three wells were necessary during peak water requirement periods rather than the two found necessary using a seasonal basis for examination.

The final row of the printout matrix, labled COST.REV, is the objective function of the problem examined. The values of the first four characters (columns 1 - 4) are the returns to fixed factors for the four crops which can be grown on the farm. The return to fixed factors in this analysis is the return to management, operator labor, interest on land, interest on machinery and irrigation inventory, taxes, and depreciation of the irrigation system selected by the linear programming analysis. Depreciation of the equipment inventory is usually handled as a fixed factor for the entire farm, but in this analysis it was handled as a quasi-variable cost. With depreciation of equipment handled as a fixed cost, the LP model maximized the net farm income rather than the net return. By handling equipment depreciation as a variable cost, the program maximized net returns. The variable equipment depreciation costs used in the activity budgets were based on the equipment mix found on actual farms in the study area and the average acreages of various crops grown on the various size farms examined.

All remaining characters in the objective function row are the costs associated with using one unit of the columnar activities. "Buying" one hour of April labor costs $2.25, "buying" one acre foot of water from W I APRIL (Well I in April) costs $.95, etc.

CHAPTER IV

Application of Linear Programming Techniques to Estimate Expected Farm Incomes

The basic linear programming model used throughout the analysis changed for each size and type of farm plan examined. The changes dealt with the resources available on the farm, the labor requirements for various crops, objective function values, and restrictions placed on the individual models. Most differences in the models were minor and were primarily concerned with the magnitude of the variables under consideration. The main structural differences in the models were related to the differences in the representative wells in the two areas studied.

Programming Results

When all the elements involved in a model farm plan examination (resources, restrictions, requirements, etc.) were compiled and expresed in equation and matrix form, the model was programmed using the IBM MPS 360 Linear Programming Routine on an IBM 360-40 computer. The results of the programming runs generated profit maximizing combinations of crops for the farm plans developed in the study. Figures 10 and 11 show the row and column sections of a typical computer printout. The numbers under the activity heading of Figure 10 indicate the quantities (in units) of each resource and restriction which entered into the final

SECTION 1 - ROWS

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
1	TL.ACRES	UL	320.00000	.	NONE	320.00000	42.70191-
2	APR.MAY	BS	406.50000	193.50000	NONE	600.00000	.
3	JUN.JULY	BS	525.00000	75.00000	NONE	600.00000	.
4	AUG.SEPT	BS	435.50000	64.50000	NONE	500.00000	.
5	APR.WATR	UL	.	.	NONE	.	1.16000-
6	MAY.WATR	UL	.	.	NONE	.	1.16000-
7	JUN.WATR	UL	.	.	NONE	.	1.33000-
8	JUL.WATR	UL	.	.	NONE	.	1.33000-
9	AUG.WATR	UL	.	.	NONE	.	1.33000-
10	SEP.WATR	UL	.	.	NONE	.	1.16000-
11	OCT.WATR	UL	.	.	NONE	.	1.16000-
12	MALT.BD	UL	50.00000	.	NONE	50.00000	30.30000-
13	ALFAL.BD	UL	150.00000	.	NONE	150.00000	20.08244-
14	A-M.BD	BS	.	1500.00000	NONE	1500.00000	.
15	J-J.BD	BS	.	1500.00000	NONE	1500.00000	.
16	A-S.BD	BS	.	1500.00000	NONE	1500.00000	.
17	1-APR.BD	BS	22.13000	103.87000	NONE	126.00000	.
18	2-APR.BD	BS	.	146.00000	NONE	146.00000	.
19	3-APR.BD	BS	.	252.00000	NONE	252.00000	.
20	4-APR.BD	BS	.	166.00000	NONE	166.00000	.
21	5-APR.BD	BS	.	152.00000	NONE	152.00000	.
22	1-MAY.BD	BS	125.47000	.53000	NONE	126.00000	.
23	2-MAY.BD	BS	.	145.00000	NONE	146.00000	.
24	3-MAY.BD	BS	.	252.00000	NONE	252.00000	.
25	4-MAY.BD	BS	0	166.00000	NONE	166.00000	.
26	5-MAY.BD	BS	.	252.00000	NONE	252.00000	.
27	1-JUN.BD	UL	126.00000	.	NONE	126.00000	.17000-
28	2-JUN.BD	BS	.	146.00000	NONE	146.00000	.
29	3-JUN.BD	BS	114.11000	137.89000	NONE	252.00000	.
30	4-JUN.BD	BS	.	166.00000	NONE	166.00000	.
31	5-JUN.BD	BS	.	252.00000	NONE	252.00000	.
32	1-JUL.BD	UL	126.00000	.	NONE	126.00000	.17000-
33	2-JUL.BD	BS	.	146.00000	NONE	146.00000	.
34	3-JUL.BD	BS	113.15000	138.85000	NONE	252.00000	.
35	4-JUL.BD	BS	.	166.00000	NONE	166.00000	.
36	5-JUL.BD	BS	.	252.00000	NONE	252.00000	.
37	1-AUG.BD	UL	126.00000	.	NONE	126.00000	.17000-
38	2-AUG.BD	BS	.	146.00000	NONE	146.00000	.
39	3-AUG.BD	BS	2.10000	249.90000	NONE	252.00000	.
40	4-AUG.BD	BS	.	166.00000	NONE	166.00000	.
41	5-AUG.BD	BS	.	252.00000	NONE	252.00000	.
42	1-SEP.BD	BS	64.35000	61.65000	NONE	126.00000	.
43	2-SEP.BD	BS	.	146.00000	NONE	146.00000	.
44	3-SEP.BD	BS	.	252.00000	NONE	252.00000	.
45	4-SEP.BD	BS	.	166.00000	NONE	166.00000	.
46	5-SEP.BD	BS	.	252.00000	NONE	252.00000	.
47	1-OCT.BD	BS	11.70000	114.30000	NONE	126.00000	.
48	2-OCT.BD	BS	.	146.00000	NONE	146.00000	.
49	3-OCT.BD	BS	.	252.00000	NONE	252.00000	.
50	4-OCT.BD	BS	.	166.00000	NONE	166.00000	.
51	5-OCT.BD	BS	.	252.00000	NONE	252.00000	.
52	COST.REV	BS	18256.23720	18256.23720-	NONE	NONE	1.00000

Figure 10: Example of Typical Results for the Linear Programming Model Used, Rows Section

solution. The slack activity column of the same figure indicates the quantities of each resource and restriction which were unused in the final solution. The upper limit column indicates the upper limit amounts of each resource that were available for use in the farm plan program. The dual activity column indicates the value of an additional unit of an activity to the final solution. Thus, row number 2, APR.MAY (April and May operator labor), indicates that the final solution utilized 406.5 units (hours) of labor, that 193.5 units were unused, that 600 were available, and that an additional unit of labor has no value in the final solution of the farm plan.

The columns section of the printout, Figure 11, presents the amount of each columnar activity which entered into the final solution. The input cost column indicates the cost of using one unit of the activity. The reduced cost is the amount by which the input cost of an activity would have to change before the activity would enter the final solution. Thus, row 55, ALFALFA, indicates that 150 units (acres) of alfalfa entered into the final solution and that the input cost for each unit of alfalfa was $67.34. An example of the reduced cost column is row 65, W-2-MAY (well 2 in May), which did not enter into the final solution at its cost of $1.39 per unit (acre-foot of water). It would have entered the final solution if its cost decreased $.23 per unit.

Analysis of Results to Determine Farm Plan Returns

The next step in the analysis of the farm plans was to determine

SECTION 2 - COLUMNS

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
53	FEEDBARL	BS	120.00000	44.96000	.	NONE	.
54	MALTING	BS	50.00000	75.76000	.	NONE	.
55	ALFALFA	BS	150.00000	67.34000	.	NONE	.
56	BUY.A-M	LL	.	2.25000-	.	NONE	2.25000-
57	BUY.J-J	LL	.	2.25000-	.	NONE	2.25000-
58	BUY.A-S	LL	.	2.25000-	.	NONE	2.25000-
59	W-1-APRL	BS	22.13000	1.16000-	.	NONE	.
60	W-2-APRL	LL	.	1.39000-	.	NONE	.23000-
61	W-3-APRL	LL	.	1.33000-	.	NONE	.17000-
62	W-4-APRL	LL	.	2.00000-	.	NONE	.84000-
63	W-5-APRL	LL	.	2.07000-	.	NONE	.91000-
64	W-1-MAY	BS	125.47000	1.16000-	.	NONE	.
65	W-2-MAY	LL	.	1.39000-	.	NONE	.23000-
66	W-3-MAY	LL	.	1.33000-	.	NONE	.17000-
67	W-4-MAY	LL	.	2.00000-	.	NONE	.84000-
68	W-5-MAY	LL	.	2.07000-	.	NONE	.91000-
69	W-1-JUNE	BS	126.00000	1.16000-	.	NONE	.
70	W-2-JUNE	LL	.	1.39000-	.	NONE	.06000-
71	W-3-JUNE	BS	114.11000	1.33000-	.	NONE	.
72	W-4-JUNE	LL	.	2.00000-	.	NONE	.67000-
73	W-5-JUNE	LL	.	2.07000-	.	NONE	.74000-
74	W-1-JULY	BS	126.00000	1.16000-	.	NONE	.
75	W-2-JULY	LL	.	1.39000-	.	NONE	.06000-
76	W-3-JULY	BS	113.15000	1.33000-	.	NONE	.
77	W-4-JULY	LL	.	2.00000-	.	NONE	.67000-
78	W-5-JULY	LL	.	2.07000-	.	NONE	.74000-
79	W-1-AUG	BS	126.00000	1.16000-	.	NONE	.
80	W-2-AUG	LL	.	1.39000-	.	NONE	.06000-
81	W-3-AUG	BS	2.10000	1.33000-	.	NONE	.
82	W-4-AUG	LL	.	2.00000-	.	NONE	.67000-
83	W-5-AUG	LL	.	2.07000-	.	NONE	.74000-
84	W-1-SEPT	BS	64.35000	1.16000-	.	NONE	.
85	W-2-SEPT	LL	.	1.39000-	.	NONE	.23000-
86	W-3-SEPT	LL	.	1.33000-	.	NONE	.17000-
87	W-4-SEPT	LL	.	2.00000-	.	NONE	.84000-
88	W-5-SEPT	LL	.	2.07000-	.	NONE	.91000-
89	W-1-OCT	BS	11.70000	1.16000-	.	NONE	.
90	W-2-OCT	LL	.	1.39000-	.	NONE	.23000-
91	W-3-OCT	LL	.	1.33000-	.	NONE	.17000-
92	W-4-OCT	LL	.	2.00000-	.	NONE	.84000-
93	W-5-OCT	LL	.	2.07000-	.	NONE	.91000-

Figure 11: Example of Typical Results for the Linear Programming Model Used, Columns Section

the total revenues and total costs of operating the farm plans. The total revenue for a farm plan was calculated by multiplying the acreages specified in the programming results by the gross return per acre received for growing a particular crop. The gross returns per acre were based on an expected yield for a crop and an expected selling price for the crop (Appendix C).

The total cost calculations for a farm plan were determined by multiplying the variable costs per acre of producing a crop by the number of acres of each crop selected in the optimum combination of crops in the farm plan. The next step was to evaluate the use of irrigation water. The program results showed which wells produced water, the quantity they produced, and cost per unit. These figures made it possible to determine the power cost of pumping irrigation water used by the selected crop mix. At the same time, the wells necessary to provide the water at least cost were designated.

Calculations for the fixed cost portion of total cost began with an examination of depreciation and interest expenses for the wells and pumping equipment designated in the program. Depreciation for the wells came directly from Table 4. Interest charged for investment in wells and pumping equipment was calculated using a 7¼% rate charged against half the total value of the wells and equipment.

Interest on farm machinery and equipment was also calculated by charging a 7¼% rate against half the total value of machinery and equipment necessary for operation of the farm plan. Interest on land was also charged at the 7¼% rate. The fixed cost of taxes paid by the farm was also included in the calculation of total cost.

The sum of all the fixed and variable costs is the total cost of the farm plan. Subtracting this figure from the total revenue provides the net return to operator labor and management for the farm plan.

The crop constraints (bounds) on the model involved in the programming of each farm plan were set at three different levels to give three possible crop combinations for each farm plan. Crop combinations grown in the Raft River Basin vary over a wide range. Cash crops grown in the southern section are primarily feed barley, malting barley and alfalfa hay. The choice of crop mix produced by a farm operator is critical to a farm's return. The choice of crop mixes in the northern section of the study area is not as critical as in the southern portion, but will have a significant effect on a farm's return. Setting crop constraints at three levels for each farm plan shows the effects of the crop choice on return levels. Return levels will be referred to as Return I, II, and III. An explanation of the crops produced to arrive at each return level is presented in Tables 5 and 6. Appendix D presents the crop bound levels applied to each farm plan and the returns (TR I, TR II, and TR III) from a plan satisfying the bounds. It was assumed that capitol was unlimited and that adequate labor was available at the $2.25 per hour rate to produce any of the crop combinations selected by programming the farm plan. The three levels of constraints on the farm plans made it possible to examine three different levels of return to operator labor and management for each of the farm plans. Each programming output was the profit maximizing crop combination which satisfied the restraints put on the model. The manager, when faced with these restraints, should produce that crop combination selected to optimize his return.

Another set of constraints which forced the shallow wells out of the final solutions were applied to simulate the cost changes faced when a farm must pump its irrigation water from a greater depth. Wells 1, 2, and 4 were blocked out of the final solutions in the north end analysis. Wells 1, 2, and 3 were blocked out during the south end analysis.

In a linear programming analysis, the returns and costs for farm plans are fixed. Examination of a stream of future incomes from a farm operation can use either a linear analysis or account for all the increases and decreases in returns and costs in the future. Predictions of future situations have improved, but not to the point where analysis can be based on them. An alternative is to assume that a linear relationship will exist into the future. In doing this, returns can be calculated for any time period desired. A point to remember is that the further out in time calculations are carried, the less confidence can be placed in them. As the analysis is extended into the future, the chance of making an error in predictions increases.

To take into account the possibility of making an error, future returns are discounted to reflect the interest which could be received by investing elsewhere and to reflect the risk of the long term investment of the assets. Basically this means that a dollar received in 5 years does not have the same value as a dollar received today. To find what the present value of the dollar to be received in 5 years is, a discount (interest) rate is applied to it for the time period. The present value (PV) equation is:

$$PV = \frac{F}{(1+i)^n}$$

Where F is the future value, i is the interest rate, and n is the number of time periods considered.

Expected farm incomes in this study were examined for a 20 year time period. Present value analysis was applied to the streams of total revenues and total costs to determine the cumulative PV of the returns and costs. The net cumulative present value for the 20 year time period is found by subtracting the cumulative PV of the total cost from the cumulative PV of the total revenue. The planner and/or manager can use this figure to aid in his decisions in evaluating his returns from investing in the farm with returns from other investment opportunities open to him. This figure can also be helpful in evaluating changes and improvements which can be made on the farm.

Next an examination of the return to operator labor and management was made to calculate the annual annuity value of the cumulative PV net return. This was done to express the return as a series of equal payments due at regular intervals. In this study the payments are yearly for a 20 year period. The equation used in calculating the annuity value was:

$$PV = R \frac{1 - \frac{1}{(1+i)^n}}{i}$$

Where R equals the annuity value, i is the interest rate, and n is the number of time periods.

Returns to Representative Farming Enterprises

Present values and annual annuity values for each farm plan examined in this study were determined for four discout rates - 4%, 6%, 7¼% and 9%. Appendix D presents these values for all four rates. The discount rate used for fiscal year 1974 by the Water Resources Council for evaluation of plans was 6 7/8%. Of the four rates examined in this study, 7¼% is the closest to this figure. The 7¼% rate was also the interest rate charged by various financial institutions when the initial data for this study was gathered. It was also found during the examination of farm returns that the various discount rates changed the present values and annuity values only slightly. The following discussions will therefore deal with only the 7¼% rate.

Northern Area of Basin

Table 5 presents a summary of the present values of the net returns and the annual annuity values for farm plans examined in the northern portion of the Raft River Basin. The three net return levels presented are the returns to the farm plan associated with the crop combinations produced as a result of the three sets of crop constraints applied to the farm plan.

The present values of the net returns to the 640 acre farm plan with shallow wells varied from a high of $715,890 to a low of $336,151. The range for the same farm plan with deep wells supplying the water for irrigation was from $700,169 to $319,444. The highest return in both cases is associated with a farm producing 408 acres of potatoes, 150 acres of alfalfa hay, and 82 acres of malting barley. The alfalfa and barley are assumed to be grown primarily for rotation purposes in the farm plan. The lowest return for this farm plan was associated with a crop mix including all five crop possibilities in the northern section of the basin.

The 960 acre farm plan had net returns whose accumulated present values ranged from $1,497,252 to $641,743. The present values of the net returns for the same farm plan with deep wells ranged from $993,823 to $626,115. The greatest return to the farm plan was realized with the production of 200 acres of alfalfa hay and 716 acres of potatoes. The

Table 5: 20 Year Accumulated Present Values and Annual Annuity Values for Farms in the Northern End of the Raft River Basin. (7¼% Interest)

	640 Acre Farm		960 Acre Farm	
	Shallow Wells	Deep Wells	Shallow Wells	Deep Wells
P.V. of NR I	715,890	700,169	1,497,252	993,823
Annuity Value	68,835	67,324	143,967	95,560
P.V. of NR II	375,315	358,125	650,473	634,742
Annuity Value	36,088	34,435	62,545	61,033
P.V. of NR III	336,151	319,444	641,743	626,115
Annuity Value	32,322	30,716	61,706	60,203

640 Acre Farm (Shallow & Deep Wells)

- Return I - 82 ac. Malting barley, 150 ac. Alfalfa hay, 408 ac. Potatoes
- Return II - 150 ac. Malting barley, 207 ac. Alfalfa hay, 150 ac. Potatoes, 133 ac. Sugar beets
- Return III - 100 ac. Feed barley, 102 ac. Malting barley, 150 ac. Alfalfa hay, 150 ac. Potatoes, 138 ac. Sugar beets

960 Acre Farm (Shallow Wells)

- Return I - 200 ac. Alfalfa hay, 716 ac. Potatoes
- Return II - 360 ac. feed barley, 150 ac. Malting barley, 150 ac Alfalfa hay, 225 ac. Potatoes, 75 ac. Sugar beets
- Return III - 310 ac. Feed barley, 225 ac. Malting barley, 200 ac Alfalfa hay, 225 ac. Potatoes

(Deep Wells)

- Return I - 200 ac. Alfalfa hay, 517 ac. Potatoes
- Return II - 360 ac. Feed barley, 150 ac. Malting barley, 150 ac. Alfalfa hay, 225 ac. Potatoes, 75 ac. Sugar beets
- Return III - 310 ac. Feed barley, 225 ac. Malting barley, 200 ac. Alfalfa hay, 225 ac. Potatoes

number of acres entering into the final solution was limited at 916 by the statutory limitation on the amount of water legally available for irrigation on 960 acres. When bounds placed on the farm model were altered to limit the number of acres of potatoes entering the final solution, the full 960 acres of available land was utilized, but the returns were reduced to $650,473 and $641,743 for the two alternate crop mixes.

When shallow wells were bounded out of the 960 acre farm plan solution, return levels varied from $993,823 to $626,115. Production of 517 acres of potatoes and 200 acres of alfalfa hay provided the net return with the greatest accumulated present value. Acreage entering into this final solution was limited by the production capabilities of the deep wells available to produce the irrigation water for the farm plan. Wells available could produce the legal limit for the farm plan, but peak water useage periods required more water than was available if the entire 960 acres entered into production.

Southern Area of Basin

A summary of the present values of the net returns to farm plans in the southern portion of the Raft River Basin appears in Table 6. Returns for the 320 acre farm plan range from a high of $134,495 to a low of $80,969. These two values show the impact on returns if feed barley is grown instead of higher value malting barley. Annual annuity values for the farm plan range from $12,932 to $7,785. When deep wells

Table 6: 20 Year Accumulated Present Values and Annual Annuity Values for Farms in the Southern End of the Raft River Basin. (7¼% Interest)

	320 Acre Farm		640 Acre Farm	
	Shallow Wells	Deep Wells	Shallow Wells	Deep Wells
P.V. of NR I	134,495	113,432	182,420	115,104
Annuity Value	12,932	10,907	17,540	11,068
P.V. of NR II	96,712	75,649	91,111	50,564
Annuity Value	9,299	7,274	8,761	4,862
P.V. of NR III	80,969	59,906	59,625	19,078
Annuity Value	7,785	5,760	5,733	1,834

320 Acre Farm (Shallow and Deep Wells)

Return I - 170 ac. Malting barley, 150 ac. Alfalfa hay
Return II - 120 ac. Feed barley, 50 ac. Malting barley, 150 ac. Alfalfa hay
Return III - 170 ac. Feed barley, 150 ac. Alfalfa hay

640 Acre Farm (Shallow Wells)

Return I - 390 ac. Malting barley, 250 ac. Alfalfa hay
Return II - 100 ac. Malting barley, 250 ac. Alfalfa hay, 290 ac. Feed barley
Return III - 390 ac. Feed barley, 250 ac. Alfalfa hay

(Deep Wells)
Return I - 305 ac. Malting barley, 250 ac. Alfalfa hay
Return II - 100 ac. Malting barley, 250 ac. Alfalfa hay, 205 ac. Feed barley
Return III - 305 ac. Feed barley, 250 ac. Alfalfa hay.

were forced into the solution, the range in annuity values was from $10,907 to $5,760 for the same crop mix.

Shallow well analysis on the 640 acre farm plan resulted in net returns with accumulated present values from $182,420 to $59,625. A total of only 555 acres entered the final solution of the deep wells analysis of the same farm. Irrigation water available from wells in the farm model was the limiting factor of production. The restricted acreage limited the accumulated present values of net returns to a range of $115,104 to $19,078. The effect of an inadequate water supply is evident in the low 20 year accumulated present value of $19,078. The 85 acres of unused land in the final solution are those which would make the farm plan either profitable or unprofitable to operate. A change from the production of feed barley and alfalfa hay to the production of malting barley and alfalfa hay would increase the annual annuity value for this farm plan from the low of $1,834 to $11,068, even when 85 acres of land are idle.

The potential returns for farms in the southern portion of the study area are much greater when malting barley is produced instead of feed barley. A sixfold increase in the annual annuity value for the 640 acre farm plan with restricted acreage dramatized two very different return possibilities for the same farm plan.

Another return possibility examined for farms in the southern portion of the Raft River Basin was the dairy option. Table 7 presents a summary of the returns from the dairy farm plans operation. The accumulated present value net return for the 320 acre farm plan in the south doubles to $268,708 when it is operated as a dairy farm. The return for the 640 acre dairy is three times the largest return for a non-dairy farm plan of the same size.

Table 7: 20 Year Accumulated Present Values and Annual Annuity Values for Dairy Farms in the Southern End of the Raft River Basin. (7¼% Interest)

	320 Acre Dairy		640 Acre Dairy	
	Shallow Wells	Deep Wells	Shallow Wells	Deep Wells
P.V. of NR	268,708	256,374	630,320	462,805
Annuity Value	25,837	24,651	60,608	44,500

320 Acre Dairy (Shallow & Deep Wells)

85 Cow Herd

640 Acre Dairy (Shallow Wells)

198 Cow Herd
(Deep Wells)
164 Cow Herd

The 320 acre dairy solutions were based on an 85 cow herd for both shallow and deep well analysis. The 640 acre dairy solutions were based on a 198 cow herd for the shallow well analysis and a 164 cow herd for the deep well analysis.

Several dairy operations are now present in the southern portion of the basin. Results of this analysis show that the dairy operation would be more profitable for the farmers in the south than the production of alfalfa hay and either feed or malting barley as cash crops.

The effect of land not being used on a farm due to a lack of irrigation water is evident in the low annuity values and accumulated net returns for farms in that situation. If the problem is not remedied, such farms could, and probably would, go out of business.

Value of Restricted Land Useage

An important and useful item of the LP results is the marginal value attached to various activities. The dual activity column furnishes these values. When water limits the number of acres entering the final solution, it takes on a marginal value. With this value, it is possible to estimate the amount a farm operator should be willing to spend on improvements for his wells and pumping equipment.

Due to the way the basic LP model used in this study was constructed, a direct estimate cannot be made from dual activity values from the printout. The objective function in the model is designed to be a return to certain fixed factors in the analysis. The actual calculated return to operator labor and management is approximately 75% of the objective function return of the printout. To demonstrate the method for determining the amount which a farmer should be willing to spend for improvements, it was assumed that dual activity values present on the printouts should be reduced by 25% to approximate their true values. The following is an oversimplification of the method for estimating the amount a farm operator should be willing to pay for well improvements.

The 960 acre farm plan producing potatoes and alfalfa hay utilized 916 acres in the shallow well analysis and 717 acres in the deep well analysis. The factor limiting land usage in the shallow analysis was total water available for irrigation on the farm. The limiting factor in the deep well analysis was irrigation water available in July. The marginal value of water at the 717 acre solution point was \$202. The value at the 916 acre solution point was \$74. A 25% reduction lowers these values to \$152 and \$56 respectively. (These marginal values hold only near the solution points. If an adequate amount of water had been available to irrigate the entire 960 acres, the marginal value of water would have been zero.) If a linear decline in the marginal value of water from 717 acres to 916 acres and from 916 acres to 960 acres is assumed, the loss in income from the idle land may be estimated in the following manner:

$\frac{\$56}{2}$ = \$28 (average marginal value per AF of water from 916 acres to 960 acres)

960 - 916 = 44 (acres of idle land)

\$28 x 44 = \$1232 (loss in income with acreage restricted to 916 acres)

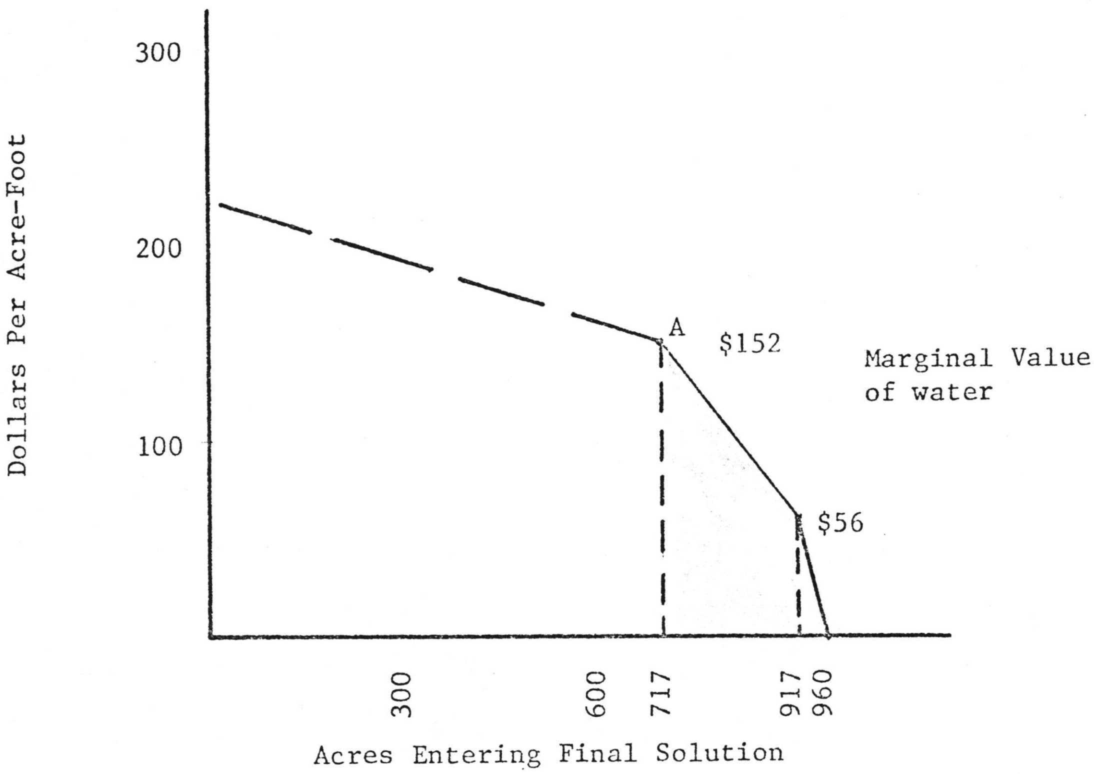
$$\frac{\$152 + \$56}{2} = \$104$$ (average marginal value per AF of water from 717 acres to 916 acres)

916 - 717 = 199 (acres of idle land)

$104 x 199 = $20,696 (additional loss in income when acreage is restricted to 717 acres)

$20,696 + $1,232 = $21,928 (total income loss from restricted acreage)

A graphical presentation of the situation takes the form of Graph 1. The marginal value for additional water would reach zero if adequate water was available to irrigate the entire 960 acres. The marginal value line does not intersect the vertical axis because the marginal value for water is not determined at a production level of zero. (The line from Point A leftward shows what the marginal value might be for this farm plan at lower solution levels.) The shaded area of the graph designates the farm income lost by not utilizing all available land in the farm plan, $21,928. The operator should be willing to spend up to that amount to improve his wells and pumping equipment to guarantee an adequate water supply. The $21,928 loss is for only one year which makes it evident that a farmer could make many improvements in the 20 years considered in this analysis.



Graph 1: Marginal Value of Water per Acre-Foot for a Farm Plan with Acreage Restricted by a Lack of Irrigation Water

CHAPTER V

Effects of Ground Water Decline on the Returns To Representative Farming Enterprises

The second objective of this study was to estimate the benefits and costs associated with varying rates of ground water decline in the Raft River Basin. The decline rates examined were 1, 2, 3, 4, 5 and 10 feet per year. Declines of 5 feet per year have occurred in parts of the basin. The 10 foot rate was examined to estimate the effect of a decline rate greater than that already experienced.

Several calculations must be made in order to examine various rates of ground water decline. As decline occurs, the power cost for pumping an acre-foot of water form a well increases. Increased power cost is, however, only a portion of the overall cost of the ground water decline. As decline occurs, and as the rate increases, the pumping equipment and wells become obsolete in a shorter than normal period of time. This obsolescence increases the depreciation and replacement costs for wells and pumping equipment. The eleven representative wells in this study were examined and cost calculations made for the improvements and changes necessary to maintain their yields at their current levels for 20 years (Appendix F). The power cost at the maximum depth a system would be pumping from at the end of the period was averaged with the cost when no decline occurred for each representative well. This was done for each of the wells for each rate of decline (Appendix G).

The increased power costs of pumping associated with the rates of decline were examined in the linear programming models. This was done by substituting the increased costs of pumping from each well for the originally programmed costs in the objective functions of the farm plan models. This involved examining 7 objective functions with differing pumping costs for both shallow and deep well analysis. The examination of the different returns for the various rates of decline was handled in the same manner as previously explained. The only difference in the calculations was that the total cost of depreciation of the wells and pumping equipment of a farm plan varied over the time period. This was caused by the improvements and changes which had to be made in wells and pumping equipment during the 20 year period. The program provided by Professor Joel Hamilton, Department of Agricultural Economics, University of Idaho, to determine the cumulative present values was used to handle these changes, so it was not a serious problem to examine varying depreciations costs.

Tables 8 through 12 present a summary of effects various rates of ground water decline have on farm plans in the Raft River Basin. An examination of each plan at four discount (interest) rates appears in Appendix H. Decline reduced the present values of net returns and annual annuity values as expected, but not in the amounts which had been anticipated.

Northern Area of Basin

Tables 8 and 9 are a presentation of the effects of a decline on farm plans in the northern portion of the Raft River Basin. The 640 acre farm plan with shallow wells has an accumulated present value of $715,890 for net return I (the return for the production of 82 acres of malting barley, 150 acres of alfalfa hay, and 408 acres of potatoes [Table 5]). The annual annuity value for the return was $68,835. One foot of decline per year decreased these values to $706,746 and $67,959 respectively. Five feet of yearly decline reduced the values to $684,404 and $65,808. The decrease in the annuity value from $68,835 to $65,808 is a 4% decrease. Ten feet of decline reduces the annuity value to $63,103, an overall 8% decrease.

Southern Area of Basin

Decline of the ground water level in the southern portion of the basin is more critical than decline in the northern section. Net returns and annuity values are much lower in the southern portion of the study area than in the northern portion. The 320 acre farm plan with shallow wells provides an accumulated present value net return of $134,495 with production of 170 acres of malting barley and 150 acres of alfalfa hay (return I, Table 6). The annual annuity value of the return is $12,932. One foot of decline per year reduces the return and annuity value to $127,591 and $12,268 respectively. The decrease of the annuity value is a decrease of 13%. Ten feet of decline per year decreases the annuity value to $9,270, an overall 28% decrease.

Table 8: Effects of Ground Water Decline on the 20 Year Accumulated Present Values and Annual Annuity Values for Farms with Shallow Wells in the Northern Portion of the Raft River Basin. (7¼% Interest)

Decline Per Year	None	1'	2'	3'	4'	5'	10'
640 Acre Farm (Shallow Wells)							
P.V. of NR I	715,890	706,746	701,180	698,108	689,266	684,404	656,269
Annuity Value	68,835	67,956	67,421	67,126	66,276	65,808	63,103
P.V. of NR II	375,315	366,119	360,564	357,448	348,585	343,756	315,620
Annuity Value	36,088	35,204	34,670	34,370	33,518	33,053	30,348
P.V. of NR III	336,151	327,049	321,536	318,544	309,744	304,998	274,763
Annuity Value	32,322	31,447	30,917	30,629	29,783	29,327	26,420
960 Acre Farm (Shallow Wells)							
P.V. of NR I	1,497,252	1,487,131	1,474,250	1,467,456	1,454,588	1,444,640	1,392,811
Annuity Value	143,967	142,993	141,755	141,102	139,864	138,908	133,924
P.V. of NR II	650,473	640,343	630,530	625,126	614,390	604,931	563,550
Annuity Value	62,545	61,571	60,628	60,108	59,076	58,166	54,188
P.V. of NR III	641,743	631,696	621,894	616,500	605,774	596,324	555,007
Annuity Value	61,706	60,740	59,798	59,279	58,248	57,339	53,366

Table 9: Effects of Ground Water Decline on the 20 Year Accumulated Present Values and Annual Annuity Values for Farms with Deep Wells in the Northern Portion of the Raft River Basin. (7¼% Interest)

Decline Per Year	None	1'	2'	3'	4'	5'	10'
640 Acre Farm (Deep Wells)							
P.V. of NR I	700,169	698,113	688,906	684,085	679,135	671,799	644,904
Annuity Value	67,324	67,126	66,241	65,777	65,301	64,956	62,010
P.V. of NR II	358,125	356,072	346,886	342,022	337,519	330,216	302,830
Annuity Value	34,435	34,238	33,354	32,887	32,454	31,752	29,118
P.V. of NR III	319,444	317,449	308,398	301,627	299,073	291,968	262,503
Annuity Value	30,716	30,524	29,654	29,033	28,757	28,074	25,241
960 Acre Farm (Deep Wells)							
P.V. of NR I	993,823	987,973	977,029	971,978	964,062	956,118	919,606
Annuity Value	95,560	94,997	93,945	93,459	92,698	91,934	88,424
P.V. of NR II	634,742	628,632	617,023	611,587	603,431	594,915	556,888
Annuity Value	61,033	60,445	59,329	58,006	58,022	57,203	53,547
P.V. of NR III	626,115	612,419	612,565	602,982	594,837	586,322	548,367
Annuity Value	60,203	58,886	58,900	57,979	57,196	56,377	52,728

Table 10: Effects of Ground Water Decline on the 20 Year Accumulated Present Values and Annual Annuity Values for Farms with Shallow Wells in the Southern Portion of the Raft River Basin. (7¼% Interest)

Decline Per Year	None	1'	2'	3'	4'	5'	10'
320 Acre Farm (Shallow Wells)							
P.V. of NR I	134,495	127,591	126,269	123,794	120,957	116,988	96,407
Annuity Value	12,932	12,268	12,141	11,903	11,630	11,249	9,270
P.V. of NR II	96,712	89,808	88,486	86,011	83,174	79,205	58,624
Annuity Value	9,299	8,635	8,508	8,270	7,998	7,616	5,637
P.V. of NR III	80,969	74,065	72,743	70,268	67,431	63,462	42,881
Annuity Value	7,785	7,122	6,995	6,757	6,484	6,102	4,123
640 Acre Farm (Shallow Wells)							
P.V. of NR I	182,420	172,941	169,446	165,019	159,656	153,248	121,076
Annuity Value	17,540	16,629	16,293	15,867	15,352	14,735	11,642
P.V. of NR II	91,111	81,633	78,138	73,711	68,348	61,940	29,768
Annuity Value	8,761	7,849	7,513	7,088	6,572	5,956	2,862
P.V. of NR III	59,625	50,147	46,652	42,225	36,862	30,454	-1,718
Annuity Value	5,733	4,822	4,486	4,060	3,544	2,928	-165

Decreases by this amount are a serious problem for a farm. The severity of the effects of decline in the southern portion of the study area is even more evident when the returns for farms producing only feed barley and alfalfa hay are examined (NR III). Annuity values for the 320 acre farm plan drop to $6,102 for shallow wells and $4,282 for deep wells when decline of 5 feet per year occurs.

The 640 acre farm in the south with deep wells and restricted acreage has a net return with an accumulated present value of $19,078 and an annual annuity value of $1,834 (Table 11) for net return III (production of 305 acres of feed barley and 250 acres of alfalfa hay [Table 6]). Five feet of decline per year decreases the annuity value to $27. Decline of ten feet per year causes an accumulated present value net loss of $20,259. Even without decline, the annuity value of $1,834 is an unacceptable return for the farm plan for 640 acres.

The dairy operations in the southern portion of the basin continued to show the best returns for farms in that area (Table 12). Five feet of decline per year decreased the annuity value for the 320 acre dairy with shallow wells by $2,898 or 11%. The annuity value with this reduction was still $22,939 which was greater than the highest annuity value for a 320 acre non-dairy farm with 5 feet of yearly decline ($11,249).

Farms in the northern section of the basin should be able to make the necessary well and pumping equipment changes with only a

Table 11: Effects of Ground Water Decline on the 20 Year Accumulated Present Values and Annual Annuity Values for Farms with Deep Wells in the Southern Portion of the Raft River Basin. (7¼% Interest)

Decline Per Year	None	1'	2'	3'	4'	5'	10'
320 Acre Farm (Deep Wells)							
P.V. of NR I	113,432	106,992	103,223	102,454	98,852	98,062	84,486
Annuity Value	10,907	10,288	9,925	9,851	9,505	9,429	8,124
P.V. of NR II	75,649	69,209	65,440	64,671	61,069	60,279	46,703
Annuity Value	7,274	6,655	6,292	6,218	5,872	5,796	4,491
P.V. of NR III	59,906	53,466	49,697	48,928	45,326	44,536	30,960
Annuity Value	5,760	5,141	4,779	4,705	4,358	4,282	2,977
640 Acre Farm (Deep Wells)							
P.V. of NR I	115,104	107,844	103,431	101,975	97,709	96,306	75,767
Annuity Value	11,068	10,370	9,945	9,805	9,395	9,260	7,285
P.V. of NR II	50,564	43,304	38,891	37,435	33,169	31,766	11,227
Annuity Value	4,862	4,164	3,740	3,600	3,189	3,054	1,080
P.V. of NR III	19,078	11,818	7,405	5,949	1,683	280	-20,259
Annuity Value	1,834	1,136	712	572	162	27	-1,948

Table 12: Effects of Ground Water Decline on the 20 Year Accumulated Present Values and Annual Annuity Values for Dairy Farms in the Southern Portion of the Raft River Basin. (7¼% Interest)

Decline Per Year	None	1'	2'	3'	4'	5'	10'
320 Acre Dairy (Shallow Wells)							
P.V. of NR I	268,708	251,195	248,335	245,715	242,690	239,566	222,006
Annuity Value	25,837	24,153	23,878	23,624	23,336	22,939	21,347
(Deep Wells)							
P.V. of NR I	256,374	249,737	245,801	244,887	241,129	240,194	230,919
Annuity Value	24,651	24,013	23,635	23,547	23,185	23,096	22,204
640 Acre Dairy (Shallow Wells)							
P.V. of NR I	630,320	620,562	616,890	612,265	606,653	600,058	576,937
Annuity Value	60,608	59,669	59,316	58,872	58,332	57,698	55,475
(Deep Wells)							
P.V. of NR I	462,805	455,577	451,131	449,790	445,545	444,184	434,545
Annuity Value	44,500	43,805	43,378	43,249	42,841	42,710	41,783

a slight reduction in their returns. When the acreage of land utilized on a farm is restricted, the ability of a farmer to make the necessary changes is reduced. This is also the case when low value cash crops are grown on a farm.

Returns for farms in the southern portion of the Raft River Basin restrict the ability to make improvements and changes in wells and pumping equipment. Returns for all farm plans, excluding dairy, are low with no ground water decline. Ten feet of decline per year resulted in a net loss for the 640 acre farm plan producing feed barley and alfalfa hay as cash crops.

Opportunity Cost of Not Pumping the Ground Water

The opportunity cost or value foregone by not pumping the ground water in the Raft River Basin is best expressed by the accumulated present value net returns and annual annuity values of the farm plans. Without the irrigation water pumped from the aquifer, agricultural use for land in the basin would be limited to desert grazing range. An extremely limited amount of land in the study area is wholly irrigated with surface water from the Raft River and Cassia Creek. An improved Bureau of Land Management grazing area in the eastern portion of the valley containing approximately 5,000 acres produced only 5,404 A.U.M. s (animal unit months) of grazing in 1971 (interview with a representative of the Burley BLM office). The value of one A.U.M. of grazing per acre

($.80 for federal lands for 1972)(11) when compared to the potential returns from irrigation of the land is minimal. The opportunity cost of not irrigating would be nearly identical to the present value net return to a farm plan.

Relative Importance of Ground Water Decline

Data have been presented which show the impacts of various yearly rates of ground water deline on estimated returns for various farm plans in the Raft River Basin. It is also important to discuss the importance of water level decline and depth to ground water in relation to other variables affecting farm plan returns. The location and size of the farm, the management capabilities of the operator, crops produced and characteristics of wells also affect returns from the farm operation.

The location of the farm, in either the northern or southern portion of the study area, has a large impact on farm income. The dissimilar crop possibilities for the two areas is of major importance to farm income. The size of the farm and the management capabilities of the farm operator also influence farm income. As farm size increases, efficiencies of equipment and labor usage tend to increase. These increased efficiencies when accompanied by a high level of management capability can affect returns significantly. The crop mix also has a major impact on return levels for the farm plans. The three crop combinations examined for each farm plan in the southern portion of the Raft River Basin can be produced with the same equipment inventory and amount of irrigation water. The 640 acre field crop plan has 20 year accumulated present value net return possibilities of $182,420, $91,111 and $59,625. This range of return possibilities, which is typical for all farm plans in the study area, shows the importance of the crop mix chosen for production on a farm.

The characteristics of wells on a farm and depth to water, although important factors influencing farm returns, are not as important as crops produced, farm size, management capabilities, and farm location. Farms located some distance from the river typically have deeper wells and greater depths to water. Power costs per unit of water pumped increase as the depth to water increases. Investment costs and depreciation expenses also increase for deep wells and associated pumping equipment. These changes in costs are relatively minor. For example, the 20 year accumulated present value net returns for the 320 acre farm plan in the southern portion of the study area is decreased by only $21,000, $234,495 to $113,432 when deep wells provide irrigation water. Similar relationships exist for other farm plans examined in this study.

The rate of ground water decline affects farm returns by affecting the power cost of pumping a unit of water (increased depth to water increases power cost), investment costs and depreciation expenses of wells and pumping equipment. Decline causes earlier obsolescence of pumping equipment and wells. Pump motors must be replaced with bigger units, wells must be deepened, and other changes must be made as the water level declines. The 20 year accumulated present value net return to the 640 acre farm plan in the southern portion of the study area decreased from $182,420 when no decline occurred to $153,248 when 5 feet of yearly decline occurred, Table 10. Ten feet of yearly decline decreased the return to $121,076. However, this return level for the most profitable crop mix was still greater than the return from the production of the next most profitable crop mix with no decline, $91,111.

As evidenced by the above, ground water decline and depth to ground water do affect farm returns, but in relatively minor amounts when compared to the importance of farm location, farm size, management capability, and crop mix produced. Administration of the ground water resource based on depth to water or rate of ground water decline alone ignores the more important factors affecting a farm's return.

CHAPTER VI

Summary and Conclusions

Summary

An economic analysis of farm plans in the Raft River Basin was performed to 1) estimate the value of water pumped from the aquifer system, 2) examine the effects of a declining ground water level on returns to farms, and 3) estimate the opportunity cost of not pumping the ground water. An examination of agricultural activities in the basin showed dissimilar crop opportunities in the northern and southern portions of the area. Therefore, the basin was divided into two areas for consideration in this analysis.

Data pertaining to costs of production, returns for crops, agricultural practices and cropping patterns in the study area were gathered in 1972 to provide the information base for this study. Activity budgets for producing crops were formulated from this data. Linear programming analysis using the information from the budgets was then applied to estimate the returns to operator labor and management from representative farm plans examined in the two divisions of the study area. This analysis was then extended to examine the effects of 6 rates of decline on the returns to operator labor and management. The added costs which a farm would experience in changing its irrigation wells and pumping equipment to maintain its irrigation water supply were examined to determine the impact from various rates of water level decline on the 20 year accumulated present value of net returns and annual annuity values for a farm.

As the rate of decline increased, the returns and annuity values decreased as expected, but not by the amounts that had been anticipated. The rate of water level decline on a farm had less impact on the returns than did the various possible crop mixes for a farm plan. Farms in the northern portion of the Raft River Basin should be able to operate with up to five feet of yearly decline and experience only slightly lower returns. Farms in the southern portion of the study area which produce the lower value crop mix of feed barley and alfalfa hay have low returns even without decline. The most profitable enterprises examined for the southern area were the 320 and 640 acre dairy farm plans. Accumulated present value net returns and annual annuity values were at a minimum three times the returns from the same size farm without dairy. Ground water decline in the southern portion of the Raft River Basin is far more serious a problem than decline in the northern portion. Income levels for farms in the southern portion are at or below subsistance levels without a decline in the ground water level. Returns in the northern portion of the study area are at a considerably higher level.

The value of irrigation water is the value of the return to operator labor and management for the crops produced in a farm plan. If the water was not pumped for use at this time, the loss would be nearly equal to this value. The alternative to irrigated agriculture for the lands currently irrigated with ground water is desert grazing. The opportunity cost of not irrigating the land is, considering a value of one A.U.M. per acre for grazing ($.80 in 1972), closely approximated by the returns per acre for irrigated farm plans.

Ground water decline affects farm returns, but by relatively minor amounts when compared to other factors. In the Raft River Basin the major factors affecting the returns to farms are the location of the farm (northern or southern portion of the basin) and crop mix produced. Characteristics of the wells on a farm, depth to water, and farm size and management capabilities also affect returns, but to a lesser degree.

Administration of the ground water resource should consider all factors affecting farm returns. The effect of ground water decline is only one measure of the economic position of a farm enterprise.

Conclusions

This analysis has shown the effects of a declining ground water level on the returns to various farm plans. The rate of decline that can be tolerated on a farm varies for different farms and different cropping patterns. The returns to farm operations in the Raft River Basin are influenced more by farm location and crop mix produced than ground water decline and depth to water.

The value of a water right is the certainty it provides the holder. When applied to ground water, the certainty concerns the level of the water and the rate of decline, if any, which can be expected. If the rate of yearly decline can be anticipated, wells and pumping equipment can be designed to minimize costs as decline occurs. The added costs incurred from ground water decline are influenced more by the time period over which the decline occurs than the depth to water.

It has been demonstrated that the depth to water and the rate of ground water decline are not the major factors affecting farm returns in the study area. These results indicate that administration of the ground water resource in the Raft River Basin to achieve the goal of "full economic development" of the resource would be more appropriate than administration to maintain "reasonable pumping levels".

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APPENDICES

APPENDIX A

Farm Activity Budgets Used In This Study

Table 1: Estimated Costs and Returns for Irrigated Grain on a 640 Acre Farm, Northern End of Raft River Basin, 1972.

Variable Costs	
Seed, barley (100#/acre)	$ 5.00
or wheat (100#/acre)	(5.50)*
Spray, 2,4-D (custom aerial application)	2.60
Machinery	
Repairs	14.34
Fuel and lubricant	1.72
Labor	
Irrigation (2 hrs. @ $2.25/hr)	4.50
All other (1.74 hrs @ $2.25/hr)	3.92
Interest on working capitol	1.16
Fixed Costs	
Depreciation	15.41
Interest on land	25.38
Taxes	4.21

Gross Returns	50 Bu	60 Bu	70 Bu	75 Bu	80 Bu	90 Bu
Feed Barley @ $.98/Bu	$49.00	58.80	68.60	73.50	78.40	88.20
Malting Barley @ $1.73/Bu	86.50	103.80	121.10	129.75	138.40	155.70
Wheat @ $1.40/Bu	70.00	84.00	98.00	105.00	112.00	126.00

*Substitute seed cost

Table 2: Estimated Costs and Returns for Irrigated Alfalfa Hay on a 640 Acre Farm, Northern End of Raft River Basin, 1972.

Variable Costs	
Spray, Weevil (custom aerial application)	$ 4.75
Machinery	
Repairs	11.64
Fuel and lubricant	3.72
Labor	
Irrigation (3 hrs. @ $2.25/hr)	6.75
All other (3.27 hrs. @ $2.25/hr)	7.36
Interest on working capitol	1.24
Fixed Costs	
Depreciation on machinery	10.33
Interest on land	25.38
Taxes	4.21

Gross Returns

	3 Ton	4 Ton	5 Ton	6 Ton
Alfalfa Hay @ $25/ton	$75	$100	$125	$150

Table 3: Estimated Costs and Returns for Irrigated Sugar Beets on a 640 Acre Farm, Northern End of Raft River Basin, 1972.

Variable Costs	
Seed (3#/acre)	$ 3.00
Fertilizer	35.00
Spray	1.50
Machinery	
Repairs	19.60
Fuel and lubricants	4.16
Labor	
Irrigation (14 hrs. @ $2.25/hr)	31.50
All other (10 hrs. @ $2.25/hr)	22.50
Interest on working capitol	4.25
Fixed Costs	
Depreciation on machinery	17.04
Interest on land	25.38
Taxes	4.21

Gross Returns

	10 Ton	12 Ton	14 Ton	15 Ton	16 Ton	18 Ton
Sugar Beets @ $14/ton	$140	$168	$196	$210	$224	$252

Table 4: Estimated Costs and Returns for Irrigated Potatoes on a 640 Acre Farm, Northern End of Raft River Basin, 1972.

Variable Costs	
Seed (20 sacks/acre)	$57.00
Seed treatment	3.60
Spray	7.25
Machinery	
Repairs	42.72
Fuel and lubricants	4.15
Labor	
Irrigation (12 hrs. @ $2.25/hr)	27.00
All other (4.29 hrs. @ $2.25/hr)	9.65
Interest on working capitol	5.49
Fixed Costs	
Depreciation on machinery	37.76
Interest on land	25.38
Taxes	4.21

Gross Returns

	200 Sacks	225 Sacks	250 Sacks	275 Sacks
Potatoes @ $2.00/cwt	$400	$450	$500	$550

Table 5: Estimated Costs and Returns for Irrigated Grain on a 960 Acre Farm, Northern End of Raft River Basin, 1972.

Variable Costs	
Seed, barley (100#/acre)	$ 5.00
or wheat (100#/acre)	(5.50)*
Machinery	
Repairs	9.06
Fuel and lubricants	1.49
Labor	
Irrigation (.89 hrs. @ $2.25/hr)	2.00
All other (1.46 hrs. @ $2.25/hr)	3.29
Interest on working capitol	.75
Fixed Costs	
Depreciation on machinery	9.22
Interest on land	25.38
Taxes	4.21

Gross Returns

	50 Bu	60 Bu	70 Bu	75 Bu	80 Bu	90 Bu
Feed Barley @ $.98/Bu	$49.00	58.80	68.60	73.50	78.40	88.20
Malting Barley @ $1.73/Bu	86.50	103.80	121.10	129.75	138.40	155.70
Wheat @ $1.40/Bu	70.00	84.00	98.00	105.00	112.00	126.00

*Substitute seed cost

Table 6: Estimated Costs and Returns for Irrigated Alfalfa Hay on a 960 Acre Farm, Northern End of Raft River Basin, 1972.

Variable Costs	
Spray, Weevil (custom aerial application)	$ 3.50
Machinery	
Repairs	17.49
Fuel and lubricants	2.64
Labor	
Irrigation (2.67 hrs. @ $2.25/hr)	6.00
All other (2.61 hrs. @ $2.25/hr)	5.87
Interest on working capitol	1.29
Fixed Costs	
Depreciation on machinery	15.89
Interest on land	25.38
Taxes	4.21

Gross Returns

	3 Ton	4 Ton	5 Ton	6 Ton
Alfalfa Hay @ $25/ton	$75	$100	$125	$150

Table 7: Estimated Costs and Returns for Irrigated Sugar Beets on a 960 Acre Farm, Northern End of Raft River Basin, 1972.

Variable Costs	
Seed (3#/acre)	$ 3.00
Fertilizer	30.00
Machinery	
Repairs	11.20
Fuel and lubricants	4.16
Labor	
Irrigation (5.16 hrs. @ $2.25/hr)	11.60
All other (20 hrs. @ $2.25/hr)	45.00
Interest on working capitol	3.80
Fixed Costs	
Depreciation on machinery	9.78
Interest on land	25.38
Taxes	4.21

Gross Returns

	10 Ton	12 Ton	14 Ton	15 Ton	16 Ton	18 Ton
Sugar Beets @ $14/ton	$140	$168	$196	$210	$224	$252

Table 8: Estimated Costs and Returns for Irrigated Potatoes on a 960 Acre Farm, Northern End of Raft River Basin, 1972.

Variable Costs	
Seed (20 sacks/acre)	$57.00
Seed treatment	3.60
Spray	4.00
Fertilizer	35.00
Machinery	
Repairs	13.74
Fuel and lubricants	4.15
Labor	
Irrigation (4.45 hrs. @ $2.25/hr)	10.00
All other (4 hrs. @ $2.25/hr)	9.00
Interest on working capitol	4.95
Fixed Costs	
Depreciation on machinery	13.03
Interest on land	25.38
Taxes	4.21

Gross Returns

	200 Sacks	225 Sacks	250 Sacks	275 Sacks
Potatoes @ $2.00/cwt	$400	$450	$500	$550

Table 9: Estimated Costs and Returns for Irrigated Grain on a 320 Acre Farm, Southern End of Raft River Valley, 1972.

Variable Costs	
Seed, barley (100#/acre)	$ 5.00
Custom harvest	7.00
Machinery	
Repairs	5.36
Fuel and lubricants	1.14
Labor	
Irrigation (1.5 hrs. @ $2.25/hr)	3.38
All other (1.15 hrs. @ $2.25/hr)	2.59
Interest on working capitol	.89
Fixed Costs	
Depreciation on machinery	4.07
Interest on land	18.12
Taxes	3.06

Gross Returns

	50 Bu	60 Bu	70 Bu	75 Bu	80 Bu	90 Bu
Feed barley @ $.98/Bu	$49.00	58.80	68.60	73.50	78.40	88.20
Malting barley @ $1.73/Bu	86.50	103.80	121.10	129.75	138.40	155.70

Table 10: Estimated Costs and Returns for Irrigated Alfalfa Hay on a 320 Acre Farm, Southern End of Raft River Basin, 1972.

Variable Costs	
Machinery	
Repairs	$ 8.61
Fuel and lubricants	2.64
Labor	
Irrigation (2.5 hrs. @ $2.25/hr)	5.62
All other (3.61 hrs. @ $2.25/hr)	8.12
Interest on working capitol	.91
Fixed Costs	
Depreciation on machinery	7.67
Interest on land	18.12
Taxes	3.06

Gross Returns	3 Ton	4 Ton	5 Ton
Alfalfa Hay @ $25/ton	$75	$100	$125

Table 11: Estimated Costs and Returns for Irrigated Grain on a 640 Acre Farm, Southern End of Raft River Basin, 1972.

Variable Costs	
Seed, barley (100#/acre)	$ 5.00
Spray, 2,4-D (custom aerial application)	2.60
Machinery	
Repairs	10.45
Fuel and lubricants	1.49
Labor	
Irrigation (1.5 hrs. @ $2.25/hr)	3.38
All other (1.46 hrs. @ $2.25/hr)	3.28
Interest on working capitol	.95
Fixed Costs	
Depreciation on machinery	12.18
Interest on land	18.12
Taxes	3.06

Gross Returns

	50 Bu	60 Bu	70 Bu	75 Bu	80 Bu	90 Bu
Feed barley @ $.98/Bu	$49.00	58.80	68.60	73.50	78.40	88.20
Malting barley @ $1.73/Bu	86.50	103.80	121.10	129.75	138.40	155.70

Table 12: Estimated Costs and Returns for Irrigated Alfalfa Hay on a 640 Acre Farm, Southern End of Raft River Basin, 1972.

Variable Costs	
Spray (custom)	$ 5.60
Machinery	
Repairs	13.71
Fuel and lubricants	2.87
Labor	
Irrigation (2.5 hrs. @ $2.25/hr)	5.62
All other (2.84 hrs. @ $2.25/hr)	6.39
Interest on working capitol	1.24
Fixed Costs	
Depreciation on machinery	12.11
Interest on land	18.12
Taxes	3.06

Gross Returns

	3 Ton	4 Ton	5 Ton
Alfalfa Hay @ $25/ton	$75	$100	$125

Table 13: Estimated Costs and Returns for Irrigated Silage Corn on a 640 Acre Farm, Southern End of Raft River Basin, 1972.

Variable Costs	
Seed, corn (20#/acre)	$12.00
Fertilizer (100 units nitrogen)	8.44
Machinery	
Repairs	10.86
Fuel and lubricants	2.75
Labor	
Irrigation (2.5 hrs. @ $2.25/hr)	5.62
All other (4 hrs. @ $2.24/hr)	9.00
Interest on working capitol	1.76
Fixed Costs	
Depreciation on machinery	8.31
Interest on land	18.12
Taxes	3.06

Gross Returns

	15 Ton	20 Ton	25 Ton
Corn silage @ $8.33/ton	$125	$166.60	$208

Table 14: Worksheet for Estimating Returns for Dairy Farms in the Southern End of the Raft River Basin, 1972.

This worksheet is an estimate of the requirements and returns to be expected for a dairy operation in the study area. The purpose of the dairy examination was to provide an estimate of an alternative income possibility for farms in the southern portion of the study area.

Crops grown for use on the dairy farm were assumed to be grown at the same cost as on other similar sized farms.

Feed Requirments for Dairy Cow and Replacement:

Hay Equivalent*	10.69 Tons
Feed Barley	80.36 Bushels

Parlor and Equipment Costs are assumed to average $500 per cow

Estimated value for a dairy cow is assumed to be $600

Gross Return from milk produced:

10,104 lb. milk @ $4,77/hd	$481,96
367.79 lb milkfat @ $1.38/lb	507.54
	$989.50

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* 3 tons of silage equals 1 ton of hay

** Idaho Agricultural Statistics, 1971 average production and prices

APPENDIX B

Table 1: Worksheet to Determine Combinations of Pump Bowls and Pump Horsepowers Necessary to Provide a Given GPM Output from Various Depths

	650 GPM		950 GPM		1100 GPM		1250 GPM		1900 GPM		2400 GPM	
South End Lift (feet)	HP	#Bowls (12")	HP	#Bowls (12")	HP	#Bowls (12")	HP	#Bowls (12")	HP	#Bowls (17")	HP	#Bowls (18")
50	10	2	15	2	20	2	20	2	30	1	40	2
80	10	3	30	3	30	3	40	3	50	2	60	2
100	25	3	40	4	40	4	40	4	60	2	100	3
150	30	5	60	6	60	6	60	6	100	3	125	4
200	40	6	75	8	75	8	100	8	125	4	150	5
250	50	8	100	10	100	10	100	10	150	5	200	6
300	60	9	125	12	125	12	125	12	200	6	250	7
350	75	11	125	13	125	13	150	13	200	7	300	8
400	75	12	150	15	150	15	175	15	250	8		

	1100 GPM		1300 GPM		1800 GPM		2000 GPM		2700 GPM	
North End Lift (feet)	HP	#Bowls (12")	HP	#Bowls (12")	HP	#Bowls (14")	HP	#Bowls (17")	HP	#Bowls (18")
50	20	2	25	2	40	2	40	1	100	2
80	30	3	40	4	60	3	60	2	100	2
100	40	4	50	4	60	3	75	2	125	3
150	60	6	75	6	100	4	100	3	150	4
200	75	8	100	8	125	6	150	4	200	5
250	100	9	100	10	150	7	200	5	250	6
300	125	11	125	12	200	8	200	6	300	7
350	150	13	150	14	200	10	250	7		
400	150	15	200	16	250	11	300	8		

APPENDIX C

Yield Levels and Returns for Crops
Produced in the Raft River Basin

Table 1: Expected Crop Yield Levels (Per Acre) Examined in Programming Analysis

Farm Size N	Farm Size S	Corn	Alfalfa	Wheat	Feed Barley	Malting Barley	Potatoes	Sugar Beets
640			4 Ton	60 Bu	75 Bu	60 Bu	200 Sacks	16 Ton
960			4½ Ton	60 Bu	90 Bu	70 Bu	200 Sacks	16 Ton
	320		4 Ton		75 Bu	60 Bu		
	640	20 Ton	4 Ton		75 Bu	60 Bu		

Gross Dollar Return Per Unit for Crops Produced:

Corn Silage	\$8.33/Ton
Alfalfa Hay	\$25.00/Ton
Wheat	\$1.40/Bu
Feed Barley	\$.98/Bu
Malting Barley	\$1.73/Bu
Potatoes	\$2.00/Sack
Sugar Beets	\$14.00/Ton

APPENDIX D

Crop Bounds Applied During the LP Analysis
of Representative Farms in the
Raft River Basin

Table 1: Crop Bounds Applied During LP Analysis of Representative Farms in the Northern Portion of the Raft River Basin.

640 Acre Farm	
Resulting Total Revenue	Bounds
TR I	Alfalfa 150 ac.
TR II	Alfalfa 150 ac., Potatoes 150 ac., Sugar beets 150 ac., Malting barley 150 ac.
TR III	100 ac. Alfalfa 150 ac., Potatoes 150 ac., 50 ac. Sugar beets 150 ac., Feed barley 100 ac.
960 Acre Farm	
Resulting Total Revenu	Bounds
TR I	Alfalfa = 200 ac.
TR II	150 ac. Alfalfa 225 ac., Potatoes 225 ac., 75 ac. Sugar beets 225 ac., Feed barley 150 ac., Malting barley 150 ac.
TR III	Alfalfa 200 ac., Potatoes 225 ac., Sugar beets 225 ac., Matling barley 225 ac.

Table 2: Crop Bounds Applied during LP Analaysis of Representative Farms in the Southern Portion of the Raft River Basin.

	Bounds
320 Acre Farm	
Resulting Total Revenue	
TR I	Alfalfa 150 ac.
TR II	Alfalfa 150 ac., Malting barley 50 ac.
TR III	Alfalfa 150 ac., Malting barley = 0 ac.
640 Acre Farm	
Resulting Total Revenue	
TR I	Alfalfa 250 ac.
TR II	Alfalfa 250 ac., Malting barley 100 ac.
TR III	Alfalfa 250 ac., Malting barley = 0 ac.

APPENDIX E

20 Year Accumulated Present Values and
Annual Annuity Values for Representative
Farm Plans in the Raft River Basin

Table 1: 20 Year Accumulated Present Values and Annual Annuity Values for a 640 Acre Farm, Northern End of Raft River Basin, Shallow Wells

Interest Rate	4%	6%	7¼%	9%
P.V.[1] of T.R.[2] I	2,537,469	2,141,575	1,940,174	1,704,411
P.V. of T.C.[3] I	1,599,506	1,350,816	1,224,284	1,075,146
P.V. of N.R.[4] I	937,963	790,759	715,890	628,265
Annuity Value	69,019	68,881	68,835	68,813
P.V. of T.R. II	1,713,218	1,445,923	1,309,944	1,150,766
P.V. of T.C. II	1,220,678	1,031,094	934,629	821,687
P.V. of N.R. II	492,450	414,829	375,315	329,079
Annuity Value	36,243	36,195	36,088	36,044
P.V. of T.R. III	1,683,157	1,420,551	1,286,960	1,130,573
P.V. of T.C. III	1,241,837	1,048,952	950,809	835,900
P.V. of N.R. III	441,320	371,591	336,151	294,673
Annuity Value	32,474	32,369	32,322	32,275

TR I = 182 Ac Malting barley, 150 Ac Alfalfa hay, 408 Ac Potatoes

TR II = 150 Ac Malting barley, 207 Ac Alfalfa hay, 150 Ac Potatoes, 133 Ac Sugar beets

TR III = 100 Ac Feed barley, 102 Ac Malting barley, 150 Ac Alfalfa hay, 150 Ac Potatoes, 138 Ac Sugar beets

[1] P.V. = Present Value

[2] T.R. = Total Revenue

[3] T.C. = Total Cost

[4] N.R. = Net Return

Table 2: 20 Year Accumulated Present Values and Annual Annuity Values for a 640 Acre Farm, Northern End of Raft River Basin, Deep Wells

Interest Rate	4%	6%	7¼%	9%
P.V. of T.R. I	2,537,469	2,141,575	1,940,174	1,704,411
P.V. of T.C. I	1,619,941	1,358,124	1,240,005	1,090,003
P.V. of N.R. I	917,528	773,451	700,169	614,403
Annuity Value	67,515	67,374	67,324	67,296
P.V. of T.R. II	1,713,218	1,445,923	1,309,940	1,150,766
P.V. of T.C. II	1,243,027	1.050,020	951,815	836,832
P.V. of N.R. II	470,191	395,903	358,125	313,934
Annuity Value	34,598	34,486	34,435	34,385
P.V. of T.R. III	1,683,157	1,420,551	1,286,960	1,130,573
P.V. of T.C. III	1,263,462	1,067,361	967,516	850,625
P.V. of N.R. III	419,595	353,200	319,444	279,948
Annuity Value	30,875	30,767	30,716	30,662

TR I = 182 Ac Malting barley, 150 Ac Alfalfa hay, 408 Ac Potatoes
TR II = 150 Ac Malting barley, 207 Ac Alfalfa hay, 150 Ac Potatoes, 133 Ac Sugar beets
TR III = 100 Ac Feed barley, 102 Ac Malting barley, 150 Ac Alfalfa hay, 150 Ac Potatoes, 138 Ac Sugar beets

Table 3: 20 Year Accumulated Present Values and Annual Annuity Values for a 960 Acre Farm, Northern End of Raft River Basin, Shallow Wells

Interest Rate	4%	6%	7¼%	9%
P.V. of T.R. I	4,198,045	3,543,065	3,209,865	2,819,815
P.V. of T.C. I	2,236,365	1,889,240	1,712,613	1,505,811
P.V. of N.R. I	1,961,680	1,653,825	1,497,252	1,314,004
Annuity Value	144,347	144,061	143,967	143,922
P.V. of T.R. II	2,359,139	1,991,066	1,803,819	1,584,626
P.V. of T.C. II	1,505,779	1,272,200	1,153,346	1,014,184
P.V. of N.R.II	853,360	718,866	650,473	570,442
Annuity Value	62,793	62,619	62,545	62,480
P.V. of T.R. III	2,270,801	1,916,509	1,736,275	1,525,291
P.V. of T.C. III	1,428,839	1,207,273	1,094,532	962,523
P.V. of N.R. III	841,962	709,236	641,743	562,768
Annuity Value	61,955	61,780	61,706	61,639

TR I = 200 Ac Alfalfa hay, 716 Ac Potatoes

TR II = 360 Ac Feed barley, 150 Ac Malting barley, 150 Ac Alfalfa hay, 225 Ac Potatoes, 75 Ac Beets

TR III = 310 Ac Feed barley, 225 Ac Malting barley, 200 Ac Alfalfa hay, 225 Ac Potatoes

Table 4: 20 Year Accumulated Present Values and Annual Annuity Values for a 960 Acre Farm, Northern End of Raft River Basin, Deep Wells

Interest Rate	4%	6%	7½%	9%
P.V. of T.R. I	3,116,255	2,630,056	2,382,717	2,093,178
P.V. of T.C. I	1,813,395	1,532,215	1,388,894	1,221,087
P.V. of N.R. I	1,302,360	1,097,841	993,823	872,091
Annuity Value	95,832	95,631	95,560	95,419
P.V. of T.R. II	2,359,139	1,991,066	1,803,819	1,584,626
P.V. of T.C. II	1,526,401	1,289,579	1,169,077	1,027,984
P.V. of N.R. II	832,738	701,487	634,742	556,642
Annuity Value	61,276	61,105	61,033	60,968
P.V. of T.R. III	2,270,801	1,916,509	1,736,275	1,525,291
P.V. of T.C. III	1,449,348	1,224,547	1,110,160	976,226
P.V. of N.R. III	321,453	691,962	626,115	549,065
Annuity Value	60,445	60,275	60,203	60,139

TR I = 200 Ac Alfalfa hay, 517 Ac Potatoes

TR II = 360 Ac Feed barley, 150 Ac Malting barley, 150 Ac Alfalfa hay, 225 Ac Potatoes, 74 Ac Beets

TR III = 310 Ac Feed barley, 225 Ac Malting barley, 200 Ac Alfalfa hay, 225 Ac Potatoes

Table 5: 20 Year Accumulated Present Values and Annual Annuity Values for a 320 Acre Farm, Southern End of Raft River Basin, Shallow Wells

Interest Rate	4%	6%	7¼%	9%
P.V. of T.R. I	443,669	374,448	339,234	298,012
P.V. of T.C. I	267,770	225,992	204,739	179,860
P.V. of N.R. I	175,899	148,456	134,495	118,152
Annuity Value	12,943	12,932	12,932	12,941
P.V. of T.R. II	394,255	332,743	301,451	264,820
P.V. of T.C. II	267,770	225,992	204,739	179,860
P.V. of N.R. II	126,485	106,751	96,712	84,960
Annuity Value	9,307	9,299	9,299	9,306
P.V. of T.R. III	373,665	315,366	285,708	250,990
P.V. of T.C. III	267,770	225,992	204,739	179,860
P.V. of N.R. III	105,895	89,374	80,969	71,130
Annuity Value	7,792	7,785	7,785	7,791

TR I = 170 Ac Malting barley, 150 Ac Alfalfa hay
TR II = 120 Ac Feed barley, 50 Ac Malting barley, 150 Ac Hay
TR III = 170 Ac Feed barley, 150 Ac Hay

Table 6: 20 Year Accumulated Present Values and Annual Annuity Values for a 320 Acre Farm, Southern End of Raft River Basin, Deep Wells

Interest Rate	4%	6%	7¼%	9%
P.V. of T.R. I	443,669	374,448	339,234	298,012
P.V. of T.C. I	295,317	249,242	225,802	198,364
P.V. of N.R. I	148,352	125,206	113,432	99,648
Annuity Value	10,916	10,906	10,907	10,914
P.V. of T.R. II	394,225	332,743	301,451	264,820
P.V. of T.C. II	295,317	249,242	225,802	198,364
P.V. of N.R. II	98,908	83,501	75,649	66,456
Annuity Value	7,278	7,294	7,274	7,279
P.V. of T.R. III	373,665	315,366	285,708	250,990
P.V. of T.C. III	295,317	349,242	225,802	198,364
P.V. of N.R. III	78,348	66,124	59,906	52,626
Annuity Value	5,765	5,760	5,760	5,764

TR I = 170 Ac Malting barley, 150 Ac Alfalfa hay
TR II = 120 Ac Feed barley, 50 Ac Malting barley, 150 Ac Hay
TR III = 170 Ac Feed barley, 150 Ac Hay

Table 7: 20 Year Accumulated Present Values and Annual Annuity Values for a 640 Acre Farm, Southern End of Raft River Basin, Shallow Wells

Interest Rate	4%	6%	7¼%	9%
P.V. of T.R. I	889,921	751,076	680,443	597,758
P.V. of T.C. I	651,343	549,720	498,023	437,505
P.V. of N.R. I	238,578	201,356	182,420	160,253
Annuity Value	17,555	17,540	17,540	17,552
P.V. of T.R. II	770,503	650,289	589,134	517,545
P.V. of T.C. II	651,343	549,720	498,023	437,505
P.V. of N.R. II	119,160	100,569	91,111	80,040
Annuity Value	8,768	8,760	8,761	8,767
P.V. of T.R. III	729,324	615,535	557,648	489,885
P.V. of T.C. III	651,343	549,720	498,023	437,505
P.V. of N.R. III	77,981	65,815	59,625	52,380
Annuity Value	5,738	5,733	5,733	5,737

TR I = 390 Ac Malting barley, 250 Ac Alfalfa hay
TR II = 100 Ac Malting barley, 250 Ac Alfalfa hay, 250 Ac Feed barley
TR III = 390 Ac Feed barley, 250 Ac Alfalfa hay

Table 8: 20 Year Accumulated Present Values and Annual Annuity Values for a 640 Acre Farm, Southern End of Raft River Basin, Deep Wells

Interest Rate	4%	6%	7¼%	9%
P.V. of T.R. I	770,014	649,876	588,760	517,216
P.V. of T.C. I	619,474	522,823	473,656	416,099
P.V. of N.R. I	150,540	127,053	115,104	101,117
Annuity Value	11,077	11,067	11,068	11,074
P.V. of T.R. II	685,604	578,636	524,220	460,519
P.V. of T.C. II	619,474	522,823	473,656	416,099
P.V. of N.R. II	66,130	55,813	50,564	44,420
Annuity Value	4,866	4,862	4,862	4,865
P.V. of T.R. III	644,426	543,882	492,734	432,859
P.V. of T.C. III	619,474	522,823	473,656	416,099
P.V. of N.R. III	24,952	21,059	19,078	16,760
Annuity Value	1,836	1,834	1,834	1,836

TR I = 305 Ac Malting barley, 250 Ac Alfalfa hay
TR II = 100 Ac Malting barley, 250 Ac Alfalfa hay, 205 Ac Feed barley
TR III = 305 Ac Feed barley, 250 Ac Alfalfa hay

Table 9: 20 Year Accumulated Present Values and Annual Annuity Values for a 320 Acre Dairy, Southern End of Raft River Basin, Shallow Wells

Interest Rate	4%	6%	7½%	9%
P.V. of T.R.	806,246	680,455	616,463	541,553
P.V. of T.C.	454,813	383,853	347,755	305,497
P.V. of N.R.	351,433	296,602	268,708	236,056
Annuity Value	25,806	25,836	25,837	25,855

Table 10: 20 Year Accumulated Present Values and Annual Annuity Values for a 320 Acre Dairy, Southern End of Raft River Basin, Deep Wells

Interest Rate	4%	6%	7½%	9%
P.V. of T.R.	806,246	680,455	616,463	541,553
P.V. of T.C.	470,945	397,468	360,089	316,333
P.V. of N.R.	335,301	282,987	256,374	225,220
Annuity Value	24,673	24,650	24,651	24,668

TR = 85 Dairy cows in herd

Table 11: 20 Year Accumulated Present Values and Annual Annuity Values for a 640 Acre Dairy, Southern End of Raft River Basin, Shallow Wells

Interest Rates	4%	6%	7 ¼%	9%
P.V. of T.R.	1,938,098	1,635,718	1,481,886	1,301,815
P.V. of T.C.	1,113,725	939,963	851,566	748,087
P.V. of N.R.	824,373	695,752	630,320	553,728
Annuity Value	60,660	60,606	60,608	60,649

TR = 198 Dairy cow herd

Table 12: 20 Year Accumulated Present Values and Annual Annuity Values for a 640 Acre Dairy, Southern End of Raft River Basin, Deep Wells

Interest Rates	4%	6%	7¼%	9%
P.V. of T.R.	1,555,569	1,312,872	1,189,406	1,044,876
P.V. of T.C.	950,289	802,025	726,601	638,307
P.V. of N.R.	605,280	510,847	462,805	406,569
Annuity Value	44,439	44,499	44,500	44,531

TR = 164 Dairy cow herd

APPENDIX F

Estimated Added Costs Required to Maintain Well Yield for the Representative Wells in the Raft River Basin

Table 1: NORTH END REPRESENTATIVE WELL I
Estimated Added Costs Required to Maintain Well Yield
for Stated Rates of Decline for a 20 Year Period

Year	Decline Rates Per Year: 1 Foot		2 Feet		3 Feet		4 Feet		5 Feet		10 Feet	
		Cost		Cost		Cost		Cost		Cost		Cost
1	(100)*		(100)		(100)		(100)		(100)		(100)	
2						$6700		$6700		$6700		$6700
3												
4												
5												
6	(105)	$3425	(110)	$6700	(115)		(120)		(125)		(150)	$8015
7												
8												
9												
10												
11	(110)		(120)		(130).		(140)		(150)	$8015	(200)	$10550
12												
13												
14								$8015				
15												
16	(115)		(130)		(145)		(160)		(175)		(250)	
17												
18												
19												
20												
21	(120)		(140)		(160		(180)		(200)		(300)	
Total Costs		$3425		$6700		$6700		$14715		$14715		$25265

*Average Pumping Level in Feet

Table 1: North End Representative Well I
Worksheet

1 Foot decline -	50 HP pump	$1725	
	30 ft. column	900	
	one 12" bowl	200	
	labor	600	
		$3425	Year 6
power cost at 120' = $1.41/AF			
2 Feet decline -	60 HP pump	$2000	
	50 ft. column	1500	
	two 12" bowls	400	
	100 HP panel	2200	
	labor	600	
		$6700	Year 6
power cost at 140' = $1.65/AF			
3 Feet decline -	same as 2 feet of decline. The 60 HP is designed to be at maximum efficiency at 150'.		Year 2
power cost at 160' = $1.83/AF			
4 Feet decline -	same as 3 feet	$6700	Year 2
	deepen well 200'	3100	
	75 HP pump	2415	
	50' column	1500	
	two 12" bowls	400	
	labor	600	
		$8015	Year 14
power cost at 180' = $2.11/AF			
5 Feet decline -	same as 4 feet decline with the second change in year 11.		
power cost at 200' = $2.29/AF			
10 Feet decline -		$6700	Year 2
		8015	Year 6
	125 HP pump	3850	
	150 HP panel	2300	
	four 12" bowls	800	
	100 ft. column	3000	
	labor	600	
		$10550	Year 12
power cost at 300' - $3.51/AF			

Table 2: NORTH END REPRESENTATIVE WELL II
Estimated Added Costs Required to Maintain Well Yield
for Stated Rates of Decline for a 20 Year Period

	Decline Rates Per Year											
Year	1 Foot		2 Feet		3 Feet		4 Feet		5 Feet		10 Feet	
		Cost		Cost		Cost		Cost		Cost		Cost
1	(150)*		(150)		(150)		(150)		(150)		(150)	
2				$5600		$5600		$5600		$5600		$5600
3												
4												
5												
6	(155)	$5600	(160)		(165)		(170)		(175)		(200)	$2500
7												
8												
9												
10												
11	(160)		(170)		(180)		(190)		(200)	$2500	(250)	
12												
13												$1500
14								$2500				
15												
16	(165)		(180)		(195)		(210)		(225)		(300)	
17												
18												
19												
20												
21	(170)		(190)		(210)		(230)		(250)		(350)	
Total Cost		$5600		$5600		$5600		$8100		$8100		$23100

*Average Pumping Level in Feet

Table 2: North End Representative Well II Worksheet

1 Foot decline -	100 HP pump	$3100	
	50 ft. column	1500	
	two 12" bowls	400	
	labor	600	
		$5600	Year 6
	Power cost at 170' = $2.07/AF		
2 Feet decline -	same as 1 foot decline		Year 2
	Power cost at 190' = $2.25/AF		
3 Feet decline -	same as 1 foot decline		Year 2
	Power cost at 210' = $2.44/AF		
4 Feet decline -	same as 1 foot decline	$5600	Year 2
	50 ft. column	1500	
	two 12" bowls	400	
	labor	600	
		$2500	Year 14
	Power cost at 230' = $2.62/AF		
5 Feet decline -	same as 4 feet decline, but with the second change in Year 11.		
	Power cost at 250' = $2.81/AF		
10 Feet decline -	same as 4 feet decline, but with second change in Year 6.		
	deepen well 200'	$3700	
	150 HP pump	4600	
	150 HP panel	2300	
	100 ft. column	3000	
	four 12" bowls	800	
	labor	600	
		$15000	Year 13
	Power cost at 350' = $3.97/AF		

Table 3: NORTH END REPRESENTATIVE WELL III
Estimated Added Costs Required to Maintain Well Yield
for Stated Rates of Decline for a 20 Year Period

	Decline Rates Per Year											
Year	1 Foot		2 Feet		3 Feet		4 Feet		5 Feet		10 Feet	
		Cost		Cost		Cost		Cost		Cost		Cost
1	(250)*		(250)		(250)		(250)		(250)		(250)	
2				$8650		$8650		$8650		$8650		$14400
3												
4												
5												
6	(255)	$8050	(260)		(265)		(270)		(275)		(300)	
7												
8												
9												
10												
11	(260)		(270)		(280)		(290)		(300)	$7100	(350)	$17400
12												
13								$7100				
14												
15												
16	(265)		(280)		(295)		(310)		(325)		(400)	
17												
18												
19												
20												
21	(270)		(290)		(310)		(330)		(350)		(450)	
Total Cost		$8050		$8650		$8650		$15750		$15750		$31800

*Average Pumping Level in Feet

Table 3: North End Representative Well III
Worksheet

1 Foot decline -	125 HP pump	$3850	
	150 HP panel	2300	
	30 ft. column	900	
	two 12" bowls	400	
	labor	600	
		$8050	Year 6
	Power cost at 270' = $3.12/AF		
2 Feet decline -	same as 1 foot decline	$8050	Year 2
	20 ft. column	600	
		$8650	Year 2
	Power cost at 290' = $3.30/AF		
3 Feet decline -	same as 2 feet decline		
	Power cost at 310' = $3.48/AF		
4 Feet decline -	same as 2 feet decline	$8650	Year 2
	150 HP pump	$4600	
	50 ft. column	1500	
	two 12" bowls	400	
	labor	600	
		$7100	Year 13
	Power cost at 330' = $3.79/AF		
5 Feet decline -	same as 4 feet decline with second change in Year 11		
	Power cost at 350' = $3.97/AF		
10 Feet decline -	deepen well 200'	$3700	
	150 HP pump	4600	
	150 HP panel	2300	
	four 12" bowls	800	
	100 ft. column	3000	
		$14400	Year 2
	250 HP pump	$ 8000	
	250 HP panel	5000	
	four 12" bowls	800	
	100 ft. column	3000	
	labor	600	
		$17400	Year 12
	Power cost at 450' = $5.39/AF		

Table 4: NORTH END REPRESENTATIVE WELL IV
Estimated Added Costs Required to Maintain Well Yield
for Stated Rates of Decline for a 20 Year Period

Year	Decline Rates Per Year					
	1 Foot	2 Feet	3 Feet	4 Feet	5 Feet	10 Feet
	Cost	Cost	Cost	Cost	Cost	Cost
1	(200)*	(200)	(200)	(200)	(200)	(200)
2		$6700	$7000	$7000	$7000	$19100
3						
4						
5						
6	(205) $6100	(210)	(215)	(220)	(225)	(250)
7						
8						
9						
10						
11	(210)	(220)	(230)	(240)	(250) $10900	(300)
12						
13						
14				$10900		
15						
16	(215)	(230)	(245)	(260)	(275)	(350) $16300
17						
18						
19						
20						
21	(220)	(240)	(260)	(280)	(300)	(400)
Total Cost	$6100	$6700	$7000	$17900	$17900	$35400

*Average Pumping Level in Feet

Table 4: North End Representative Well IV
Worksheet

1 Foot decline -	150 HP pump	$4600	
	20 ft. column	600	
	one 14" bowl	300	
	labor	600	
		$6100	Year 6
Power cost at 220' = $2.57/AF			
2 Feet decline -	same as 1 foot decline	$6100	Year 2
	20 ft. column	$ 600	
		$6700	Year 2
Power cost at 240' = $2.75/AF			
3 Feet decline -	same as 2 feet decline	$6700	Year 2
	10 ft. column	300	
		$7000	Year 2
Power cost at 260' = $2.94/AF			
4 Feet decline -	same as 3 feet decline	$7000	Year 2
	200 HP pump	$6200	
	200 HP panel	2300	
	one 14" bowl	300	
	50 ft. column	1500	
	labor	600	
		$10900	Year 14
Power cost at 280' = $3.12/AF			
5 Feet decline -	same as 4 feet decline with second change in Year 11		
Power cost at 300' = $3.31/AF			
10 Feet decline -	deepen well 200'	$4300	
	200 HP pump	6200	
	200 HP panel	2300	
	150 ft. column	4500	
	four 14" bowls	1200	
	labor	600	
		$19100	Year 2
	250 HP pump	8000	
	250 HP panel	5000	
	one 14" bowl	300	
	80 ft. column	2400	
	labor	600	
		$16300	Year 16
Power cost at 400' = $4.59/AF			

Table 5: NORTH END REPRESENTATIVE WELL V
Estimated Added Costs Required to Maintain Well Yield
for Stated Rates of Decline for a 20 Year Period

Year	Decline Rates Per Year: 1 Foot	Cost	2 Feet	Cost	3 Feet	Cost	4 Feet	Cost	5 Feet	Cost	10 Feet	Cost
1	(200)*		(200)		(200)		(200)		(200)		(200)	
2												$13500
3												
4												
5												
6	(205)		(210)		(215)		(220)	$13500	(225)	$13500	(250)	
7												
8						$11000						
9												
10												
11	(210)		(220)	$11000	(230)		(240)		(250)		(300)	
12												
13												$20250
14												
15												
16	(215)		(230)		(245)		(260)		(275)		(350)	
17												
18												
19												
20												
21	(220)		(240)		(260)		(280)		(300)		(400)	
Total Cost				$11000		$11000		$13500		$13500		$33750

*Average Pumping Level in Feet

Table 5: North End Representative Well V
Worksheet

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1 Foot decline - no changes, but efficiency would be low at end of period

Power cost at 220' = $2.51/AF

2 Feet decline -	200 HP pump	$6200	
	200 HP panel	2300	
	one 17" bowl	400	
	50 ft. column	1500	
	labor	600	
		$11000	Year 11

Power cost at 240' = $2.86/AF

3 Feet decline - same as 2 feet decline with change in Year 8

Power cost at 260' = $3.04/AF

4 Feet decline -	same as 2 feet decline	$11000	
	one 17" bowl	400	
	50 ft. column	1500	
	labor	600	
		$13500	Year 6

Power cost at 280' = $3.23/AF

5 Feet decline - same as 4 feet decline

Power cost at 300' = $3.41/Af

10 Feet decline -	same as 4 feet decline	$13500	Year 2
	300 HP pump	$10350	
	300 HP panel	5500	
	100 ft. column	3000	
	two 17" bowls	800	
	labor	600	
		$20250	Year 13

Power cost at 400' = $4.66/AF

Table 6: NORTH END REPRESENTATIVE WELL VI
Estimated Added Costs Required to Maintain Well Yield
for Stated Rates of Decline for a 20 Year Period

	Decline Rates Per Year											
Year	1 Foot		2 Feet		3 Feet		4 Feet		5 Feet		10 Feet	
		Cost		Cost		Cost		Cost		Cost		Cost
1	(200)*		(200)		(200)		(200)		(200)		(200)	
2												$20250
3												
4												
5										$15500		
6	(205)		(210)		(215)		(220)	$15500	(225)		(250)	
7												
8						$15500						
9												
10												
11	(210)		(220)	$15500	(230)		(240)		(250)		(300)	
12												$15000
13												
14												
15												
16	(215)		(230)		(245)		(260)		(275)	$12800	(350)	
17												
18												
19												
20												
21	(220)		(240)		(260)		(280)		(300)		(400)	
Total Cost				$15500		$15500		$15500		$28300		$35250

*Average Pumping Level in Feet

Table 6: North End Representative Well VI
Worksheet

1 Foot decline -	no change		
	Power cost at 220' = $2.51/AF		
2 Feet decline -	250 HP pump	$ 8000	
	250 HP panel	5000	
	50 ft. column	1500	
	one 18" bowl	400	
	labor	600	
		$15500	Year 11
	Power cost at 240' = $2.81/AF		
3 Feet decline -	same as 2 feet decline with change in Year 8		
	Power cost at 260' = $3.00/AF		
4 Feet decline -	same as 2 feet decline with change in Year 6		
	Power cost in 280' = $3.18/AF		
5 Feet decline -	same as 2 feet decline	$15500	Year 5
	300 HP pump	10300	
	one 18" bowl	400	
	50 ft. column	1500	
	labor	600	
		$12800	Year 16
	Power cost at 300' = $3.48/AF		
10 Feet decline -	300 HP pump	$10350	
	300 HP panel	5500	
	two 18" bowls	800	
	100 ft. column	3000	
	labor	600	
		$20250	Year 2

$15,000 estimate to carry the system through 400 foot of lift. Year 12

Power cost at 400' estimated to be approximately $4.41/AF

Table 7: SOUTH END REPRESENTATIVE WELL I
Estimated Added Costs Required to Maintain Well Yield
for Stated Rates of Decline for a 20 Year Period

Year	Decline Rates Per Year: 1 Foot		2 Feet		3 Feet		4 Feet		5 Feet		10 Feet	
		Cost		Cost		Cost		Cost		Cost		Cost
1	(80)*		(80)		(80)		(80)		(80)		(80)	
2						$7025		$7025		$7025		$7025
3												
4												
5												
6	(85)	$6225	(90)	$7025	(95)		(100)		(105)		(130)	$7615
7												
8												
9												
10												
11	(90)		(100)		(110)		(120)		(130)	$7615	(180)	
12												
13												
14												
15												$10550
16	(95)		(110)		(125)	$5600	(140)	$6200	(155)		(230)	
17												
18												
19												
20												
21	(100)		(120)		(140)		(160)		(180)		(280)	
Total Cost		$6225		$7025		$12625		$13225		$14640		$25190

*Average Pumping Level in Feet

Table 7: South End Representative Well I
Worksheet

1 Foot decline -	40 HP pump	$1725	
	20 ft. column	600	
	one 12" bowl	200	
	deepen well 200'	3100	
	labor	600	
		$6225	Year 6
Power cost at 100' = $1.20/AF			
2 Feet decline -	50 HP pump	$1725	
	40 ft. column	1200	
	two 12" bowls	400	
	deepen well 200'	3100	
	labor	600	
		$7025	Year 6
Power cost at 120' = $1.45/AF			
3 Feet decline -	50 HP pump	$1725	
	40 ft. column	1200	
	two 12" bowls	400	
	deepen well 200'	3100	
	labor	600	
		$7025	Year 6
-	60 HP pump	$2000	
	20 ft. column	600	
	100 HP electric panel	2200	
	one 12" bowl	200	
	labor	600	
		$5600	Year 16
Power cost at 140' = $1.70/AF			
4 Feet decline -	same as 3 feet decline on changes. You are just over the lift range of 150 ft. at the end of the time period.		
Power cost at 160' = $1.89/AF			
5 Feet decline -	50 HP pump	$1725	
	40 ft. column	1200	
	two 12" bowls	400	
	deepen well 200'	3100	
	labor	600	
		$7025	Year 2

Table 7 (cont.)

5 Feet decline (cont.)

	- 75 HP pump	$2415	
	60 ft. column	1800	
	three 12" bowls	600	
	labor	600	
	100 HP panel	2200	
		$7615	Year 11
Power cost at 180' = $2.18/AF			
10 Feet decline -	same as five feet decline	$7025	Year 2
		7615	Year 6
	125 HP pump	3850	
	150 HP panel	2300	
	four 12" bowls	800	
	100 ft. column	3000	
	labor	600	
		$10550	Year 15
Power cost at 280' = $3.44/AF			

Table 8: SOUTH END REPRESENTATIVE WELL II
Estimated Added Costs Required to Maintain Well Yield
for Stated Rates of Decline for a 20 Year Period

	Decline Rates Per Year											
Year	1 Foot		2 Feet		3 Feet		4 Feet		5 Feet		10 Feet	
		Cost		Cost		Cost		Cost		Cost		Cost
1	(100)*		(100)		(100)		(100)		(100)		(100)	
2						$6700		$6700		$6700		$6700
3												
4												
5												
6	(105)	$3425	(110)	$6700	(115)		(120)		(125)		(150)	$8015
7												
8												
9												
10												
11	(110)		(120)		(130)		(140)		(150)	$8015	(200)	$10550
12												
13												
14								$8015				
15												
16	(115)		(130)		(145)		(160)		(175)		(250)	
17												
18												
19												
20												
21	(120)		(140)		(160)		(180)		(200)		(300)	
Total Cost		$3425		$6700		$6700		$14715		$14715		$25265

*Average Pumping Level in Feet

Table 8: South End Representative Well II
Worksheet

1 Foot decline -	50 HP pump	$1725	
	30 ft. column	900	
	one 12" bowl	200	
	labor	600	
		$3425	Year 6
	Power cost at 120" = $1.41/AF		
2 Feet decline -	60 HP pump	$2000	
	50 ft. column	1500	
	two 12" bowls	400	
	100 HP panel	2200	
	labor	600	
		$6700	Year 6
	Power cost at 140' = $1.65/AF		
3 Feet decline -	same as 2 feet decline. The 60 HP is designed to be at maximum efficiency at 150'.		Year 2
	Power cost at 160' = $1.83/AF		
4 Feet decline -	same as 3 feet decline	$6700	Year 2
	deepen well 200'	3100	
	75 HP pump	2415	
	50 ft. column	1500	
	two 12" bowls	400	
	labor	600	
		$8015	Year 14
	Power cost at 180' = $2.11/AF		
5 Feet decline -	same as 4 feet decline with the second change in Year 11.		
	Power cost at 200' - $2.29/AF		
10 Feet decline -		$6700	Year 2
		8015	Year 6
	125 HP pump	3850	
	150 HP panel	2300	
	four 12" bowls	800	
	100 ft. column	3000	
	labor	600	
		$10550	Year 12
	Power cost at 300' = $3.51/AF		

Table 9: SOUTH END REPRESENTATIVE WELL III
Estimated Added Costs Required to Maintain Well Yield
for Stated Rates of Decline for a 20 Year Period

	Decline Rates Per Year											
Year	1 Foot		2 Feet		3 Feet		4 Feet		5 Feet		10 Feet	
		Cost		Cost		Cost		Cost		Cost		Cost
1	(100)*		(100)		(100)		(100)		(100)		(100)	
2		$5600		$5600		$5600		$5600		$5600		$5600
3												
4												
5												
6	(105)		(110)		(115)		(120)		(125)		(150)	
7												$8650
8												
9												
10												
11	(110)		(120)		(130)		(140)		(150)		(200)	$9400
12												
13												
14								$8650		$8650		
15												
16	(115)		(130)		(145)		(160)		(175)		(250)	$15500
17												
18												
19												
20												
21	(120)		(140)		(160)		(180)		(200)		(300)	
Total Cost		$5600		$5600		$5600		$14250		$14250		$39150

*Average Pumping Level in Feet

Table 9: South End Representative Well III
Worksheet

1 Foot decline -	100 HP pump	$3100	
	50 ft. column	1500	
	one 17" bowl	400	
	labor	600	
		$5600	Year 2
Power cost at 120' = $1.45/AF			
2 Feet decline -	same as 1 foot decline		Year 2
Power cost at 140' = $1.64/AF			
3 Feet decline -	same as 1 foot decline		Year 2
Power cost at 160' = $1.82/AF			
4 Feet decline -	same as 1 foot decline	$5600	Year 2
	125 HP pump	3850	
	50 ft. column	1500	
	one 17" bowl	400	
	150 HP panel	2300	
	labor	600	
		$8650	Year 14
Power cost at 180' = $2.09/AF			
5 Feet decline -	same as 4 feet decline		
Power cost at 200' = $2.27/AF			
10 Feet decline -	same as 4 feet	$5600	Year 2
		8650	Year 7
	150 HP pump	4600	
	150 HP panel	2300	
	50 ft. column	1500	
	one 17" bowl	400	
	labor	600	
		$9400	Year 11
	200 HP pump	6200	
	200 HP panel	2300	
	one 17" bowl	400	
	70 ft. column	2100	
	deepen well 200'	3900	
	labor	600	
		$15500	Year 16
Power cost at 300' = $3.45/AF			

Table 10: SOUTH END REPRESENTATIVE WELL IV
Estimated Added Costs Required to Maintain Well Yield
for Stated Rates of Decline for a 20 Year Period

	Decline Rates Per Year											
Year	1 Foot		2 Feet		3 Feet		4 Feet		5 Feet		10 Feet	
		Cost		Cost		Cost		Cost		Cost		Cost
1	150)*		(150)		(150)		(150)		(150)		(150)	
2				$5600		$5600		$7500		$7500		$7500
3												
4												
5												
6	(155)	$3815	(160)		(165)		(170)		(175)		(200)	
7												
8												
9												
10												
11	(160)		(170)		(180)		(190)		(200)		(250)	
12												$11100
13												
14												
15												
16	(165)		(180)		(195)		(210)		(225)		(300)	
17												
18												
19												
20												
21	(170)		(190)		(210)		(230)		(250)		(350)	
Total Cost		$3815		$5600		$5600		$7500		$7500		$18600

*Average Pumping Level in Feet

Table 10: South End Representative Well IV
Worksheet

1 Foot decline -	75 HP pump	$2415	
	20 ft. column	600	
	one 12" bowl	200	
	labor	600	
		$3815	Year 6
Power cost at 170' = $1.96/AF			
2 Feet decline -	100 HP pump	$3100	
	50 ft. column	1500	
	two 12" bowls	400	
	labor	600	
		$5600	Year 2
Power cost at 190' = $2.27/AF			
3 Feet decline -	same as 2 feet decline		Year 2
Power cost at 210' = $2.46/AF			
4 Feet decline -	100 HP pump	$3100	
	100 ft. column	3000	
	four 12" bowls	800	
	labor	600	
		$7500	Year 2
Power cost at 230' = $2.64/AF			
5 Feet decline -	same as 4 feet decline		Year 2
Power cost at 250' = $2.83/AF			
10 Feet decline -	same as 4 feet	$7500	Year 2
	150 HP pump	$4600	
	150 HP panel	2300	
	three 12" bowls	600	
	100 ft. column	3000	
	labor	600	
		$11100	Year 12
Power cost at 350' = $4.00/AF			

Table 11: SOUTH END REPRESENTATIVE WELL V
Estimated Added Costs Required to Maintain Well Yield
for Stated Rates of Decline for a 20 Year Period

	Decline Rates Per Year											
Year	1 Foot		2 Feet		3 Feet		4 Feet		5 Feet		10 Feet	
		Cost		Cost		Cost		Cost		Cost		Cost
1	(150)*		(150)		(150)		(150)		(150)		(150)	
2				$8650		$8650		$11300		$11300		$11300
3												
4												
5												
6	(155)	$8650	(160)		(165)		(170)		(175)		(200)	
7												
8												
9												
10												
11	(160)		(170)		(180)		(190)		(200)		(250)	
12												
13												$12900
14												
15												
16	(165)		(180)		(195)		(210)		(225)		(300)	
17												
18												
19												
20												
21	(170)		(190)		(210)		(230)		(250)		(350)	
Total Cost		$8650		$8650		$8650		$11300		$11300		$24200

*Average Pumping Level in Feet

Table 11: South End Representative Well V
Worksheet

1 Foot decline -	125 HP pump	$3850	
	150 HP panel	2300	
	one 17" bowl	400	
	50 ft. column	1500	
	labor	600	
		$8650	Year 6
Power cost at 170' = $2.00/AF			
2 Feet decline -	same as 1 foot decline		Year 2
Power cost at 190' = $2.18/AF			
3 Feet decline -	same as 1 foot decline		Year 2
Power cost at 210' = $2.36/AF			
4 Feet decline -	150 HP pump	$4600	
	150 HP panel	2300	
	100 ft. column	3000	
	two 17" bowls	800	
	labor	600	
		$11300	Year 2
Power cost at 230' = $2.63/AF			
5 Feet decline -	same as 4 feet decline		Year 2
Power cost at 250' = $2.82/AF			
10 Feet decline -	same as 4 feet decline	$11300	Year 2
	200 HP pump	6200	
	200 HP panel	2300	
	two 17" bowls	800	
	100 ft. column	3000	
	labor	600	
		$12900	Year 13
Power cost at 350' = $3.71/AF			

APPENDIX G

20 Year Average Power Costs for Representative
Wells in the Raft River Basin

Table 1: North End Representative Wells

20 Year Average Power Cost (in dollars) Per Acre Foot of Water Pumped for Indicated Yearly Rates of Decline

	Well I (100')	Well II (150')	Well III (250')	Well IV (200')	Well V (200')	Well VI (200')
no decline	1.16	1.76	2.81	2.29	2.33	2.32
1' decline	1.28	1.92	2.96	2.43	2.42	2.42
2' decline	1.40	2.01	3.06	2.52	2.60	2.56
3' decline	1.50	2.10	3.15	2.62	2.68	2.66
4' decline	1.64	2.19	3.30	2.70	2.78	2.75
5' decline	1.72	2.28	3.39	2.80	2.87	2.90
10' decline	2.34	2.86	4.10	3.44	3.50	3.36

Table 2: South End Representative Wells

20 Year Average Power Cost (in dollars) Per Acre Foot of Water Pumped for Indicated Yearly Rates of Decline

	Well I (80')	Well II (100')	Well III (100')	Well IV (150')	Well V (150')
no decline	.95	1.16	1.13	1.69	1.74
1' decline	1.08	1.28	1.29	1.83	1.86
2' decline	1.20	1.40	1.38	1.98	1.96
3' decline	1.32	1.50	1.48	2.08	2.05
4' decline	1.42	1.64	1.61	2.17	2.18
5' decline	1.57	1.72	1.70	2.26	2.28
10' decline	2.20	2.34	2.29	2.84	2.82

APPENDIX H

Effects of Ground Water Decline on the Accumulated Present Value Net Returns and Annual Annuity Values for Farm Plans in the Raft River Basin

Table 1: Effects of Ground Water Decline on the 20 Year Accumulated Present Values And Annual Annuity Values for a 640 Acre Farm, Northern End of Raft River Basin, Shallow Wells

Decline Per Year	None	1'	2'	3'	4'	5'	10'
4% Interest							
P.V. of NR I	937,963	924,122	918,534	915,039	901,944	896,234	858,301
Annuity Value	69,019	68,074	67,589	67,332	66,369	65,948	63,157
P.V. of NR II	492,540	479,632	473,056	469,485	456,356	450,715	412,785
Annuity Value	36,246	35,293	34,809	34,546	33,583	30,165	30,374
P.V. of NR III	441,320	428,533	422,007	418,604	405,594	400,025	359,351
Annuity Value	32,474	31,533	31,053	30,802	29,845	29,435	26,442
6% Interest							
P.V. of NR I	790,759	780,381	774,451	771,222	760,995	755,823	724,422
Annuity Value	68,881	67,977	67,451	67,180	66,289	65,838	63,103
P.V. of NR II	414,829	404,394	398,475	395,192	384,951	379,813	348,414
Annuity Value	36,195	35,226	34,710	34,424	33,532	33,085	30,350
P.V. of NR III	371,591	361,267	355,392	342,249	342,076	337,030	303,315
Annuity Value	32,369	31,469	30,957	30,684	29,798	29,358	26,421
7¼% Interest							
P.V of NR I	715,890	706,746	701,180	698,108	689,266	684,404	656,269
Annuity Value	68,835	67,956	67,421	67,126	66,276	65,808	63,103
P.V. of NR II	375,315	366,119	360,564	357,448	348,585	343,756	315,620
Annuity Value	36,088	35,204	34,670	34,370	33,518	33,053	30,348
P.V. of NR III	336,151	327,049	321,536	318,544	309,744	304,998	274,763
Annuity Value	32,322	31,447	30,917	30,629	29,783	29,327	26,420
9% Interest							
P.V. of NR I	628,265	620,547	615,441	612,573	605,276	600,817	576,441
Annuity Value	68,813	67,968	67,409	67,095	66,295	65,807	63,137
P.V. of NR II	329,079	321,315	316,218	313,317	305,997	301,566	277,191
Annuity Value	36,044	35,193	34,635	34,317	33,516	33,030	30,360
P.V. of NR III	294,673	286,991	281,932	279,139	271,873	267,516	241,296
Annuity Value	32,275	31,434	30,880	30,574	29,717	29,301	26,429

Table 2: Effects of Ground Water Decline on the 20 Year Accumulated Present Values And Annual Annuity Values for a 640 Acre Farm, Northern End of Raft River Basin, Deep Wells

Decline Per Year	None	1'	2'	3'	4'	5'	10'
4% Interest							
P.V. of NR I	917,528	914,838	901,087	894,750	888,328	878,263	843,589
Annuity Value	67,515	67,317	66,305	65,839	65,366	64,626	62,074
P.V. of NR II	470,191	467,500	453,773	447,385	441,545	431,550	396,211
Annuity Value	34,598	34,400	33,390	32,920	32,490	31,755	29,155
P.V. of NR III	419,595	416,986	403,436	397,144	391,263	381,526	343,468
Annuity Value	30,875	30,683	29,686	29,223	28,791	28,074	25,274
6% Interest							
P.V. of NR I	773,451	771,179	760,480	755,138	749,683	741,437	711,914
Annuity Value	67,374	67,176	66,244	65,779	65,303	64,585	62,013
P.V. of NR II	395,903	393,632	382,958	377,568	372,606	364,405	334,332
Annuity Value	34,486	34,288	33,359	32,889	32, 457	31,743	29,123
P.V. of NR III	353,200	350,997	340,471	335,163	330,168	322,184	289,817
Annuity Value	30,767	30,575	29,658	29,195	28,760	28,065	25,245
7¼% Interest							
P.V. of NR I	700,169	698,113	688,906	684,085	679,135	671,799	644,904
Annuity Value	67,324	67,126	66,241	65,777	65,301	64,596	62,010
P.V. of NR II	358,125	356,072	346,886	342,022	337,519	330,216	302,830
Annuity Value	34,435	34,238	33,354	32,887	32,454	31,752	29,118
P.V. of NR III	319,444	317,449	308,398	301,627	299,073	291,968	262,503
Annuity Value	30,716	30,524	29,654	29,033	28,757	28,074	25,241
9% Interest							
P.V. of NR I	614,418	612,600	605,075	600,876	596,531	590,251	566,436
Annuity Value	67,296	67,097	66,273	65,813	65,337	64,650	62,041
P.V. of NR II	313,934	312,127	304,619	300,382	296,431	290,167	265,935
Annuity Value	34,385	34,187	33,365	32,901	32,468	31,782	29,128
P.V. of NR III	279,948	278,195	270,806	266,635	262,655	256,564	230,507
Annuity Value	30,662	30,470	29,661	29,204	28,768	28,181	25,247

Table 3: Effects of Ground Water Decline on the 20 Year Accumulated Present Values And Annual Annuity Values for a 960 Acre Farm, Northern End of Raft River Basin, Shallow Wells

Decline Per Year	None	1'	2'	3'	4'	5'	10'
4% Interest							
P.V. of NR I	1,961,680	1,947,561	1,929,691	1,921,281	1,903,005	1,890,183	1,821,760
Annuity Value	144,347	143,308	141,993	141,375	140,030	139,086	134,052
P.V. of NR II	853,360	839,247	826,102	819,522	804,098	791,917	737,819
Annuity Value	62,793	61,755	60,787	60,303	59,168	58,272	54,291
P.V. of NR III	841,962	827,941	814,808	808,243	792,831	780,662	726,647
Annuity Value	61,955	60,923	59,956	59,473	58,339	57,444	53,469
6% Interest							
P.V. of NR I	1,653,825	1,642,370	1,627,828	1,620,465	1,605,810	1,592,881	1,537,491
Annuity Value	144,061	143,064	141,797	141,155	139,879	138,927	133,928
P.V. of NR II	718,866	707,466	696,472	690,654	678,377	667,986	622,330
Annuity Value	62,619	61,626	60,668	60,161	59,092	58,187	54,210
P.V. of NR III	709,236	697,860	686,939	681,132	668,866	658,486	612,899
Annuity Value	61,780	60,789	59,838	59,332	58,264	57,359	53,388
7¼% Interest							
P.V. of NR I	1,497,252	1,487,131	1,474,250	1,467,456	1,454,588	1,444,640	1,392,811
Annuity Value	143,967	142,993	141,755	141,102	139,864	138,908	133,924
P.V. of NR II	650,473	640,343	630,530	625,126	614,390	604,931	563,550
Annuity Value	62,545	61,571	60,628	60,108	59,076	58,166	54,188
P.V. of NR III	641,743	631,696	621,894	616,500	605,774	596,324	555,007
Annuity Value	61,706	60,740	59,798	59,279	58,248	57,339	53,366
9% Interest							
P.V. of NR I	1,314,004	1,305,427	1,294,458	1,288,361	1,277,528	1,268,747	1,223,380
Annuity Value	143,922	142,982	141,781	141,113	139,926	138,965	133,996
P.V. of NR II	570,442	561,850	553,341	548,453	539,458	531,110	494,719
Annuity Value	62,480	61,539	60,607	60,072	59,086	58,172	54,186
P.V. of NR III	562,768	554,256	545,756	540,877	531,892	523,552	487,216
Annuity Value	61,639	60,707	59,776	59,242	58,258	57,344	53,364

Table 4: Effects of Ground Water Decline on the 20 Year Accumulated Present Values And Annual Annuity Values for a 960 Acre Farm, Northern End of Raft River Basin, Deep Wells

Decline Per Yar	None	1'	2'	3'	4'	5'	10'
4% Interest							
P.V. of NR I	1,302,360	1,294,241	1,278,823	1,272,191	1,261,662	1,250,908	1,202,832
Annuity Value	95,832	95,235	94,100	93,612	92,838	92,046	10,589
P.V. of NR II	832,738	824,273	807,987	800,852	790,011	778,408	728,447
Annuity Value	61,276	60,653	59,455	58,930	58,132	57,285	53,602
P.V. of NR III	821,453	800,942	802,987	789,598	778,770	767,268	717,302
Annuity Value	60,445	58,936	59,087	58,101	57,305	56,458	52,782
6% Interest							
P.V. of NR I	1,097,841	1,091,235	1,078,804	1,073,210	1,064,413	1,055,523	1,015,130
Annuity Value	95,631	95,055	93,972	93,485	92,719	91,945	88,426
P.V. of NR II	701,487	694,590	681,428	675,409	666,347	656,831	614,761
Annuity Value	61,105	60,504	59,358	58,834	58,044	57,215	53,551
P.V. of NR III	691,962	676,028	676,777	665,910	656,858	647,342	605,353
Annuity Value	60,275	58,887	58,952	58,006	57,218	56,389	52,731
7¼% Interest							
P.V. of NR I	993,823	987,973	977,029	971,978	964,062	956,118	919,606
Annuity Value	95,560	94,997	93,945	93,459	92,698	91,934	88,424
P.V. of NR II	634,742	628,632	617,023	611,587	603,431	594,915	556,888
Annuity Value	61,033	60,445	59,329	58,006	58,022	57,203	53,547
P.V. of NR III	626,115	612,419	612,565	602,982	594,837	586,322	548,367
Annuity Value	60,203	58,886	58,900	57,979	57,196	56,377	52,728
9% Interest							
P.V. of NR I	872,091	967,119	857,869	853,469	846,585	839,734	807,753
Annuity Value	95,519	94,975	93,962	93,480	92,726	91,975	88,472
P.V. of NR II	556,642	551,441	541,607	536,871	529,777	522,423	489,110
Annuity Value	60,968	60,399	59,322	58,803	58,026	57,220	53,572
P.V. of NR III	549,065	537,901	537,396	529,313	522,227	514,875	481,624
Annuity Value	60,139	58,916	58,860	57,975	57,199	56,394	52,752

Table 5: Effects of Ground Water Decline on the 20 Year Accumulated Present Values And Annual Annuity Values for a 320 Acre Farm, Southern End of Raft River Basin, Shallow Wells

Decline Per Year	None	1'	2'	3'	4'	5'	10'
4% Interest							
P.V. of NR I	175,895	166,597	164,821	161,882	157,735	152,498	124,894
Annuity Value	12,943	12,259	12,128	11,912	11,607	11,221	9,190
P.V. of NR II	126,485	117,183	115,407	112,468	108,321	103,084	75,480
Annuity Value	9,307	8,623	8,492	8,276	7,971	7,585	5,554
P.V. of NR III	105,895	96,593	94,817	91,878	87,731	82,494	54,890
Annuity Value	7,792	7,108	6,977	6,761	6,456	6,070	4,039
6% Interest							
P.V. of NR I	148,456	140,742	139,268	136,630	133,365	189,969	106,031
Annuity Value	12,932	12,260	12,131	11,902	11,617	11,234	9,236
P.V. of NR II	106,751	99,037	97,563	94,925	91,660	87,264	64,326
Annuity Value	9,299	8,627	8,499	8,269	7,984	7,601	5,603
P.V. of NR III	89,374	81,660	80,186	77,548	74,283	69,887	46,949
Annuity Value	7,785	7,113	6;985	6,755	6,471	6,088	4,090
7¼% Interest							
P.V. of NR I	134,495	127,591	126,269	123,794	120,957	116,988	96,407
Annuity Value	12,932	12,268	12,141	11,903	11,630	11,249	9,270
P.V. of NR II	96,712	89,808	88,486	86,011	83,174	79,205	58,624
Annuity Value	9,299	8,635	8,508	8,270	7,998	7,616	5,637
P.V. of NR III	80,969	74,065	72,743	70,268	67,431	63,462	42,881
Annuity Value	7,785	7,122	6,995	6,757	6,484	6,102	4,123
9% Interest							
P.V. of NR I	118,152	112,197	111,052	108,777	106,420	102,953	85,111
Annuity Value	12,941	12,289	12,163	11,914	11,656	11,276	9,322
P.V. of NR II	84,960	79,005	77,860	75,585	73,228	69,761	51,919
Annuity Value	9,306	8,653	8,528	8,279	8,021	7,641	5,687
P.V. of NR III	71,130	65,175	64,030	61,755	59,398	55,931	38,089
Annuity Value	7,791	7,139	7,013	6,764	6,506	6,126	4,172

Table 6: Effects of Ground Water Decline on the 20 Year Accumulated Present Values And Annual Annuity Values for a 320 Acre Farm, Southern End of Raft River Basin, Deep Wells

Decline Per Year	None	1'	2'	3'	4'	5'	10'
4% Interest							
P.V. of NR I	148,352	139,204	135,230	134,224	129,582	128,555	109,475
Annuity Value	10,916	10,243	9,951	9,877	9,536	9,460	8,056
P.V. of NR II	98,908	89,760	85,786	84,780	80,144	79,111	60,031
Annuity Value	7,278	6,605	6,312	6,238	5,897	5,821	4,417
P.V. of NR III	78,348	69,200	65,226	64,220	59,584	58,551	39,471
Annuity Value	5,765	5,092	4,800	4,726	7,384	4,308	2,904
6% Interest							
P.V. of NR I	125,206	117,863	113,999	113,150	109,195	108,323	92,929
Annuity Value	10,906	10,267	9,930	9,856	9,512	9,436	8,095
P.V. of NR II	83,501	76,158	72,294	71,445	67,490	66,618	51,224
Annuity Value	7,274	6,634	6,297	6,223	5,879	5,803	4,462
P.V. of NR III	66,124	58,781	54,917	54,068	50,113	49,241	33,847
Annuity Value	5,760	5,120	4,784	4,710	4,365	7,289	2,948
7¼% Interest							
P.V. of NR I	113,432	106,992	103,223	102,454	98,852	98,062	84,486
Annuity Value	10,907	10,288	9,925	9,851	9,505	9,429	8,124
P.V. of NR II	75,649	69,209	65,440	64,671	61,069	60,279	46,703
Annuity Value	7,274	6,655	6,292	6,218	5,872	5,796	4,491
P.V. of NR III	59,906	53,466	49,697	48,928	45,326	44,536	30,960
Annuity Value	5,760	5,141	4,779	4,705	4,358	4,282	2,977
9% Interest							
P.V. of NR I	99,648	94,250	90,631	89,956	86,776	86,082	74,574
Annuity Value	10,914	10,323	9,927	9,853	9,504	9,428	8,168
P.V. of NR II	66,456	61,058	57,439	56,764	53,584	52,890	41,382
Annuity Value	7,279	6,688	6,291	6,217	5,869	5,793	4,533
P.V of NR III	52,626	47,228	43,609	42,934	39,754	39,060	27,552
Annuity Value	5,764	5,173	4,776	4,703	4,354	4,278	3,018

Table 7: Effects of Ground Water Decline on the 20 Year Accumulated Present Values And Annual Annuity Values for a 640 Acre Farm, Southern End of Raft River Basin, Shallow Wells

Decline Per Year	None	1'	2'	3'	4'	5'	10'
4% Interest							
P.V. of NR I	238,578	225,711	220,901	215,914	208,118	199,674	157,284
Annuity Value	17,555	16,609	16,255	15,888	15,314	14,693	11,574
P.V. of NR II	119,160	106,293	101,483	96,496	88,700	80,256	37,866
Annuity Value	8,768	7,821	7,467	7,101	6,527	5,906	2,786
P.V. of NR III	77,981	65,114	60,304	55,317	47,521	39,077	-3,313
Annuity Value	5,738	4,791	4,437	4,070	3,497	2,875	-244
6% Interest							
P.V. of NR I	201,356	190,735	186,800	182,165	176,007	168,911	133,295
Annuity Value	17,540	16,615	16,272	15,868	15,332	14,714	11,611
P.V. of NR II	100,569	89,949	86,014	81,379	75,211	68,125	32,509
Annuity Value	8,760	7,835	7,493	7,089	6,551	5,934	2,832
P.V. of NR III	65,815	55,195	51,260	46,625	40,467	33,371	-2,245
Annuity Value	5,733	4,808	4,465	4,061	3,525	2,907	-196
7¼% Interest							
P.V. of NR I	182,420	172,941	169,446	165,019	159,656	153,248	121,076
Annuity Value	17,540	16,629	16,293	15,867	15,352	14,735	11,642
P.V. of NR II	91,111	81,633	78,138	73,711	68,348	61,940	29,768
Annuity Value	8,761	7,849	7,513	7,088	6,572	5,956	2,862
P.V. of NR III	59,625	50,147	46,652	42,225	36,862	30,454	-1,718
Annuity Value	5,733	4,822	4,486	4,060	3,544	2,928	-165
9% Interest							
P.V. of NR I	160,253	152,108	149,122	144,968	140,499	134,898	106,758
Annuity Value	17,552	16,660	16,333	15,878	15,389	14,775	11,693
P.V. of NR II	80,040	71,895	68,909	64,755	60,286	54,685	26,545
Annuity Value	8,767	7,875	7,548	7,093	6,603	5,990	2,907
P.V. of NR III	52,380	44,235	41,249	37,095	32,626	27,025	-1,115
Annuity Value	5,737	4,845	4,518	4,063	3,573	2,960	-122

Table 8: Effects of Ground Water Decline on the 20 Year Accumulated Present Values And Annual Annuity Values for a 640 Acre Farm, Southern End of Raft River Basin, Deep Wells

Decline Per Year	None	1'	2'	3'	4'	5'	10'
4% Interest							
P.V. of NR I	150,540	140,319	135,500	133,600	128,094	126,259	98,074
Annuity Value	11,077	10,325	9,971	9,831	9,426	9,291	7,217
P.V. of NR II	66,130	55,909	51,090	49,190	43,684	41,849	13,664
Annuity Value	4,866	4,114	3,759	3,620	3,214	3,074	1,005
P.V. of NR III	24,952	14,731	9,912	8,012	2,506	671	-27,514
Annuity Value	1,836	1,084	729	590	184	49	-2,025
6% Interest							
P.V. of NR I	127,053	118,803	114,228	112,622	107,933	106,384	83,305
Annuity Value	11,067	10,349	9,950	9,810	9,402	9,267	7,257
P.V. of NR II	55,813	47,563	42,988	41,382	36,693	35,144	12,065
Annuity Value	4,862	4,143	3,745	3,605	3,196	3,061	1,051
P.V. of NR III	21,059	12,809	8,234	6,628	1,939	390	-22,689
Annuity Value	1,834	1,116	717	577	169	34	-1,976
7¼% Interest							
P.V. of NR I	115,104	107,844	103,431	101,975	97,709	96,306	75,767
Annuity Value	11,068	10,370	9,945	9,805	9,395	9,260	7,285
P.V. of NR II	50,564	43,304	38,891	37,435	33,169	31,766	11,227
Annuity Value	4,862	4,164	3,740	3,600	3,189	3,054	1,080
P.V. of NR III	19,078	11,818	7,405	5,949	1,683	280	-20,259
Annity Value	1,834	1,136	712	572	162	27	-1,948
9% Interest							
P.V. of NR I	101,117	94,998	90,814	89,535	85,771	84,539	66,914
Annuity Value	11,074	10,405	9,947	9,807	9,388	9,259	7,329
P.V. of NR II	44,420	38,301	34,117	32,838	29,064	27,842	10,217
Annuity Value	4,865	4,195	3,737	3,597	3,183	3,050	1,119
P.V. of NR III	16,760	10,641	6,457	5,178	1,404	182	-17,443
Annuity Value	1,836	1,165	707	567	154	20	-1,911

Table 9: Effects of Ground Water Decline on the 20 Year Accumulated Present Values And Annual Annuity Values for a 320 Acre Dairy, Southern End of Raft River Basin, Shallow Wells

Decline Per Year	None	1'	2'	3'	4'	5'	10'
4% Interest							
P.V. of NR I	351,433	328,255	324,468	321,338	316,946	311,506	289,160
Annuity Value	25,860	24,154	23,875	23,645	23,322	22,922	21,277
6% Interest							
P.V. of NR I	296,602	277,177	274,005	217,208	267,735	263,167	244,688
Annuity Value	25,836	24,144	23,868	23,625	23,322	22,924	21,313
7¼% Interest							
P.V. of NR I	268,708	251,195	248,335	245,715	242,690	239,566	222,006
Annuity Value	25,837	24,153	23,878	23,624	23,336	22,939	21,347
9% Interest							
P.V. of NR I	236,056	220,761	218,265	215,863	213,341	209,737	195,427
Annuity Value	25,855	24,180	23,906	23,643	23,367	22,972	21,405

Table 10: Effects of Ground Water Decline on the 20 Year Accumulated Present Values And Annual Annuity Values for a 320 Acre Dairy, Southern End of Raft River Basin, Deep Wells

Decline Per Year	None	1'	2'	3'	4'	5'	10'
4% Interest							
P.V. of NR I	335,301	325,895	321,704	320,528	315,667	314,444	300,991
Annuity Value	24,673	23,980	23,672	23,584	23,228	23,138	22,148
6% Interest							
P.V. of NR I	282,987	275,426	271,378	270,369	266,241	265,209	254,563
Annuity Value	24,650	23,992	23,639	23,551	23,192	23,102	22,174
7¼% Interest							
P.V. of NR I	256,374	249,737	245,801	244,887	241,129	240,194	230,919
Annuity Value	24,651	24,013	23,635	23,547	23,185	23,096	22,204
9% Interest							
P.V. of NR I	225,220	219,629	215,864	215,060	211,744	210,923	203,194
Annuity Value	24,668	24,056	23,643	23,555	23,192	23,102	22,256

ɔle 11: Effects of Ground Water Decline on the 20 Year Accumulated Present Values And Annual Annuity Values for a 640 Acre Dairy, Southern End of Raft River Basin, Shallow Wells

Decline Per Year	None	1'	2'	3'	4'	5'	10'
4% Interest							
P.V. of NR I	824,373	811,139	806,098	800,853	792,730	784,042	753,490
Annuity Value	60,660	59,686	59,316	58,930	58,332	57,693	55,444
6% Interest							
P.V. of NR I	695,752	684,823	680,693	675,840	669,407	662,104	636,478
Annuity Value	60,606	59,654	59,294	58,871	58,311	57,675	55,442
7¼% Interest							
P.V. of NR I	630,320	620,562	616,890	612,265	606,653	600,058	576,937
Annuity Value	60,608	59,669	59,316	58,872	58,332	57,698	55,475
9% Interest							
P.V. of NR I	553,728	545,337	542,195	537,868	533,180	527,415	507,225
Annuity Value	60,649	59,730	59,386	58,912	58,399	57,767	55,556

Table 12: Effects of Ground Water Decline on the 20 Year Accumulated Present Values And Annual Annuity Values for a 640 Acre Dairy, Southern End of Raft River Basin, Deep Wells

Decline Per Year	None	1'	2'	3'	4'	5'	10'
4% Interest							
P.V. of NR I	605,280	595,126	590,241	588,488	583,010	581,229	567,300
Annuity Value	44,439	43,791	43,432	43,303	42,900	42,769	41,744
6% Interest							
P.V. of NR I	510,847	502,655	498,022	496,543	491,876	490,374	479,326
Annuity Value	44,499	43,785	43,382	43,253	42,846	42,716	41,753
7¼% Interest							
P.V. of NR I	462,805	455,577	451,131	449,790	445,545	444,184	434,545
Annuity Value	44,500	43,805	43,378	43,249	42,841	42,710	41,783
9% Interest							
P.V. of NR I	406,569	400,495	396,265	395,087	391,342	390,146	382,098
Annuity Value	44,531	43,866	43,403	43,273	42,863	42,732	41,851