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Economic Analysis of Draining Wetlands in Kidder County, North Dakota

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Highlights

The purpose of this study was to estimate the profitability of draining wetlands for agricultural production under various drainage costs and commodity price alternatives. Drainage cost alternatives were one-year, amortized, and no drainage. One-year drainage costs reflected a short-run situation while amortized drainage costs represented long-run conditions. Commodity prices used were 1987 August forward contract, historic county average, and government target prices for wheat and barley.

Revenues were highest for the government target price, amortized drainage cost option, followed by historic county average price, amortized drainage cost option, and government target price, no drainage option. If a farmer receives government target or historic county average prices, draining some wetlands is economically feasible. However, the Swampbuster Provision of the Food Security Act of 1985 makes farmers ineligible for target prices if crops are grown on converted wetland acres. Farm Bill provisions also call for lower loan rates which will reduce both cash prices and future county average prices. Possible loss of government target prices and lower cash and future county average prices makes draining wetlands an irrational economic decision. Therefore, Swampbuster will be a disincentive to wetland drainage in North Dakota only as long as cash grain prices are low.

ECONOMIC ANALYSIS OF DRAINING WETLANDS IN KIDDER COUNTY, NORTH DAKOTA

James F. Baltezore, Jay A. Leitch, William C. Nelson*

Wetland drainage is a highly controversial issue in the United States, especially in the Prairie Pothole Region of the Upper Great Plains. While drainage is often a rational decision by individual landowners, it may involve external costs to society that exceed landowner benefits. One incentive for drainage has been government farm programs which provide crop price subsidies which may distort normal market operations (Office of Technology Assessment 1984).

The purpose of this study was to estimate the potential profitability of draining wetlands for agricultural production under various cost/price situations. Specifically, a linear programming model was developed to examine variations in net revenues across a range of avoidance and drainage costs. Avoidance costs were the added expense of farming around wetlands. Other variables incorporated in the analysis were production costs, field productivity levels, and commodity prices.

History of Central Grasslands Research Station

The Central Grasslands Research Station (CGRS) is in western Kidder and eastern Stutsman counties of North Dakota, within the physiographic region called the Missouri Coteau. The Coteau separates the Missouri Plateau from the Drift Prairie (Figure 1). Coteau topography is characterized by rolling hills, rocky soils, and scattered wetlands. CGRS was selected for the study because (1) data were available from other studies at the station, (2) the

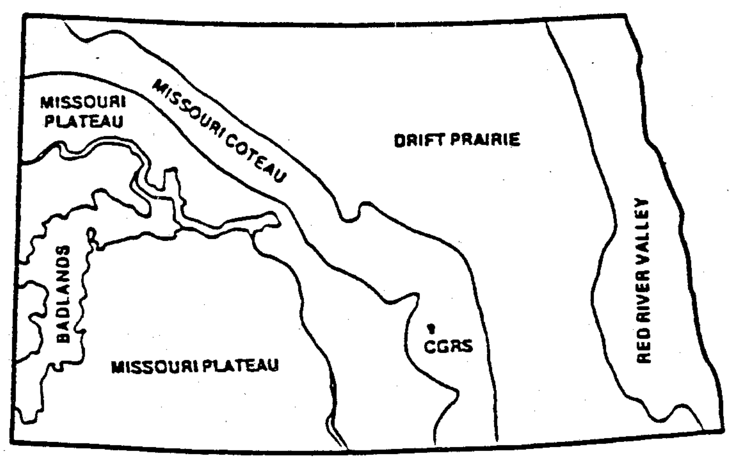

Figure 1. Physiographic Subdivisions of North Dakota

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cropland-wetland mix is representative of North Dakota's coteau region and (3) an analysis on private land might be seen as encouraging drainage in a time when drainage is a highly political issue.

The CGRS (Figure 2) was established in 1980 with funds provided by the Forty-Seventh Legislative Assembly (House Bill 1528). Station research focuses on rangeland and pasture management, livestock management, and wildlife habitat and nesting studies. The station contains 5,336 acres of which 1,360 acres (25.5 percent) are cropland, 3,432 acres (64.3 percent) are rangeland, 427 acres (8 percent) are wetlands, and 117 acres (2.2 percent) are roads and building sites (Lura 1985).

Procedure

The study was conducted using three agricultural commodity price options for wheat and barley including historic county average, August 1987 forward contract, and government target prices. The analysis assessed short- and long-run farm-level planning horizons. Short-run analysis examined drainage costs and returns on a cash flow basis in the year of drain construction.

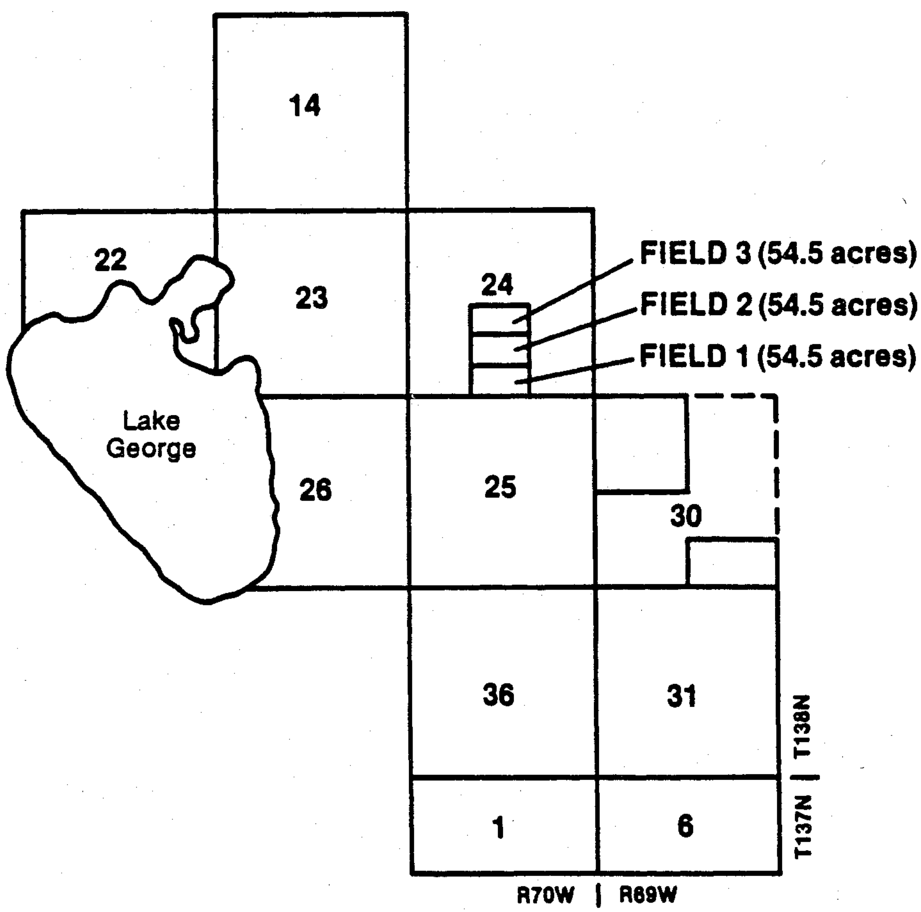

Figure 2. Central Grasslands Research Station, Stutsman and Kidder Counties, North Dakota

Long-run situations amortized drainage costs over five years, reflecting conditions expected over longer time periods.

A linear programming model was developed representing a 163-acre land area in the CGRS. The study site, located in section 24, Kidder County, was divided into three fields of equal size (54.5 acres). Wetlands ranged in size from 0.2 acres to 11 acres. Total wetland acres were 17.4 percent, 25.1 percent, and 15.0 percent of the land in fields one, two, and three, respectively.

Linear Programming

Linear programming (LP) uses a mathematical technique to analyze the use and optimal allocation of resources (i.e., land, labor, and capital) within the farm business. The essential characteristic of an LP problem is a function or objective to be minimized or maximized subject to a limited resource base and alternative uses for available resources. Resources which limit the objective function are constraints. Alternative uses of resources are activities.

Once constraints, activities, and resource requirements were determined, they were arranged into an LP matrix. The LP matrix was analyzed using a computer program called DHLLP (Laughlin 1984) to determine which activities and activity levels maximized the objective function (net revenue) subject to the given constraints.

Matrix Development

The initial step in matrix development was calculation of avoidance costs. Avoidance costs represent an additional crop production expense due to increased overlap during field operations. Additional turns are required to farm around wetlands which increases overlap and acreage covered, causing effective working acres[1] to exceed actual field size. As the number of wetlands increased or as their size grew, working acreage increased, thereby raising production costs and lowering net revenue.

Farm implement size also affects total working acres. Wider implements increase working acreage due to further overlap during field operations. Total working acres were calculated for each farm implement by size and field under existing wetland conditions. Working acreage was also estimated for each farm implement based on a 54.5-acre field without wetlands.

An index was developed to estimate the increased costs of farming around wetlands caused by overlap during field operations. The index was estimated by dividing working acres by actual field size. An example shows

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[1]Working acres were calculated using a program developed by Ron Haugen, Department of Agricultural Economics, North Dakota State University, 1986.

that index values for chisel plowing field one with and without drainage are 1.02 and 1.06, respectively. This implies that the cost of chisel plowing field one is 4 percent higher with wetlands. The index also shows that wider implements have larger index values. For example, on drained fields, a 48-foot drag has a 4 percent larger index value than a 20-foot chisel plow (1.06 vs 1.02). Index values were arranged in the LP matrix under appropriate field operations and corresponding activities. A summary of LP matrix coefficients and total working acres for each field operation by field is presented in Appendix A.

Drainage Ditch Construction Costs

It was assumed a ditch with an average width of 24 feet and an average depth of 3 feet (Figure 3) was sufficient to drain all wetland areas in study fields. Ditch size was estimated after reviewing local topographic maps and an on-site visit. The ditch was shaped to allow farm machinery to pass over it during normal field operations. Soil removed from ditch areas was placed in the wetland being drained to raise the wetland's ground level preventing water retention in future years.

All ditches started in the approximate center of wetlands and ended at outer field boundaries. Ditch lengths, locations, and beginning and ending points are shown in Figure 4 and in Table 1.

It was assumed that drainage would be done with a 160-horsepower tractor owned by the farmer and a rented seven-cubic-yard scraper. Operating costs associated with scraping included the variable costs of both tractor and scraper (Table 2). Tractor costs included fuel, lubrication, and maintenance. (Costs were based on procedures presented by Benson and Ohannesian, 1980, and were adjusted to reflect 1986 production costs.) Scraper costs included lubrication, repairs, and rental fees.

The farm operator rented a seven-yard scraper for $20 per hour. Rental rate was based on a $200 per day rental fee[2] and a 10-hour work day. The farmer was assumed to be willing and able to construct drainage ditches during slack periods in the fall, thereby eliminating cash outlays for labor.

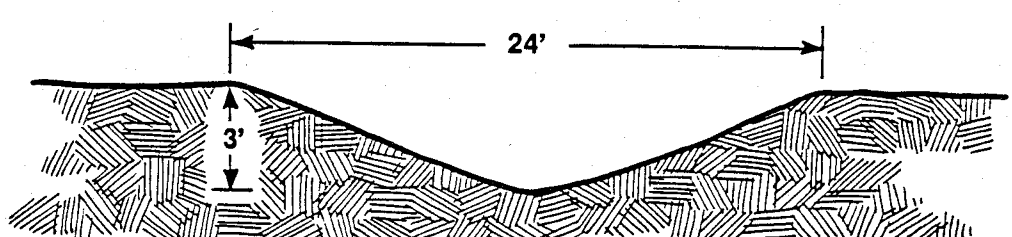

Figure 3. Drainage Ditch Specifications

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[2]Rental charge based on rates provided by a local farm implement dealer.

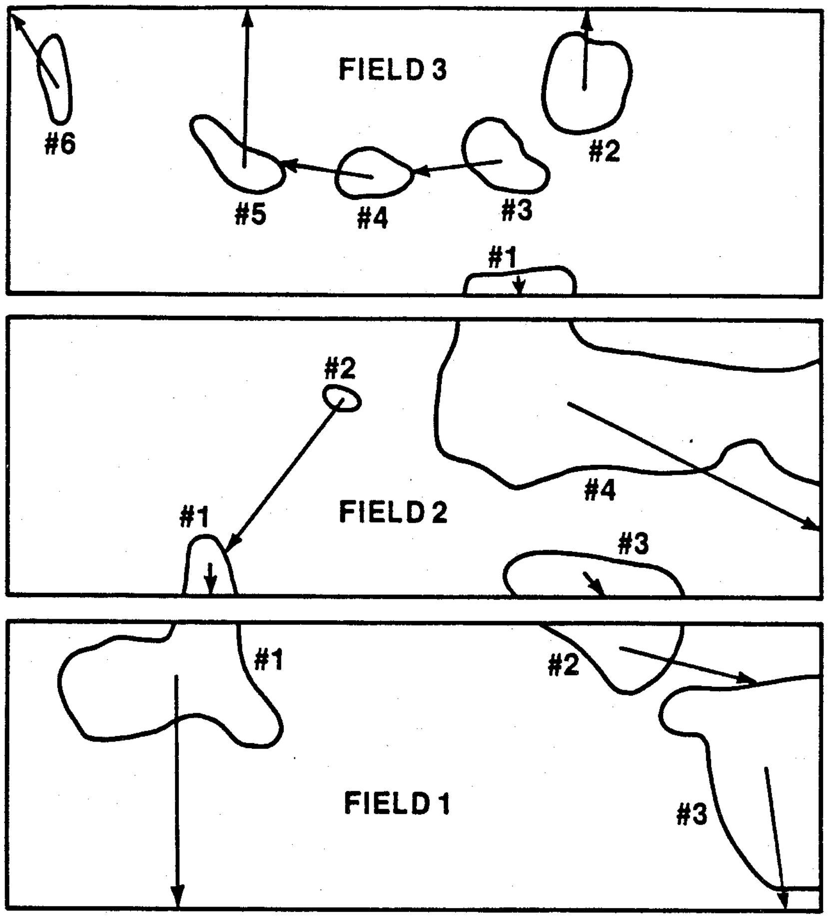

Figure 4. Wetland Numbers and Ditch Locations For Individual Wetlands By Field

Scraper speed was assumed to be five miles per hour unloading and traveling unloaded and loaded, and one mile per hour during loading, for a three-miles-per-hour average traveling speed.[3] Operators were constrained to a maximum of 40 trips per hour or no more than one trip every 1.5 minutes.

Ditch construction costs were based on time spent moving soil from cut to fill areas, which was determined by the volume of soil moved. For example, total yards moved in draining wetland one, field one, were:

Ditch length = 229 yards
Ditch width = 8 yards
Ditch depth = 1 yard

[3]This assumes time spent loading and unloading is the same. The distance traveled while unloading is five times greater than the distance traveled while loading.

TABLE 1. WETLAND NUMBERS, SIZES, AND DRAINAGE DITCH LENGTHS BY FIELD

Field/Wetland	Size	Drainage Ditch Length
	--acres--	--yards--
Field 1	54.5	
Wetland 1	4.1	229
Wetland 2	1.6	117
Wetland 3	3.8	158
Total	9.5	
Field 2	54.5	
Wetland 1	0.6	39
Wetland 2	0.2	196
Wetland 3	1.9	39
Wetland 4	11.0	313
Total	13.7	
Field 3	54.5	
Wetland 1	1.1	18
Wetland 2	2.9	78
Wetland 3	1.4	117
Wetland 4	1.3	98
Wetland 5	0.8	156
Wetland 6	0.7	78
Total	8.2	

TABLE 2. VARIABLE COSTS OF DRAINAGE DITCH CONSTRUCTION PER HOUR, 1986

Tractor Variable Costs per Hour	
Fuel (9.6 gal./hr. x $.90/gal.)	$ 8.64
Lubrication (10% x $8.64/hr.)	$ .86
Maintenance	$ 2.83
Total	$12.33
Scraper Variable Costs per Hour	$27.57
TOTAL variable scraping costs per hour	$39.90

$$\frac{\text{Length x width x depth}}{2} = \text{Total soil moved (yd}^3\text{)}$$

$$\text{TOTAL soil moved} = \frac{229 \times 8 \times 1}{2} = 916 \text{ yards}^3$$

Scraper trips required for ditch construction were estimated by dividing total cubic yards moved by scraper capacity. Scraper capacity was assumed to be six yards in the seven-yard scraper. Scraper trips for field one, wetland one, were:

$$\frac{916 \text{ yards}^3}{6 \text{ yards}^3\text{/round trip}} = 153 \text{ round trips}$$

Scraper round trips per hour were based on the average miles traveled per trip. Trips per hour were estimated by multiplying average scraper speed per hour by average trips per mile:

Average miles traveled per trip

$$229 \text{ yards} \times \frac{1 \text{ mile}}{1{,}760 \text{ yards}} \times 2 = .26 \text{ miles/trip}$$

Average trips per hour

$$\frac{3 \text{ miles}}{\text{hour}} \times \frac{1 \text{ trip}}{.26 \text{ miles}} = 11.54 \text{ round trips/hour}$$

Ditch length was multiplied by two to incorporate the actual distance traveled by the scraper during one round trip in picking up soil, placing it in a wetland, and returning for another load. Total hours spent scraping were estimated by dividing scraper round trips by round trips per hour:

$$\frac{153 \text{ round trips}}{11.54 \text{ round trips/hour}} = 13 \text{ hours}$$

Variable cost of wetland drainage was estimated by multiplying total hours spent scraping by total variable scraping cost per hour. Drainage cost per acre was estimated by dividing total variable drainage cost by the number of wetland acres. For example, total variable drainage cost for field one, wetland one, equaled:

$$13 \text{ hours} \times \$39.90\text{/hour} = \$518.70,$$

and variable drainage cost per acre was:

$$\frac{\$518.70}{4.1 \text{ acres}} = \$126.51 \text{ per acre}$$

A field weighted average drainage cost (WADC) per acre was calculated by multiplying drainage cost per acre of each wetland by the resulting quotient of wetland size divided by total wetland acreage of the field as presented below for field one.

Weighted average drainage cost per acre:

$$\$126.51 \ \frac{4.1}{9.5} + \$95.58 \ \frac{1.6}{9.5} + \$66.53 \ \frac{3.8}{9.5} = WADC_1$$

$$\$54.60 + \$16.10 + \$26.61 = \$97.31/\text{acre}$$

An amortized drainage cost per acre was calculated multiplying $WADC_1$ by an amortization factor. It was assumed that the ditch must be reconstructed every five years at an interest rate of 10 percent yielding a .264 amortization rate.[4] Amortized drainage cost per acre to drain field one was $25.69 per drained acre per year (Table 3).

Custom drainage costs were also estimated for each drainage situation (Table 3). Custom land leveling costs are $6 per acre for surveying, $.50 per cubic yard for loading soil into scrapers, and $.02 per cubic yard per hundred feet for hauling soil from cut to fill areas (Edwardson 1985). Comparing the two costs indicates that custom drainage charges are substantially higher than when the farmer does his own drainage work. Ditch construction costs, one-year drainage costs per acre, and amortized drainage costs per acre per year are provided in Appendix B for all wetlands and fields.

TABLE 3. FARMER AND CUSTOM DRAINAGE COSTS PER ACRE, 1986

Drainage Type	One Year Drainage Costs	Amortized Drainage Costs
	----------dollars/acre----------	
Field one		
Farmer	97.31	25.69
Custom	179.24	47.32
Field two		
Farmer	96.63	25.51
Custom	149.88	39.57
Field three		
Farmer	73.54	19.41
Custom	216.37	57.12

[4]This is a worst case scenario, most ditches would not require this level of maintenance.

Crop Production Costs and Returns

Crop alternatives were limited to wheat and barley, with wheat restricted to no more than one-half of the tillable acreage. Crops were planted using conventional tillage methods. Variable production costs (including interest but excluding hauling and avoidance costs) per acre for wheat and barley were $37.12 and $43.14 per acre, respectively. Variable production costs per acre for each field operation are presented in Appendix C.

Total variable costs per acre varied among fields due to yield variations and avoidance cost differences resulting from wetland drainage (Table 4). Wetland drainage affected the average yield of the field, changing the field's hauling cost per acre. Fields with drainage had hauling costs greater than fields without drainage due to higher per acre yields on drained fields.

TABLE 4. SUMMARY OF WHEAT AND BARLEY PRODUCTION COSTS, 1986

	Wheat	Barley
	----dollars/acre----	
Variable production cost	36.12	41.76
Including interest	37.12	43.14
Including hauling costs		
Without drainage		
All fields	39.06	45.81
With drainage		
Field 1	39.08	45.85
Field 2	39.10	45.86
Field 3	39.08	45.84
Including avoidance costs		
Without drainage		
Field 1	42.13	50.16
Field 2	44.06	52.87
Field 3	45.89	54.88
With drainage		
Field 1	39.98	47.16
Field 2	40.00	47.18
Field 3	39.98	47.15

Avoidance costs included additional production expenses associated with overlap during field operations. Production costs for fields without wetland drainage were greater than production costs for fields with wetland drainage (Table 4). For example, the cost of raising wheat on field one without drainage, yet excluding avoidance costs, was $39.06 per acre. However, if avoidance costs were included, variable production cost was $42.13 per acre, an increase of $3.67 per acre. Wheat product costs (including avoidance costs) for field one with and without drainage were $39.98 and $42.13 per acre, respectively. This implies that a farmer producing wheat could lower production costs $2.15 per acre by draining wetlands within field one.

Crop revenues were based on county average yields and three price options. Prices used were historic county average, 1987 August forward contract, and government target prices (Table 5). Historic county average price is the average price a farmer received for wheat or barley at the local elevator from 1980 through 1984. August forward contract prices represent an agreement between the farmer and elevator. The farmer agrees to deliver a specified quantity and quality of wheat and barley in August in return for prices guaranteed by the elevator earlier in the year. Government target price is the price received for wheat or barley if the farmer participates in government commodity programs. To receive government target prices, the farmer must set-aside 25 percent and 20 percent of his wheat and barley acreage, respectively.

TABLE 5. HISTORIC COUNTY AVERAGE, AUGUST FORWARD CONTRACT, AND GOVERNMENT TARGET PRICES FOR WHEAT AND BARLEY

	Wheat	Barley
	---dollars/bu.---	
Historic county average[a]	3.68	2.18
August forward contract[b]	2.50	1.27
Government target[c]	4.38	2.60

[a]Historic county average prices were derived from commodity prices received in Kidder County from 1980 through 1984 (North Dakota Crop and Livestock Reporting Service, 1986).
[b]August forward contract prices were based on local elevator quotes provided on April 4, 1987.
[c]Government target prices were those issued by the _Food Security Act of 1985_ for wheat and barley.

Yield estimates were based on county averages over the five-year period from 1980 through 1984. County average wheat and barley yields were 20.46 bushels per acre and 34.98 bushels per acre, respectively, for undrained fields. Yields on drained fields varied depending upon wetland sizes and ditch lengths and locations within each field. It was assumed that yields within ditch areas were 25 percent less than the county average while yields within wetlands after drainage were assumed to be 15 percent greater than the county average (Edwardson 1985). Post-drainage average yields were estimated by calculating wetland, cropland, and ditch areas for each field. Acreage estimates were then multiplied by projected yields for each area to estimate the number of bushels produced by wetland, field, and ditch areas. Area bushels were summed to achieve total field bushels. Total field bushels were divided by field size to estimate an adjusted yield per acre for the field (Table 6).

Gross revenues per acre for wheat and barley were calculated by multiplying prices received by estimated yields for each field with and without drainage. Table 7 presents gross revenues per acre and by field for wheat and barley with and without drainage for each price option. Prices, yields, and revenues by crop are presented in Appendix D.

Linear Programming Alternatives

Nine alternatives were analyzed reflecting both short- and long-run situations. Short-run alternatives assumed the entire drainage cost was incurred and paid by first year revenues from drained fields. Long-run conditions were reflected by amortizing drainage costs. An additional alternative represented each field without drainage. Price options with and without drainage were analyzed to determine if fields with drainage produce higher net economic returns than fields without drainage. A linear programming matrix of the farm model is provided in Appendix E along with a description of each activity and constraint used. An example LP result is presented in Appendix F.

TABLE 6. YIELDS PER ACRE FOR WHEAT AND BARLEY BY FIELD WITH AND WITHOUT DRAINAGE

	Wheat	Barley
Without drainage		
All fields	20.46	34.98
With drainage		
Field 1	20.89	35.72
Field 2	21.12	36.11
Field 3	20.82	35.60

TABLE 7. GROSS REVENUE PER ACRE AND BY FIELD FOR WHEAT AND BARLEY WITH AND WITHOUT DRAINAGE USING GOVERNMENT TARGET, AUGUST FORWARD CONTRACT, AND HISTORIC COUNTY AVERAGE PRICES

	Wheat		Barley	
	Acre	Field	Acre	Field
	dollars			
Government target prices				
Without drainage				
Field 1	89.61	4,032.45	90.95	4,092.75
Field 2	89.61	3,659.09	90.95	3,710.76
Field 3	89.61	4,148.94	90.95	4,210.98
With drainage				
Field 1	91.50	4,986.75	92.87	5,061.42
Field 2	92.50	5,041.25	93.89	5,117.00
Field 3	91.20	4,970.40	92.56	5,044.52
August forward contract prices				
Without drainage				
Field 1	51.15	2,301.75	44.42	1,998.90
Field 2	51.15	2,086.92	44.42	1,812.34
Field 3	51.15	2,368.24	44.42	2,056.65
With drainage				
Field 1	52.22	2,845.99	45.36	2,472.12
Field 2	52.80	2,877.60	45.86	2,499.37
Field 3	52.05	2,836.73	45.21	2,463.95
Historic county average prices				
Without drainage				
Field 1	75.26	3,386.70	76.26	3,431.70
Field 2	75.26	3,070.61	76.26	3,111.41
Field 3	75.26	3,484.54	76.26	3,530.84
With drainage				
Field 1	76.88	4,189.96	77.87	4,243.92
Field 2	77.71	4,235.19	78.71	4,289.70
Field 3	76.62	4,175.79	77.60	4,229.20

Results and Sensitivity Analysis

Table 8 presents the general drainage cost alternatives analyzed. For each alternative, an analysis of the sensitivity of revenue to fluctuations in yields, commodity prices, and drainage costs was conducted. Examining variations in break-even points for wheat and barley prices and yields with and without drainage costs provides insight into the model's sensitivity.

TABLE 8. NAMES FOR EACH PRICE OPTION AND DRAINAGE COST ALTERNATIVE

Price Option	Drainage Cost Alternatives		
	One Year	Amortized	No Drainage
	name		
August forward contract	A-D-T	A-D-A	A-N
Historic county average	H-D-T	H-D-A	H-N
Government target	G-D-T	G-D-A	G-N

For example, alternative H-D-T shows an operator can rationally pay as much as $175.74 to drain an acre of wetland in field one (Table 9) given historic average prices and yields for wheat and barley. Break-even wheat and barley prices, given adjusted average yields and one-year drainage costs, are $3.38 per bushel and $1.80 per bushel, respectively. Drainage would be profitable at commodity prices equal to or greater than the break-even level. Given historic average prices for wheat and barley and one-year drainage costs, break-even yields are 19.22 bushels per acre for wheat and 29.52 bushels per acre for barley. The shadow price shows that revenue or the objective function will increase $13.52 for each composite acre of land added to field one. A composite acre contains the same proportion of wetland and cropland as the entire field. Shadow prices represent increases in the objective function if one additional unit of the constraint (acres in field one) is added into the model.

Shadow prices represent the marginal value of an additional composite acre of land. If the shadow price is greater than zero, it is profitable to add another composite acre into production. Shadow prices can be used to compare the economic benefits of drainage with the economic benefits of renting farmland as alternatives to increase farm size and income. If the shadow price is less than the marginal returns from renting farmland, the farm operator would be better off renting farmland than draining wetlands. However, if marginal returns from renting farmland are less than the shadow price, the farm operator should consider draining wetlands.

If rental rates per acre are less than the amortized cost per acre to drain wetlands, an alternative to increase an operation size is to rent additional farmland. Average cash rent for wheat and barley cropland is $19.69 per acre in the CGRS area (Johnson 1987). Comparing rental rates to amortized drainage costs of $25.92, $25.51, and $19.41 per acre suggests that renting farmland is a viable alternative to wetland drainage in order to increase farm size.

Amortizing drainage costs (H-D-A) does not affect the break-even drainage cost for field one (Table 9). However, the break-even price for barley drops from $1.80 per bushel to $1.45 per bushel given amortized drainage

TABLE 9. BREAK-EVEN PRICES, DRAINAGE COSTS, AND COMMODITY YIELDS AND SHADOW PRICES FOR ONE YEAR, AMORTIZED, AND NO DRAINAGE COSTS WITH HISTORIC COUNTY AVERAGE PRICES AND YIELDS

Alternative	Break-Even Drainage Costs[a]	Break-Even Prices[b] Wheat	Break-Even Prices[b] Barley	Break-Even Yields[c] Wheat	Break-Even Yields[c] Barley	Shadow Prices[d]
	-----------dollars/acre-----------			-bushels/acre-		----dollars---
H-D-T (one year drainage costs)						
Field 1	-175.74	3.38	1.80	19.22	29.52	13.52
Field 2	-125.11	3.39	1.98	19.44	32.82	7.16
Field 3	-201.81	3.38	1.64	19.15	26.74	19.30
H-D-A (amortized drainage costs)						
Field 1	-175.74	3.38	1.45	19.22	23.74	26.11
Field 2	-125.11	3.39	1.48	19.44	24.62	25.04
Field 3	-201.81	3.38	1.41	19.15	23.00	27.45
H-N (no drainage)						
Field 1	- 0 -	3.33	1.43	18.55	22.99	26.14
Field 2	- 0 -	3.30	1.51	18.33	24.22	23.45
Field 3	- 0 -	3.29	1.57	18.28	25.16	24.40

[a]This assumes county average prices and yields for wheat and barley.
[b]This assumes county average yield for wheat and barley.
[c]This assumes county average prices for wheat and barley.
[d]This represents the amount of increase in the revenue function if one composite acre is forced into the model.

costs and adjusted historic average yield. Barley break-even yield declines from 29.52 bushels per acre to 23.74 bushels per acre for field one. Adding one composite acre of land to field one will increase farm revenue $26.11.

Eliminating drainage (H-N) changes the break-even prices for wheat and barley to $3.33 per bushel and $1.43 per bushel, respectively, given adjusted historic average yields for field one. Break-even wheat and barley yields are 18.55 bushels per acre and 22.99 bushels per acre, respectively, given historic county average prices. The shadow price for field one given historic county average prices and yields is $26.14.

Incorporating August 1987 forward contract prices and one-year drainage costs into the analysis (A-D-T) shows that draining wetlands in fields one and two is not profitable; however, draining wetlands within field three is marginally profitable. Drainage costs for fields one and two exceed the additional crop production revenue on drained wetlands. One-year costs of draining these fields are $98.16 for field one and $96.63 for field two. The maximum price the farmer could rationally invest per acre per year to drain fields one and two is $69.59 and $50.47, respectively, given historic yields and contract prices.

Draining wetlands in field three is profitable under the assumed model conditions. Wheat can be profitably grown; however, barley production cannot generate sufficient returns to recover both production and wetland drainage costs. Therefore, only half of the field's wetlands are drained and only half of the field's acreage is used in crop production. Break-even prices and yields for wheat and barley and shadow prices for wheat with one year drainage costs for each field are presented in Table 10.

Amortized drainage costs (A-D-A) produce the same drainage break-even prices (Table 10). Break-even prices and yields for wheat and barley are considerably less than one-year drainage break-even prices and yields.

TABLE 10. BREAK-EVEN PRICES, DRAINAGE COSTS, AND COMMODITY YIELDS AND SHADOW PRICES FOR ONE YEAR, AMORTIZED, AND NO DRAINAGE COSTS WITH AUGUST FORWARD CONTRACT PRICES AND HISTORIC COUNTY AVERAGE YIELDS

Alternative	Break-even Drainage Costs[a]	Break-Even Prices[b]		Break-Even Yields[c]		Wheat Shadow Prices[d]
		Wheat	Barley	Wheat	Barley	
	---------dollars/acre----------			bushels/acre		----dollars---
A-D-T (one year drainage costs)						
Field 1	-69.59	2.74	1.80	22.88	50.67	- 0 -
Field 2	-50.47	3.05	1.98	25.76	56.34	- 0 -
Field 3	-79.46	2.50	1.64	20.46	45.90	.89
A-D-A (amortized drainage costs)						
Field 1	-69.59	2.13	1.45	16.84	40.75	7.61
Field 2	-50.47	2.04	1.49	18.61	42.26	6.27
Field 3	-79.46	2.06	1.41	17.24	39.49	9.04
A-N (no drainage)						
Field 1	- 0 -	2.01	1.40	16.84	39.46	9.04
Field 2	- 0 -	2.08	1.46	17.61	41.58	7.13
Field 3	- 0 -	2.20	1.54	18.35	43.19	5.27

[a]This assumes county average yields and August forward contract prices for wheat and barley.
[b]This assumes county average yields for wheat and barley.
[c]This assumes August forward contract prices for wheat and barley.
[d]This represents the amount of increase in the revenue function if one composite acre of wheat is forced into the model.

Wheat production is profitable; however, barley revenues do not recover both production and drainage costs. Wheat shadow prices range from $6.27 per acre for field two to $9.04 per acre for field three.

Eliminating drainage from the model produces barley returns below variable production costs. Therefore, no barley is produced. Wheat production is profitable with shadow prices of $9.04, $7.13, and $5.27 per acre for fields one, two, and three, respectively (Table 10). A summary of break-even prices and yields along with shadow prices by field for government target price options is provided in Table 11.

TABLE 11. BREAK-EVEN PRICES, DRAINAGE COSTS, AND COMMODITY YIELDS AND SHADOW PRICES FOR ONE YEAR, AMORTIZED, AND NO DRAINAGE COSTS WITH GOVERNMENT TARGET PRICES AND HISTORIC COUNTY AVERAGE YIELDS

Alternative	Break-Even Drainage Costs[a]	Break-Even Prices[b]		Break-Even Yields[c]		Shadow Prices[d]
		Wheat	Barley	Wheat	Barley	
	--------dollars/acre----------			bushels/acre		---dollars---
G-D-T (one year drainage costs)						
Field 1	-202.90	4.17	1.94	19.91	26.66	18.84
Field 2	-143.75	4.15	2.18	20.03	30.23	12.23
Field 3	-233.44	4.20	1.73	19.96	23.66	24.84
G-D-A (amortized drainage costs)						
Field 1	-202.90	4.22	1.48	20.15	20.41	31.84
Field 2	-143.75	4.22	1.54	20.36	21.36	30.68
Field 3	-233.44	4.23	1.43	20.11	19.61	33.25
G-N (no drainage costs)						
Field 1	- 0 -	4.18	1.43	19.53	19.28	32.66
Field 2	- 0 -	4.13	1.51	19.31	20.31	30.51
Field 3	- 0 -	4.12	1.57	19.24	21.10	28.88

[a]This assumes county average yields and government target prices for wheat and barley.
[b]This assumes county average yields for wheat and barley.
[c]This assumes government target prices for wheat and barley.
[d]This represents the amount of increase in the revenue function if one composite acre is forced into the model.

Net revenues[5] under short-run conditions varied from $661 with forward contract prices to $3,310 with government target prices (Table 12). Revenues from forward contract barley prices did not recover production costs under one-year drainage costs, amortized costs, or with no drainage costs. In other words, it did not pay to produce barley with these prices.

Long-run net revenues varied from $1,249 using forward contract prices to $5,418 with government target prices. Revenues generated from no drainage alternatives ranged from $942 with forward contract prices to $4,290 with government target prices.

Net revenues from undrained fields exceeded those of drained fields when the entire drainage cost was charged in one year for each price option. Drained fields with amortized drainage costs had the highest net revenue. A farm operator, therefore, may incur a decrease in net revenue the year of drainage; however, the present value of future net revenues will be greater than returns on undrained fields.

TABLE 12. REVENUES GENERATED FROM SHORT-RUN ONE-YEAR DRAINAGE COSTS, LONG-RUN AMORTIZED DRAINAGE COSTS, AND NO DRAINAGE COSTS FOR AUGUST FORWARD CONTRACT, HISTORIC COUNTY AVERAGE, AND GOVERNMENT TARGET PRICES

Drainage Cost Options	Price Scenarios: August Contract	Historic Average	Government Target
	------------1986 dollars------------		
Short-run	660.86[a]	2,682.16	3,310.21
Long-run	1,249.40[b]	4,787.01	5,417.61
No drainage	941.98[c]	3,625.53	4,289.99

[a]Revenue assumes that the farmer drains all of field three and plants wheat on the entire field; fields one and two are not drained and wheat is planted on both fields.
[b]Revenue assumes that all fields are drained and wheat is planted on fields in place of barley.
[c]Revenue assumes that only wheat is planted.

[5]Net revenues excluded fixed costs and were not adjusted for any changes in property taxes resulting from wetland drainage.

Summary

Revenues generated from *short-run*, *long-run*, and *no drainage cost* alternatives show that revenue is highest for the *long-run government target price* option ($5,417) followed by *long-run historic average* ($4,787) and *no drainage government target* ($4,290) *price* options.

Revenues assuming forward contract prices for barley and one-year, amortized, or no-drainage cost alternatives are insufficient to cover variable crop production costs per acre. Wheat production, assuming *one-year drainage costs*, is not an economically viable option. Income from wheat production cannot recover production costs and one-year drainage expenses within fields one and two. Wheat production with forward contract prices is economically feasible given amortized or no-drainage cost alternatives.

Historic county average and government target prices for wheat and barley provide the farmer positive economic returns for one-year, amortized, and no-drainage cost alternatives.

Draining wetlands is economically infeasible given August contract and historic average price options and one-year drainage costs if drainage is done by hiring custom operators. Custom drainage rates per acre average two times higher than those used in this study. Therefore, net revenues are significantly lower and are negative under one-year custom drainage costs reducing economic incentives to drain wetlands. An economic incentive exists to drain wetlands in fields one and three given government target prices; however, draining wetlands in field two is not economically feasible. Amortizing custom drainage costs provides positive returns under each price option; however, farm returns to drainage would be higher if the farmer did his own drainage work.

Examining shadow prices by field shows little difference between shadow prices with *amortized drainage costs* and *no drainage* for historic average and government target price options. Shadow prices for *one-year drainage costs* are considerably less than *amortized* and *no drainage cost* alternatives for each price option. Given August contract prices, there is little difference in shadow prices for field two; however, there is a difference for fields one and three. The shadow price for field one with *amortized drainage costs* is less than the shadow price with *no drainage*. The shadow price for field three with *amortized costs* is greater than the shadow price with *no drainage*. This implies that the farm operator would receive higher farm income by draining field three than leaving it undrained. Conversely, the farmer would earn more farm income by not draining field one than if he drained it. The farmer would be indifferent in his decision concerning field two. This suggests that returns to drainage are highest for field three and the lowest for field one.

Conclusions

It is difficult to generalize about the profitability of converting wetlands to cropland because each wetland has a different return to drainage. Factors affecting drainage returns are drainage costs and expected crop production expenses, yields, and prices. These factors are different for each wetland. Therefore, drainage decisions should be made on a wetland by wetland basis.

Revenues generated from short-run, long-run, and no-drainage cost alternatives show that if a farmer does not amortize or spread his drainage costs for the given year over five, he would appear better off not draining. However, extending the analysis for the short-run drainage cost alternative over more than one year may lead to positive net returns.

If a farmer can only receive forward contract prices for wheat and barley, it is not economically feasible to raise wheat and barley, much less invest in drainage to grow more wheat and barley given one-year drainage costs. Wheat production is profitable assuming amortized and no-drainage cost alternatives; however, barley revenues still do not recover both production expenses and drainage costs. This suggests that drainage is profitable if only wheat is grown. However, farmers should incorporate rotational crop practices. Planting wheat on the same land year-after-year increases disease in the soil. Soil disease can reduce the productive capacity of the soil over time to where average yields cannot be maintained. At this point, wheat production would also be economically infeasible. Therefore, forward contract price option is not an economically viable option for farmers considering wetland drainage.

Historic county average prices for wheat and barley provide the farm operator positive net returns both with and without drainage. However, provisions in the Food Security Act of 1985 (P.L. 99-198) call for lower loan rates over the next four years. The loan rate acts as a price ceiling in the grain market. Lower loan rates will reduce future county average prices making it unlikely that farmers will receive commodity prices as high as past historic county average prices during the next four years. Therefore, the only viable price option for farmers considering wetland drainage is that offered through government target price programs. **If a farmer receives government target prices, draining some wetlands is economically feasible given conditions presented in this study.**

The Food Security Act of 1985 contains provisions making farmers ineligible for target prices if crops are grown on wetland acres converted after December 23, 1985 (Swampbuster Provisions). Loss of price support on all program crops makes draining wetlands an irrational economic decision when there are no profitable alternative nonprogram crops. Therefore, Swampbuster will work to reduce drainage of wetlands in areas of North Dakota similar to the CGRS, but only as long as cash grain prices remain low.

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Appendix A

APPENDIX TABLE A1. SUMMARY OF LP MATRIX COEFFICIENTS AND TOTAL WORKING ACRES BY TILLAGE OPERATION

	Chisel Plow	Field Cultivate	Drag	Plant	Spray	Swath	Combine	Haul
<u>Control Field (No Wetlands)</u>								
Cropland Area - 54.5 acres								
Total working acres	55.74	56.25	57.56	55.99	57.69	55.74	54.5	54.5
LP matrix coefficient	1.02	1.03	1.06	1.02	1.06	1.02	1	1
<u>Field 1</u>								
Cropland area - 45.0 acres								
Total working acres	47.75	49.35	53.35	48.55	53.75	47.75	45.0	45.0
LP matrix coefficient	1.06	1.10	1.18	1.08	1.19	1.06	1	1
<u>Field 2</u>								
Cropland area - 40.8 acres								
Total working acres	44.82	47.17	53.07	45.99	53.66	44.82	40.8	40.8
LP matrix coefficient	1.10	1.16	1.30	1.13	1.31	1.10	1	1
<u>Field 3</u>								
Cropland area - 46.3 acres								
Total working acres	56.61	56.67	61.91	55.63	62.43	56.61	46.3	46.3
LP matrix coefficient	1.18	1.22	1.34	1.20	1.35	1.18	1	1

Appendix B

APPENDIX TABLE B1. ONE-YEAR DRAINAGE AND AMORTIZED DRAINAGE COSTS BY WETLANDS AND FIELDS

	Ditch Length	Total Yards Moved	Scraper Trips	Distance Traveled	Trips Per Hour	Hours Spent Scraping	Total Variable Costs	Variable Cost Per Acre	Weighted Average Per Acre
	-yds-	-yds^3-		-mi/trip-					
Field 1									
Wetland 1	228.80	915.20	152.53	0.26	11.54	13.22	527.46	128.65	55.32
Wetland 2	123.20	492.80	82.13	0.14	21.43	3.83	152.93	95.58	16.25
Wetland 3	158.40	633.60	105.60	0.18	16.67	6.34	252.81	66.53	26.61
One-year drainage cost									98.18
Amortized drainage cost per acre = 25.92 (10% over 5 yrs.)									
Field 2									
Wetland 1	35.20	140.80	23.47	0.04	40.00	0.59	23.41	39.01	1.56
Wetland 2	193.60	774.40	129.07	0.22	13.64	9.46	377.65	1888.25	18.88
Wetland 3	35.20	140.80	23.47	0.04	40.00	0.59	23.41	12.32	1.72
Wetland 4	316.80	1267.20	211.20	0.36	8.33	25.34	1011.23	91.93	74.46
One-year drainage cost									96.63
Amortized drainage cost per acre = 25.51 (10% over 5 yrs.)									
Field 3									
Wetland 1	17.60	70.40	11.73	0.02	40.00	0.29	11.70	10.64	1.38
Wetland 2	70.40	281.60	46.93	0.08	37.50	1.25	49.94	17.22	6.03
Wetland 3	123.20	492.80	82.13	0.14	21.43	3.83	152.93	101.95	18.35
Wetland 4	88.00	352.00	58.67	0.10	30.00	1.96	78.03	65.02	9.75
Wetland 5	158.40	633.60	105.60	0.18	16.67	6.34	252.81	316.01	31.60
Wetland 6	70.40	281.60	46.93	0.08	37.50	1.25	49.94	71.34	6.42
One-year drainage cost									73.54
Amortized drainage cost per acre = 19.41 (10% over 5 yrs.)									

Appendix C

APPENDIX TABLE C1. SPRING WHEAT VARIABLE PRODUCTION COSTS PER ACRE

Operation	Size of Tractor Used	Type and Size of Machine	Machine Time Required	Total Tractor and Machine Cost	Hourly Labor Required	Total Labor Cost	Amount & Type	Total Variable Cost
	--hp---		hrs./ac.	---$/ac.----	hrs./ac.	$/ac.	-------$/ac.--------	-$/ac.--
Chisel Plow	160	20' chisel plow	.115	2.10	.117	.61		2.71
Field Cult.	160	28' field cult.	.186	3.86	.437	2.27	anhydrous $2.67	8.80
Drag	75	48' spring tooth	.033	.29	.036	.22	pre-plant herbicide $1.06	1.62
Plant	75	24' grain drill	.105	1.68	.139	.98	seed $4.14 nitrogen $1.53 phosphorus $2.79	11.12
Spray	75	50' sprayer	.042	.42	.053	.37	post plant herbicide $3.11	3.90
Swath		20' swather	.103	.86	.103	.54		1.40
Combine		large	.159	5.33	.176	.124		6.57
Total								$36.12

SOURCE: Benson and Ohannesian; Reff, 1986.

APPENDIX TABLE C2. BARLEY VARIABLE PRODUCTION COSTS PER ACRE, 1986.

Operation	Size of Tractor Used	Type and Size of Machine	Machine Time Required	Total Tractor and Machine Cost	Hourly Labor Required	Total Labor Cost	Amount & Type	Total Variable Cost
	--hp---		hrs./ac.	---$/ac.----	hrs./ac.	$/ac.	-------$/ac.--------	-$/ac.--
Chisel Plow	160	20' chisel plow	.115	2.10	.117	.61		2.71
Field Cult.	160	28' field cult.	.186	3.86	.437	2.27	anhydrous $4.80	10.93
Drag	75	48' spring tooth	.033	.29	.036	.18		.47
Plant	75	24' grain drill	.105	1.68	.139	.98	seed $5.46	8.12
Spray	75	50' sprayer	.042	.42	.053	.37	post plant herbicide $10.97	11.76
Swath		20' swather	.103	.86	.103	.54		1.40
Combine		large	.159	5.33	.176	1.24		6.57
Total								$41.96

SOURCE: Benson and Ohannesian; Reff, 1986.

<u>Hauling Costs - Wheat</u>

20 miles x $1.50/mile = $30
$30 ÷ 600 bu. = $.05/bu.

No Drainage:
(20.46 bu./ac. x $.05/bu.) + $.92/ac. (labor) = $1.94/ac.

With Drainage:
Field 1: (20.89 bu./ac. x $.05/bu.) + $.92/ac. (labor) = $1.96/ac.
Field 2: (21.12 bu./ac. x $.05/bu.) + $.92/ac. (labor) = $1.98/ac.
Field 3: (20.82 bu./ac. x $.05/bu.) + $.92/ac. (labor) = $1.96/ac.

<u>Hauling Costs - Barley</u>

No Drainage:
(34.98 bu./ac. x $.05/bu.) + $.92/ac. (labor) = $2.67/ac.

With Drainage:
Field 1: (35.72 bu./ac. x $.05/ac.) + $.92/ac. (labor) = $2.71/ac.
Field 2: (36.11 bu./ac. x $.05/ac.) + $.92/ac. (labor) = $2.73/ac.
Field 3: (35.60 bu./ac. x $.05/ac.) + $.92/ac. (labor) = $2.70/ac.

<u>Interest on Operating Capital for Wheat</u>

* 8% interest rate for 4 months
$36.12/ac. x 8% x (125/360) = $1.00/ac.

<u>Interest on Operating Capital for Barley</u>

* 8% interest rate for 4 months
$41.96/ac. x 8% x (125/360) = $1.18/ac.

Appendix D

APPENDIX TABLE D1. COUNTY AVERAGE PRICES AND YIELDS FOR WHEAT AND BARLEY IN KIDDER COUNTY FROM 1980-1984

	Year	Yield	Prices
		bu./ac.	-$/bu.-
Spring wheat	1980	8.8	$3.82
	1981	24.5	3.56
	1982	23.5	3.73
	1983	20.0	3.74
	1984	25.5	3.54
Mean		20.46	3.68
Malting barley	1980	16.6	2.65
	1981	39.0	2.18
	1982	41.8	1.98
	1983	36.5	2.18
	1984	41.0	1.92
Mean		34.98	2.18

SOURCE: North Dakota Crop and Livestock Reporting Service, 1986.

APPENDIX TABLE D2. DISTRIBUTION OF DITCH AREAS WITHIN WETLANDS AND FIELDS BY FIELD

	Wetland	Field	Total	Wetland	Field	Total
	--------percent----------			--------------acres---------------		
Field 1						
Wetland						
1	25[a]	75[b]	100	.09	.29	.38
2	33	66	100	.07	.13	.20
3	80	20	100	.21	.05	.26
Total				.37	.47	.84
Percent				44	56	100
Field 2						
Wetland						
1	100	0	100	.06	0	.06
2	10	90	100	.03	.29	.32
3	00	0	100	.06	0	.06
4	50	50	100	.26	.26	.52
Total				.41	.55	.96
Percent				43	57	100
Field 3						
Wetland						
1	100	0	100	.03	0	.03
2	66	33	100	.08	.04	.12
3	33	66	100	.07	.13	.20
4	33	66	100	.05	.09	.14
5	20	80	100	.05	.21	.26
6	50	50	100	.06	.06	.12
Total				.34	.53	.87
Percent				39	61	100

[a]Represents the percent of the ditch contained within the wetland.
[b]Represents the percent of the ditch contained within the field.

Revenues Using Historic County Average Prices for Wheat

Without Drainage:

20.46 bu./ac. x \$3.68/bu. = \$75.29/ac.

With Drainage:

Yields in wetland areas are 15 percent greater than county average yields
Yields in ditch areas are 25 percent less than county average

20.46 bu./ac. x 1.15 = 23.53 bu./ac.
20.46 bu./ac. x .75 = 15.35 bu./ac.

Field 1

Wetland	9.13 acres	x	23.53 bu./ac.	=	214.84 bu.
Field	44.53 acres	x	20.46 bu./ac.	=	911.07 bu.
Ditch	.84 acres	x	15.34 bu./ac.	=	12.89 bu.
Total	54.5 acres				1,138.80 bu.

Average yield/acre = 1,138.80 bu. / 54.5 ac. = 20.89 bu./ac.

Average revenue/acre = 20.89 bu./ac. x \$3.68/bu. = \$76.88/ac.

Field 2

Wetland	13.29 acres	x	23.53 bu./ac.	=	312.65 bu.
Field	40.25 acres	x	20.46 bu./ac.	=	823.51 bu.
Ditch	.96 acres	x	15.34 bu./ac.	=	14.73 bu.
Total	54.5 acres				1,150.89 bu.

Average yield/acre = 1,150.89 bu. / 54.5 ac. = 21.12 bu./ac.

Average revenue/acre = 21.12 bu./ac. x \$3.68/bu. = \$77.71/ac.

Field 3

Wetland	7.86 acres	x	23.53 bu./ac.	=	184.94 bu.
Field	45.77 acres	x	20.46 bu./ac.	=	936.45 bu.
Ditch	.87 acres	x	15.34 bu./ac.	=	13.35 bu.
Total	54.5 acres				1,134.74 bu.

Average yield/acre = 1,134.74 bu. / 54.5 ac. = 20.82 bu./ac.

Average revenue/acre = 20.82 bu./ac. x \$3.68/bu. = \$76.62/ac.

Revenues Using Forward Contract Prices for Wheat

Without Drainage:

20.46 bu./ac. x \$2.50/bu. = \$51.15/ac.

With Drainage:

Field 1: 20.89 bu./ac. x \$2.50/bu. = \$52.22/ac.
Field 2: 21.12 bu./ac. x \$2.50/bu. = \$52.80/ac.
Field 3: 20.82 bu./ac. x \$2.50/bu. = \$52.05/ac.

Revenues Using Government Target Prices for Wheat

Without Drainage:

20.46 bu./ac. x \$4.38/bu. = \$89.61/ac.

With Drainage:

Field 1: 20.89 bu./ac. x \$4.38/bu. = \$91.50/ac.
Field 2: 21.12 bu./ac. x \$4.38/bu. = \$92.50/ac.
Field 3: 20.82 bu./ac. x \$4.38/bu. = \$91.20/ac.

Revenues Using Historic County Average Prices for Barley

Without Drainage:

34.98 bu. x $2.18/bu. = $76.26

With Drainage:

Wetland Yields = 34.98 bu./ac. x 1.15/ac. = $40.23 bu.
Ditch Yields = 34.98 bu./ac. x .75/ac. = $26.23 bu.

Field 1

Wetland	9.13 ac. x	40.23 bu./ac. =	367.30 bu.
Field	44.53 ac. x	34.98 bu./ac. =	1,557.66 bu.
Ditch	.84 ac. x	26.23 bu./ac. =	22.03 bu.
Total	54.50 acres		1,946.99 bu.

$\overline{X}$ = 35.72 bu. x $2.18/bu. = $77.87/ac.

Field 2

Wetland	13.29 ac. x	40.23 bu./ac. =	534.66 bu.
Field	40.25 ac. x	34.98 bu./ac. =	1,407.94 bu.
Ditch	.96 ac. x	26.23 bu./ac. =	25.18 bu.
Total	54.50 acres		1,967.78 bu.

$\overline{X}$ = 36.11 bu./ac. x 2.18/bu. = $78.71/ac.

Field 3

Wetland	7.86 ac. x	40.23 bu./ac. =	316.21 bu.
Field	45.77 ac. x	34.98 bu./ac. =	1,601.03 bu.
Ditch	.87 ac. x	26.23 bu./ac. =	22.82 bu.
Total	54.50 acres		1,940.01 bu.

$\overline{X}$ = 35.60 bu/ac. x 2.18/bu. = $77.60/ac.

Revenues Using Forward Contract Prices for Barley

Without Drainage:

34.98 bu. x $1.27/bu. = $44.42/ac.

With Drainage:

Field 1: 35.72 bu./ac. x $1.27/bu. = $45.36/ac.
Field 2: 36.11 bu./ac. x $1.27/bu. = $45.86/ac.
Field 3: 35.60 bu./ac. x $1.27/bu. = $45.21/ac.

Revenues Using Government Target Prices for Barley

Without Drainage:

34.98 bu. x $2.60/bu. = $90.95/ac.

With Drainage:

Field 1: 35.72 bu./ac. x $2.60/bu. = $92.87/ac.
Field 2: 36.11 bu./ac. x $2.60/bu. = $93.89/ac.
Field 3: 35.60 bu./ac. x $2.60/bu. = $92.56/ac.

Appendix E

APPENDIX TABLE E1. EXAMPLE LINEAR PROGRAMMING MATRIX

ROW/ COLUMN	WHT1	WHT1A	WHT2	WHT2A	WHT3	WHT3A	BAR1	BAR1A	BAR2	BAR2A	RHS
REVENUE	91.500	89.610	92.500	89.610	91.200	89.610	92.870	90.950	93.890	90.950	0.00
FIELD1	1.330	--	--	--	--	--	1.250	--	--	--	54.50L
FIELD1A	--	1.330	--	--	--	--	--	1.250	--	--	0.00L
FIELD2	--	--	1.330	--	--	--	--	--	1.250	--	54.50L
FIELD2A	--	--	--	1.330	--	--	--	--	--	1.250	0.00L
FIELD3	--	--	--	--	1.330	--	--	--	--	--	54.50L
FIELD3A	--	--	--	--	--	1.330	--	--	--	--	0.00L
DF1	-0.174	--	--	--	--	--	-0.174	--	--	--	0.00E
DF2	--	--	-0.251	--	--	--	--	--	-0.251	--	0.00E
DR3	--	--	--	--	-0.151	--	--	--	--	--	0.00E
LANDW	1.330	--	--	--	--	--	--	--	--	--	27.25L
LANDW2	--	--	1.330	--	--	--	--	--	--	--	27.25L
LANDW3	--	--	--	--	1.330	--	--	--	--	--	27.25L
LANDW1A	--	1.000	--	--	--	--	--	--	--	--	0.00L
LANDW2A	--	--	--	1.000	--	--	--	--	--	--	0.00L
LANDW3A	--	--	--	--	--	1.000	--	--	--	--	0.00L
CHPLOWT	-1.020	-1.060	-1.020	-1.100	-1.020	-1.180	-1.020	-1.060	-1.020	-1.100	0.00E
FDCULTT	-1.030	-1.100	-1.030	-1.160	-1.030	-1.220	--	--	--	--	0.00E
DRAGT	-1.060	-1.180	-1.060	-1.300	-1.060	-1.340	--	--	--	--	0.00E
PLANTT	-1.030	-1.080	-1.030	-1.130	-1.030	-1.200	--	--	--	--	0.00E
SPRAYT	-1.060	-1.190	-1.060	-1.310	-1.060	-1.350	--	--	--	--	0.00E
SWATHT	-1.020	-1.060	-1.020	-1.100	-1.020	-1.180	-1.020	-1.060	-1.020	-1.100	0.00E
COMBT	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000	0.00E
WHF1T	-1.000	--	--	--	--	--	--	--	--	--	0.00E
WHF1AT	--	-1.000	--	--	--	--	--	--	--	--	0.00E
WHF2T	--	--	-1.000	--	--	--	--	--	--	--	0.00E
WHF2AT	--	--	--	-1.000	--	--	--	--	--	--	0.00E
WHF3T	--	--	--	--	-1.000	--	--	--	--	--	0.00E
WHF3AT	--	--	--	--	--	-1.000	--	--	--	--	0.00E
BFDCULTT	--	--	--	--	--	--	-1.030	-1.100	-1.030	-1.160	0.00E
BDRAGT	--	--	--	--	--	--	-1.060	-1.180	-1.060	-1.300	0.00E
BPLANTT	--	--	--	--	--	--	-1.030	-1.080	-1.030	-1.130	0.00E
BSPRAYT	--	--	--	--	--	--	-1.060	-1.190	-1.060	-1.310	0.00E
BHF1T	--	--	--	--	--	--	-1.000	--	--	--	0.00E
BHF1AT	--	--	--	--	--	--	--	-1.000	--	--	0.00E
BHF2T	--	--	--	--	--	--	--	--	-1.000	--	0.00E
BHF2AT	--	--	--	--	--	--	--	--	--	-1.000	0.00E
BHF3T	--	--	--	--	--	--	--	--	--	--	0.00E
BHF3AT	--	--	--	--	--	--	--	--	--	--	0.00E
WINTT	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000	--	--	--	--	0.00E
BINTT	--	--	--	--	--	--	-1.000	-1.000	-1.000	-1.000	0.00E

-CONTINUED-

APPENDIX TABLE E1. EXAMPLE LINEAR PROGRAMMING MATRIX (CONTINUED)

ROW/ COLUMN	BAR3	BAR3A	DRAIN1	DRAIN2	DRAIN3	CHPLOW	WFDCULT	DRAG	WPLANT	WSPRAY	RHS
REVENUE	92.560	90.950	-98.180	-96.630	-73.540	-2.710	-8.800	-1.620	-11.120	-3.900	0.00
FIELD1	--	--	--	--	--	--	--	--	--	--	54.50L
FIELD1A	--	--	--	--	--	--	--	--	--	--	0.00L
FIELD2	--	--	--	--	--	--	--	--	--	--	54.50L
FIELD2A	--	--	--	--	--	--	--	--	--	--	0.00L
FIELD3	1.250	--	--	--	--	--	--	--	--	--	54.50L
FIELD3A	--	1.250	--	--	--	--	--	--	--	--	0.00L
DF1	--	--	0.775	--	--	--	--	--	--	--	0.00E
DF2	--	--	--	0.775	--	--	--	--	--	--	0.00E
DR3	-0.151	--	--	--	0.775	--	--	--	--	--	0.00E
LANDW	--	--	--	--	--	--	--	--	--	--	27.25L
LANDW2	--	--	--	--	--	--	--	--	--	--	27.25L
LANDW3	--	--	--	--	--	--	--	--	--	--	27.25L
LANDW1A	--	--	--	--	--	--	--	--	--	--	0.00L
LANDW2A	--	--	--	--	--	--	--	--	--	--	0.00L
LANDW3A	--	--	--	--	--	--	--	--	--	--	0.00L
CHPLOWT	-1.020	-1.180	--	--	--	1.000	--	--	--	--	0.00E
FDCULTT	--	--	--	--	--	--	1.000	--	--	--	0.00E
DRAGT	--	--	--	--	--	--	--	1.000	--	--	0.00E
PLANTT	--	--	--	--	--	--	--	--	1.000	--	0.00E
SPRAYT	--	--	--	--	--	--	--	--	--	1.000	0.00E
SWATHT	-1.020	-1.180	--	--	--	--	--	--	--	--	0.00E
COMBT	-1.000	-1.000	--	--	--	--	--	--	--	--	0.00E
WHF1T	--	--	--	--	--	--	--	--	--	--	0.00E
WHF1AT	--	--	--	--	--	--	--	--	--	--	0.00E
WHF2T	--	--	--	--	--	--	--	--	--	--	0.00E
WHF2AT	--	--	--	--	--	--	--	--	--	--	0.00E
WHF3T	--	--	--	--	--	--	--	--	--	--	0.00E
WHF3AT	--	--	--	--	--	--	--	--	--	--	0.00E
BFDCULTT	-1.030	-1.220	--	--	--	--	--	--	--	--	0.00E
BDRAGT	-1.060	-1.340	--	--	--	--	--	--	--	--	0.00E
BPLANTT	-1.030	-1.200	--	--	--	--	--	--	--	--	0.00E
BSPRAYT	-1.060	-1.350	--	--	--	--	--	--	--	--	0.00E
BHF1T	--	--	--	--	--	--	--	--	--	--	0.00E
BHF1AT	--	--	--	--	--	--	--	--	--	--	0.00E
BHF2T	--	--	--	--	--	--	--	--	--	--	0.00E
BHF2AT	--	--	--	--	--	--	--	--	--	--	0.00E
BHF3T	-1.000	--	--	--	--	--	--	--	--	--	0.00E
BHF3AT	--	-1.000	--	--	--	--	--	--	--	--	0.00E
WINTT	--	--	--	--	--	--	--	--	--	--	0.00E
BINTT	-1.000	-1.000	--	--	--	--	--	--	--	--	0.00E

-CONTINUED-

APPENDIX TABLE E1. EXAMPLE LINEAR PROGRAMMING MATRIX (CONTINUED)

ROW/ COLUMN	SWATH	COMBINE	WHF1	WHF1A	WHF2	WHF2A	WHF3	WHF31A	WINT	BFDCULT	RHS
REVENUE	-1.400	-6.570	-1.960	-1.940	-1.980	-1.940	-1.960	-1.940	-1.000	-10.930	0.00
FIELD1	--	--	--	--	--	--	--	--	--	--	54.50L
FIELD1A	--	--	--	--	--	--	--	--	--	--	0.00L
FIELD2	--	--	--	--	--	--	--	--	--	--	54.50L
FIELD2A	--	--	--	--	--	--	--	--	--	--	0.00L
FIELD3	--	--	--	--	--	--	--	--	--	--	54.50L
FIELD3A	--	--	--	--	--	--	--	--	--	--	0.00L
DF1	--	--	--	--	--	--	--	--	--	--	0.00E
DF2	--	--	--	--	--	--	--	--	--	--	0.00E
DR3	--	--	--	--	--	--	--	--	--	--	0.00E
LANDW	--	--	--	--	--	--	--	--	--	--	27.25L
LANDW2	--	--	--	--	--	--	--	--	--	--	27.25L
LANDW3	--	--	--	--	--	--	--	--	--	--	27.25L
LANDW1A	--	--	--	--	--	--	--	--	--	--	0.00L
LANDW2A	--	--	--	--	--	--	--	--	--	--	0.00L
LANDW3A	--	--	--	--	--	--	--	--	--	--	0.00L
CHPLOWT	--	--	--	--	--	--	--	--	--	--	0.00E
FDCULTT	--	--	--	--	--	--	--	--	--	--	0.00E
DRAGT	--	--	--	--	--	--	--	--	--	--	0.00E
PLANTT	--	--	--	--	--	--	--	--	--	--	0.00E
SPRAYT	--	--	--	--	--	--	--	--	--	--	0.00E
SWATHT	1.000	--	--	--	--	--	--	--	--	--	0.00E
COMBT	--	1.000	--	--	--	--	--	--	--	--	0.00E
WHF1T	--	--	1.000	--	--	--	--	--	--	--	0.00E
WHF1AT	--	--	--	1.000	--	--	--	--	--	--	0.00E
WHF2T	--	--	--	--	1.000	--	--	--	--	--	0.00E
WHF2AT	--	--	--	--	--	1.000	--	--	--	--	0.00E
WHF3T	--	--	--	--	--	--	1.000	--	--	--	0.00E
WHF3AT	--	--	--	--	--	--	--	1.000	--	--	0.00E
BFDCULTT	--	--	--	--	--	--	--	--	--	1.000	0.00E
BDRAGT	--	--	--	--	--	--	--	--	--	--	0.00E
BPLANTT	--	--	--	--	--	--	--	--	--	--	0.00E
BSPRAYT	--	--	--	--	--	--	--	--	--	--	0.00E
BHF1T	--	--	--	--	--	--	--	--	--	--	0.00E
BHF1AT	--	--	--	--	--	--	--	--	--	--	0.00E
BHF2T	--	--	--	--	--	--	--	--	--	--	0.00E
BHF2AT	--	--	--	--	--	--	--	--	--	--	0.00E
BHF3T	--	--	--	--	--	--	--	--	--	--	0.00E
BHF3AT	--	--	--	--	--	--	--	--	--	--	0.00E
WINTT	--	--	--	--	--	--	--	--	1.000	--	0.00E
BINTT	--	--	--	--	--	--	--	--	--	--	0.00E

-CONTINUED-

APPENDIX TABLE E1. EXAMPLE LINEAR PROGRAMMING MATRIX (CONTINUED)

ROW/ COLUMN	BDRAG	BPLANT	BSPRAY	BHF1	BHF1A	BHF2	BHF2A	BHF3	BHF3A	BINT	RHS
REVENUE	-0.470	-8.120	-11.760	-2.710	-2.670	-2.730	-2.670	-2.700	-2.670	-1.180	0.00
FIELD1	--	--	--	--	--	--	--	--	--	--	54.50L
FIELD1A	--	--	--	--	--	--	--	--	--	--	0.00L
FIELD2	--	--	--	--	--	--	--	--	--	--	54.50L
FIELD2A	--	--	--	--	--	--	--	--	--	--	0.00L
FIELD3	--	--	--	--	--	--	--	--	--	--	54.50L
FIELD3A	--	--	--	--	--	--	--	--	--	--	0.00L
DF1	--	--	--	--	--	--	--	--	--	--	0.00E
DF2	--	--	--	--	--	--	--	--	--	--	0.00E
DR3	--	--	--	--	--	--	--	--	--	--	0.00E
LANDW	--	--	--	--	--	--	--	--	--	--	27.25L
LANDW2	--	--	--	--	--	--	--	--	--	--	27.25L
LANDW3	--	--	--	--	--	--	--	--	--	--	27.25L
LANDW1A	--	--	--	--	--	--	--	--	--	--	0.00L
LANDW2A	--	--	--	--	--	--	--	--	--	--	0.00L
LANDW3A	--	--	--	--	--	--	--	--	--	--	0.00L
CHPLOWT	--	--	--	--	--	--	--	--	--	--	0.00E
FDCULTT	--	--	--	--	--	--	--	--	--	--	0.00E
DRAGT	--	--	--	--	--	--	--	--	--	--	0.00E
PLANTT	--	--	--	--	--	--	--	--	--	--	0.00E
SPRAYT	--	--	--	--	--	--	--	--	--	--	0.00E
SWATHT	--	--	--	--	--	--	--	--	--	--	0.00E
COMBT	--	--	--	--	--	--	--	--	--	--	0.00E
WHF1T	--	--	--	--	--	--	--	--	--	--	0.00E
WHF1AT	--	--	--	--	--	--	--	--	--	--	0.00E
WHF2T	--	--	--	--	--	--	--	--	--	--	0.00E
WHF2AT	--	--	--	--	--	--	--	--	--	--	0.00E
WHF3T	--	--	--	--	--	--	--	--	--	--	0.00E
WHF3AT	--	--	--	--	--	--	--	--	--	--	0.00E
BFDCULTT	--	--	--	--	--	--	--	--	--	--	0.00E
BDRAGT	1.000	--	--	--	--	--	--	--	--	--	0.00E
BPLANTT	--	1.000	--	--	--	--	--	--	--	--	0.00E
BSPRAYT	--	--	1.000	--	--	--	--	--	--	--	0.00E
BHF1T	--	--	--	1.000	--	--	--	--	--	--	0.00E
BHF1AT	--	--	--	--	1.000	--	--	--	--	--	0.00E
BHF2T	--	--	--	--	--	1.000	--	--	--	--	0.00E
BHF2AT	--	--	--	--	--	--	1.000	--	--	--	0.00E
BHF3T	--	--	--	--	--	--	--	1.000	--	--	0.00E
BHF3AT	--	--	--	--	--	--	--	--	1.000	--	0.00E
WINTT	--	--	--	--	--	--	--	--	--	--	0.00E
BINTT	--	--	--	--	--	--	--	--	--	1.000	0.00E

APPENDIX TABLE E2. LINEAR PROGRAMMING ACTIVITIES

Activities	Description
WHT1	Wheat acres grown on field one (W/D)*
WHT1A	Wheat acres grown on field one (WO/D)**
WHT2	Wheat acres grown on field two (W/D)
WHT2A	Wheat acres grown on field two (WO/D)
WHT3	Wheat acres grown on field three (W/D)
WHT3A	Wheat acres grown on field three (WO/D)
BAR1	Barley acres grown on field one (W/D)
BAR1A	Barley acres grown on field one (WO/D)
BAR2	Barley acres grown on field two (W/D)
BAR2A	Barley acres grown on field two (WO/D)
BAR3	Barley acres grown on field three (W/D)
BAR3A	Barley acres grown on field three (WO/D)
DRAIN1	Number of wetland acres drained in field one
DRAIN2	Number of wetland acres drained in field two
DRAIN3	Number of wetland acres drained in field three
CHPLOW	Number of cropland acres that were chisel plowed
WFDCULT	Number of wheat acres that were field cultivated
DRAG	Number of cropland acres that were dragged
WPLANT	Number of wheat acres that were planted
WSPRAY	Number of wheat acres that were sprayed
SWATH	Number of cropland acres that were swathed
COMBINE	Number of wheat acres that were combined
WHF1	Number of wheat acres that were hauled from field one (W/D)
WHF1A	Number of wheat acres that were hauled from field one (WO/D)
WHF2	Number of wheat acres that were hauled from field two (W/D)
WHF2A	Number of wheat acres that were hauled from field two (WO/D)
WHF3	Number of wheat acres that were hauled from field three (W/D)
WHF3A	Number of wheat acres that were hauled from field three (WO/D)
WINT	Number of wheat acres that had interest expense
BFDCULT	Number of barley acres that were field cultivated
BDRAG	Number of barley acres that were dragged
BSPRAY	Number of wheat acres that sprayed
BHF1	Number of wheat acres that were hauled from field one (W/D)
BHF1A	Number of wheat acres that were hauled from field one (WO/D)
BHF2	Number of wheat acres that were hauled from field two (W/D)
BHF2A	Number of wheat acres that were hauled from field two (WO/D)
BHF3	Number of wheat acres that were hauled from field three (W/D)
BHF3A	Number of wheat acres that were hauled from field three (WO/D)
BINT	Number of barley acres that had interest expense

*(W/D) represents with drainage
**(WO/D) represents without drainage

APPENDIX TABLE E3. LINEAR PROGRAMMING CONTSTRAINTS

Constraints	Description
FIELD1	Number of acres from field one used (W/D)*
FIELD1A	Number of acres from field one used (WO/D)**
FIELD2	Number of acres from field two used (W/D)
FIELD2A	Number of acres from field two used (WO/D)
FIELD3	Number of acres from field three used (W/D)
FIELD3A	Number of acres from field three used (WO/D)
DF1	Drainage expense transfer for field one
DF2	Drainage expense transfer for field two
DF3	Drainage expense transfer for field three
LANDW	Wheat acres restriction for field one (W/D)
LANDW2	Wheat acres restriction for field two (W/D)
LANDW3	Wheat acres restriction for field three (W/D)
LANDW1A	Wheat acres restriction for field one (WO/D)
LANDW2A	Wheat acres restriction for field two (WO/D)
LANDW3A	Wheat acres restriction for field three (WO/D)
CHPLOWT	Chisel plowing expense transfer
FDCULTT	Field cultivating expense transfer for wheat
DRAGT	Dragging expense transfer for wheat
PLANTT	Planting expense transfer for wheat
SPRAYT	Spraying expense transfer for wheat
SWATHT	Swathing expense transfer for wheat
COMBT	Combining expense transfer for wheat
WHF1T	Hauling wheat from field one expense transfer (W/D)
WHF1AT	Hauling wheat from field one expense transfer (WO/D)
WHF2T	Hauling wheat from field two expense transfer (W/D)
WHF2AT	Hauling wheat from field two expense transfer (WO/D)
WHF3T	Hauling wheat from field three expense transfer (W/D)
WHF3AT	Hauling wheat from field three expense transfer (WO/D)
BFDCULTT	Field cultivating expense transfer for barley
BDRAGT	Dragging expense transfer for barley
BPLANTT	Planting expense transfer for barley
BSPRAYT	Spraying expense transfer for barley
BHF1T	Hauling barley from field one expense transfer (W/D)
BHF1AT	Hauling barley from field one expense transfer (WO/D)
BHF2T	Hauling barley from field two expense transfer (W/D)
BHF2AT	Hauling barley from field two expense transfer (WO/D)
BHF3T	Hauling barley from field three expense transfer (W/D)
BHF3AT	Hauling barley from field three expense transfer (WO/D)
WINTT	Wheat interest expense transfer
BINTT	Barley interest expense transfer

*(W/D) represents with drainage
**(WO/D) represents without drainage

Appendix F

Output From DHLLP Model for G-D-T

PROBLEM NAME = G-D-T
STATUS = OPTIMAL
OBJECTIVE FUNCTION 'REVENUE' VALUE = 3310.207487781849

ROWS SECTION:

ROW NUMBER	ROW NAME	INITIAL LEVEL	ACTUAL LEVEL	SLACK AMOUNT	SHADOW PRICE
1	FIELD1	54.50000	54.50000	0.00000	-18.84120
2	FIELD1A	0.00000	0.00000	0.00000	-32.66544
3	FIELD2	54.50000	54.50000	0.00000	-12.22958
4	FIELD2A	0.00000	0.00000	0.00000	-30.51040
5	FIELD3	54.50000	54.50000	0.00000	-24.84120
6	FIELD3A	0.00000	0.00000	0.00000	-28.87664
7	DF1	0.00000	-0.00000	0.00000	0.00000
8	DF2	0.00000	-0.00000	0.00000	0.00000
9	DR3	0.00000	0.00000	0.00000	0.00000
10	LANDW	27.25000	27.25000	0.00000	-3.20992
11	LANDW2	27.25000	27.25000	0.00000	-3.59258
12	LANDW3	27.25000	27.25000	0.00000	-2.84902
13	LANDW1A	0.00000	0.00000	0.00000	-4.05617
14	LANDW2A	0.00000	0.00000	0.00000	-5.01157
15	LANDW3A	0.00000	0.00000	0.00000	-5.32847
16	CHPLOWT	0.00000	0.00000	0.00000	0.00000
17	FDCULTT	0.00000	-0.00000	0.00000	0.00000
18	DRAGT	0.00000	-0.00000	0.00000	0.00000
19	PLANTT	0.00000	-0.00000	0.00000	0.00000
20	SPRAYT	0.00000	-0.00000	0.00000	0.00000
21	SWATHT	0.00000	0.00000	0.00000	0.00000
22	COMBT	0.00000	0.00000	0.00000	0.00000
23	WHF1T	0.00000	0.00000	0.00000	0.00000
24	WHF1AT	0.00000	0.00000	0.00000	0.00000
25	WHF2T	0.00000	0.00000	0.00000	0.00000
26	WHF2AT	0.00000	0.00000	0.00000	0.00000
27	WHF3T	0.00000	0.00000	0.00000	0.00000
28	WHF3AT	0.00000	0.00000	0.00000	0.00000
29	BFDCULTT	0.00000	0.00000	0.00000	0.00000
30	BDRAGT	0.00000	-0.00000	0.00000	0.00000
31	BPLANTT	0.00000	0.00000	0.00000	0.00000
32	BSPRAYT	0.00000	-0.00000	0.00000	0.00000
33	BHF1T	0.00000	0.00000	0.00000	0.00000
34	BHF1AT	0.00000	0.00000	0.00000	0.00000
35	BHF2T	0.00000	0.00000	0.00000	0.00000
36	BHF2AT	0.00000	0.00000	0.00000	0.00000
37	BHF3T	0.00000	0.00000	0.00000	0.00000
38	BHF3AT	0.00000	0.00000	0.00000	0.00000
39	WINTT	0.00000	0.00000	0.00000	0.00000
40	BINTT	0.00000	-0.00000	0.00000	0.00000

* - BASIC VARIABLE
AO - ALTERNATE OPTIMA

COLUMN SECTION:

COLUMN NUMBER	COLUMN NAME	IN BASIS	REVENUE VALUE	BASIS LEVEL	SHADOW PRICE
1	WHT1	***	91.50000	20.48872	0.00000
2	WHT1A	***	89.61000	0.00000	0.00000
3	WHT2	***	92.50000	20.48872	0.00000
4	WHT2A	***	89.61000	0.00000	0.00000
5	WHT3	***	91.20000	20.48872	0.00000
6	WHT3A	***	89.61000	0.00000	0.00000
7	BAR1	***	92.87000	21.80000	0.00000
8	BAR1A	***	90.95000	0.00000	0.00000
9	BAR2	***	93.89000	21.80000	0.00000
10	BAR2A	***	90.95000	0.00000	0.00000
11	BAR3	***	92.56000	21.80000	0.00000
12	BAR3A	***	90.95000	0.00000	0.00000
13	DRAIN1	***	-98.18000	9.51087	0.00000
14	DRAIN2	***	-96.63000	13.71792	0.00000
15	DRAIN3	***	-73.54000	8.21220	0.00000
16	CHPLOW	***	-2.71000	129.40349	0.00000
17	WFDCULT	***	-8.80000	63.31015	0.00000
18	DRAG	***	-1.62000	65.15413	0.00000
19	WPLANT	***	-11.12000	63.31015	0.00000
20	WSPRAY	***	-3.90000	65.15413	0.00000
21	SWATH	***	-1.40000	129.40349	0.00000
22	COMBINE	***	-6.57000	126.86617	0.00000
23	WHF1	***	-1.96000	20.48872	0.00000
24	WHF1A	***	-1.94000	0.00000	0.00000
25	WHF2	***	-1.98000	20.48872	0.00000
26	WHF2A	***	-1.94000	0.00000	0.00000
27	WHF3	***	-1.96000	20.48872	0.00000
28	WHF3A	***	-1.94000	0.00000	0.00000
29	WINT	***	-1.00000	61.46616	0.00000
30	BFDCULT	***	-10.93000	67.36200	0.00000
31	BDRAG	***	-0.47000	69.32400	0.00000
32	BPLANT	***	-8.12000	67.36200	0.00000
33	BSPRAY	***	-11.76000	69.32400	0.00000
34	BHF1	***	-2.71000	21.80000	0.00000
35	BHF1A	***	-2.67000	0.00000	0.00000
36	BHF2	***	-2.73000	21.80000	0.00000
37	BHF2A	***	-2.67000	0.00000	0.00000
38	BHF3	***	-2.70000	21.80000	0.00000
39	BHF3A	***	-2.67000	0.00000	0.00000
40	BINT	***	-1.18000	65.40000	0.00000

*** - BASIC VARIABLE
AO - ALTERNATE OPTIMA

***** OBJECTIVE FUNCTION SENSITIVITY *****
PROBLEM NAME = G-D-T
OBJECTIVE FUNCTION 'REVENUE' VALUE = 3310.207487781849

COLUMNS:

VARIABLE NUMBER	VARIABLE NAME	BASIS LEVEL	REVENUE VALUE	RANGE LOW	RANGE HIGH	MIN VALUE
7	BAR1	21.80000	92.87000	69.31850	96.88241	
8	BAR1A	0.00000	90.95000	50.11820	94.76218	
9	BAR2	21.80000	93.89000	78.60302	98.38073	
10	BAR2A	0.00000	90.95000	52.81200	95.66012	
11	BAR3	21.80000	92.56000	61.50849	96.12128	
12	BAR3A	0.00000	90.95000	54.85420	95.95796	
13	DRAIN1	9.51087	-98.18000	-202.89839	198.41966	
14	DRAIN2	13.71792	-96.63000	-143.75572	133.52188	
15	DRAIN3	8.21220	-73.54000	-233.43977	231.34270	
1	WHT1	20.48872	91.50000	87.23080	*********	
3	WHT2	20.48872	92.50000	87.72186	*********	
5	WHT3	20.48872	91.20000	87.41080	*********	
2	WHT1A	0.00000	89.61000	85.55383	*********	
4	WHT2A	0.00000	89.61000	84.59843	*********	
6	WHT3A	0.00000	89.61000	84.28153	*********	
16	CHPLOW	129.40348	-2.71000	-17.69723	55.33535	
17	WFDCULT	63.31015	-8.80000	-12.47884	*********	
18	DRAG	65.15413	-1.62000	-5.05743	*********	
19	WPLANT	63.31015	-11.12000	-14.79884	*********	
20	WSPRAY	65.15413	-3.90000	-7.30855	*********	
21	SWATH	129.40348	-1.40000	-16.38723	56.64535	
22	COMBINE	126.86616	-6.57000	-21.85698	52.63626	
23	WHF1	20.48872	-1.96000	-6.22920	*********	
24	WHF1A	0.00000	-1.94000	-5.99617	*********	
25	WHF2	20.48872	-1.98000	-6.75813	*********	
26	WHF2A	0.00000	-1.94000	-6.95157	*********	
27	WHF3	20.48872	-1.96000	-5.74920	*********	
28	WHF3A	0.00000	-1.94000	-7.26847	*********	
30	BFDCULT	67.36200	-10.93000	-25.77172	-7.47245	
31	BDRAG	69.32400	-0.47000	-14.89168	2.76067	
32	BPLANT	67.36200	-8.12000	-22.96173	-4.66245	
33	BSPRAY	69.32400	-11.76000	-26.18168	-8.55648	
34	BHF1	21.80000	-2.71000	-26.26151	1.30241	
35	BHF1A	0.00000	-2.67000	-43.50180	1.14219	
36	BHF2	21.80000	-2.73000	-18.01698	1.76073	
37	BHF2A	0.00000	-2.67000	-40.80800	2.04012	
38	BHF3	21.80000	-2.70000	-33.75150	0.86128	
39	BHF3A	0.00000	-2.67000	-38.76580	2.33796	
29	WINT	61.46616	-1.00000	-4.78920	*********	
40	BINT	65.40000	-1.18000	-16.46698	2.38128	

***** RIGHT HAND SIDE SENSITIVITY *****
PROBLEM NAME = G-D-T
OBJECTIVE FUNCTION 'REVENUE' VALUE = 3310.207487781849

ROWS:

ROW NUMBER	ROW NAME	INITIAL LEVEL	ACTUAL LEVEL	SLACK AMOUNT	RANGE LOW	RANGE HIGH
1	FIELD1	54.50000	54.50000	0.00000	27.2500	*********
2	FIELD1A	0.00000	0.00000	0.00000	-72.8193	*********
3	FIELD2	54.50000	54.50000	0.00000	27.2500	*********
4	FIELD2A	0.00000	0.00000	0.00000	-66.1488	*********
5	FIELD3	54.50000	54.50000	0.00000	27.2500	*********
6	FIELD3A	0.00000	0.00000	0.00000	-64.1889	*********
7	DF1	0.00000	-0.00000	0.00000	-7.3709	*********
8	DF2	0.00000	-0.00000	0.00000	-10.6314	*********
9	DR3	0.00000	0.00000	0.00000	-6.3645	*********
10	LANDW	27.25000	27.25000	0.00000	0.0000	54.5000
11	LANDW2	27.25000	27.25000	0.00000	0.0000	54.5000
12	LANDW3	27.25000	27.25000	0.00000	0.0000	54.5000
13	LANDW1A	0.00000	0.00000	0.00000	-54.7514	54.7514
14	LANDW2A	0.00000	0.00000	0.00000	-49.7360	49.7360
15	LANDW3A	0.00000	0.00000	0.00000	-48.2623	48.2623
16	CHPLOWT	0.00000	0.00000	0.00000	-129.4035	*********
17	FDCULTT	0.00000	-0.00000	0.00000	-63.3101	*********
18	DRAGT	0.00000	-0.00000	0.00000	-65.1541	*********
19	PLANTT	0.00000	-0.00000	0.00000	-63.3101	*********
20	SPRAYT	0.00000	-0.00000	0.00000	-65.1541	*********
21	SWATHT	0.00000	0.00000	0.00000	-129.4035	*********
22	COMBT	0.00000	0.00000	0.00000	-126.8662	*********
23	WHF1T	0.00000	0.00000	0.00000	-20.4887	*********
24	WHF1AT	0.00000	0.00000	0.00000	*********	*********
25	WHF2T	0.00000	0.00000	0.00000	-20.4887	*********
26	WHF2AT	0.00000	0.00000	0.00000	*********	*********
27	WHF3T	0.00000	0.00000	0.00000	-20.4887	*********
28	WHF3AT	0.00000	0.00000	0.00000	*********	*********
29	BFDCULTT	0.00000	0.00000	0.00000	-67.3620	*********
30	BDRAGT	0.00000	-0.00000	0.00000	-69.3240	*********
31	BPLANTT	0.00000	0.00000	0.00000	-67.3620	*********
32	BSPRAYT	0.00000	-0.00000	0.00000	-69.3240	*********
33	BHF1T	0.00000	0.00000	0.00000	-21.8000	*********
34	BHF1AT	0.00000	0.00000	0.00000	*********	*********
35	BHF2T	0.00000	0.00000	0.00000	-21.8000	*********
36	BHF2AT	0.00000	0.00000	0.00000	*********	*********
37	BHF3T	0.00000	0.00000	0.00000	-21.8000	*********
38	BHF3AT	0.00000	0.00000	0.00000	*********	*********
39	WINTT	0.00000	0.00000	0.00000	-61.4662	*********
40	BINTT	0.00000	-			

L1:mla