STATE OF COLORADO

1427 DEPARTMENT OF LAW

AGRICULTURAL ENGINEERING STUDY
SOUTHERN UTE & UTE MOUNTAIN
UTE INDIAN RESERVATIONS

NAVAJO WATERSHED

FINAL REPORT

DESIGN & COST ESTIMATE FOR
OFF-FARM IRRIGATION FACILITIES &
PIA DETERMINATION

JUNE 1987

BK-C22-100-04/05

8064.100

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D.1 GENERAL

The purpose of this task report is to present the methodology for determining practicably irrigable acreage (PIA) for the Navajo Watershed on the Southern Ute Reservation. The test for PIA requires that the revenues exceed the cost. The land under consideration when cropped and irrigated must return sufficient net positive income to pay for the costs of providing irrigation water to the farm headgate. In order to determine PIA it is necessary to conceptually design an irrigation transmission system to deliver water to the farm headgate for each arable parcel. The annualized cost of the off-farm irrigation water transmission system is compared to the net positive income (payment capacity) of the parcel.

Arable lands were identified by Stoneman and Landers. Potential crops, irrigation water requirements, on-farm irrigation systems cost, and other related agronomic information were prepared by Boyle and presented in Task A and B reports. Economic methodology and net agricultural returns were prepared by Western Research Corporation.

This preliminary PIA analysis compares the preliminary net agricultural return with the cost of water delivery from the primary water source to the parcel headgate. For this preliminary analysis, the highest net agricultural return for each climatic zone is used.

Off-farm irrigation transmission facilities were conceptually designed for those parcels with preliminary payment capacities greater than the off-farm water pumping costs. The pumping cost was re-evaluated, added to the facilities cost, and compared to the preliminary payment capacity.

To complete the PIA analysis, the cropping pattern and payment capacities were reviewed by the economist taking into account the practicality of the cropping pattern for the particular parcel and any agronomic costs that might be particular to the parcel. Several iterations of this process between the economist and the engineer were sometimes necessary in order to develop the most economical parcel and facilities layout. Those parcels that still exhibited positive residual payment capacity after these further analyses were then determined to be practicably irrigable.

D.2 SELECTION OF PARCELS FOR OFF-FARM DESIGN

Parcels to be considered for PIA analysis were identified in the Task B Report along with on-farm irrigation costs. The Task B report identified irrigation costs for handmove sprinkler, sideroll sprinkler, gravity (furrow or basin), center pivot, and center pivot with sprinkler in the corners. Computer tabulation compared on-farm irrigation costs to the crop payment capacity for a grass hay/pasture rotation.

The first step in making this task analysis was determination of the

presently irrigated lands on Southern Ute Indian lands. W. W. Wheeler & Associates, Inc., hydrology consultant, identified from aerial photographs and other information available to them the lands presently irrigated and provided to Boyle a marked print of the base map. The amount of irrigated acreage was then planimetered from the base map and tabulated. It should be noted that presently irrigated land covers some land not classified and Class 6 (non-irrigable) soils as determined by Stoneman-Landers, soil consultants.

For the remaining irrigable parcels, an analysis was made to determine the residual water payment capacity when only the off-farm static pumping lift costs where added to the on-farm costs identified in Task B. Based on the elevation of the nearest water supply and the elevation of the highest point in each parcel, the static lift to serve the parcel was calculated using the computer program developed for the Task B report. The power cost to lift the annual water requirement to each field was then calculated assuming a 75 percent pumping plant efficiency which is a conservatively high assumption; and a field delivery pressure of 60 psi for all but gravity irrigated fields.

It should be noted that the parcel water payment capacity residual analysis (Appendix D.1) was slightly modified from the analysis presented in the Task B draft report. Land leveling costs for gravity irrigated fields were not included in the Task B on-farm costs. The Task B report, however, estimated land leveling

quantities in the range of one foot average cuts at a cost of $0.50 to $1.00 per cubic yard. As a conservatively low estimate, an average 6-inch cut at $0.50 per cubic yard for a total cost of $403 per acre was assumed for this Task D analysis. Amortizing this cost at 8-3/8 percent interest over 50 years gives a cost of $34.40, or in round numbers, $35 per acre. This cost was then included in the on-farm costs for gravity irrigation.

D.3 OFF-FARM IRRIGATION TRANSMISSION SYSTEM COST

D.3.1 General

The off-farm irrigation transmission facilities will generally consist of transmission pipelines, pumping stations, and diversion facilities. Roads for access to pump stations; rights-of-way; and the extension of electrical power services to pumping stations were not included in the cost analysis. Costs for those items included are based on experience with similar facilities. All costs are then amortized using a discount rate of 8-3/8 percent over a 50 year project life.

D.3.2 Pumping Stations

Pump station costs were estimated using an equation which considers flow and horsepower as variables. The equation is based on Boyle's experience with various size agricultural pump stations which include pump motor, pump structure, valves, surge control, and power panel. The equation is:

$$\text{Cost } (\$) = 2441(\text{GPM})^{0.41} + 150(\text{HP})^{1.05}$$

where GPM is the system flow rate in gallons per minute and HP is the gross horsepower.

D.3.3 Pipelines

The cost of pipelines is estimated based on experience in water transmission pipeline work. The least cost type of pipe material for the various diameters is reflected in the estimate. Pipeline costs have been compared with pipeline cost estimates from the United States Bureau of Reclamation (USBR) Dolores Project as well as the Animas-La Plata Definite Plan Report. Installed estimated pipeline costs are shown in Table D.1.

D.3.4 River Diversion Structures

River diversion structures were included for parcels over 30 acres. The diversion structure would be constructed across the river to form a pool of water with sufficient depth for the pump to draw from. A weir type diversion structure consists of a 4 foot high wall with a footing and riprap on each side for stability and protection from ice damage. The estimated cost of the structure is $210 per foot. The diversion structures were estimated to be 50 feet long for the Navajo River.

It may not be practical to build a massive diversion to serve a small parcel. A farmer farming a small parcel with low flow requirements would probably have a simple temporary diversion which could be nothing more than a berm graded across the river with a backhoe or

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TABLE D.1
PIPELINE COSTS

Pipe Diamet. (inch)	Installed Cost - $/ft 1/					
	100 psi	150 psi	200 psi	250 psi	300 psi	350 psi
4	10.50	11.00	11.50	12.00	12.50	13.00
6	12.00	12.50	13.00	14.00	14.50	15.00
8	15.50	16.00	17.00	17.50	18.50	20.00
10	20.00	21.00	22.50	23.50	25.00	26.50
12	24.00	26.50	28.50	31.00	33.00	35.00
14	28.50	32.00	35.00	38.00	41.00	44.00
15	31.00	34.50	38.50	42.50	45.50	49.00
16	34.00	37.50	42.00	46.00	50.00	54.00
18	41.00	45.00	50.00	54.00	59.50	65.00
20	48.50	53.00	58.00	63.50	69.00	75.00
21	50.50	55.50	60.50	66.00	71.50	77.00
24	62.00	69.00	75.50	82.00	88.50	95.50
27	75.50	82.00	88.50	96.50	104.00	112.00
30	89.50	96.50	103.00	111.00	120.00	128.50
33	104.50	111.00	116.50	126.50	137.50	148.50
36	115.50	122.00	130.50	142.00	155.00	166.00

1/ Unit construction cost including 10% allowance for appurtenances.

dozer to form a shallow pool for his pump to take suction from if flows in the stream are low. If stream flows were too large to allow installation of a temporary diversion, a low flow could most likely be pumped without a diversion.

The berm may require regrading several times during the irrigation season. However, the overall cost of such diversions is minimal. The decision on the type and size of diversion will vary with each parcel and would require extensive review in the field. Therefore, in order to simplify the analysis it is assumed that no special diversion structure will be required for parcels of 30 acres or less.

In cases where several parcels can be served from one diversion and the combined acreage is over 30 acres, the cost of the diversion is divided between the parcels in proportion to parcel acreage. This approach is believed to be conservative (in favor of generating PIA) and realistic for this type of analysis.

D.3.5 Other Costs

Annual maintenance of major facilities including pipelines, pump stations, and river diversions is estimated at 0.5 percent of the initial construction cost.

The cost of electrical energy is assumed to be $0.068605/KWhr for the Southern Ute area and $0.065039/KWhr for the Mountain Ute area. These are commercial user rates being charged during the first half

of 1985. A detailed discussion of the power costs was previously provided.

D.3.6 Other Costs not Included

Other known costs which could be considered are costs for access roads to the pump stations, right-of-way costs where pipelines or pump stations may be on non-Indian land, and costs to provide electric power service to the pump station. These costs are either minor and/or difficult to estimate with available information. Therefore, for these preliminary analyses, they have not been considered at this time.

The cost of power line extensions to serve pumping facilities could be quite high, especially if three phase power is required. Three phase power will be required for pump stations over 25 horsepower.

D.4 PRELIMINARY PRACTICABLE IRRIGABLE ACREAGE

D.4.1 Existing Irrigated Lands

Lands currently irrigated are assumed to be PIA requiring no further evaluation. No currently irrigated acreage was found in the Najavo watershed.

D.4.2 Water Supply

An examination of the hydrology data for the Navajo River shows that there is sufficient virgin flow during the summer irrigation periods to serve the potential arable lands directly from the river.

Therefore, it was not necessary to perform any operational studies involving storage reservoirs.

D.4.3 Cropping Pattern

For the preliminary analysis of PIA, a cropping pattern with the highest net agricultural returns was used. Table D.2 identifies this cropping pattern as well as the net agricultural return. The parcels in the Navajo Watershed are located in climatic zone J.

D.4.4 Preliminary PIA Analysis

A preliminary PIA analysis was performed comparing a parcel's payment capacity with a preliminary estimate of the cost to pump water from the river to the parcel. This preliminary water cost was based on the static pumping lift (the difference in elevation from the water surface in the river to the elevation of the parcel) for gravity irrigated fields or plus a field delivery pressure of 60 psi for sprinkler irrigation. The Navajo River, which would supply water to the parcels in the Navajo watershed, is located to the east and south of the Southern Ute Reservation. The water surface elevation was taken at the point in Colorado where the river comes closest to the reservation. The water surface elevation at this location is higher than a point further downstream in New Mexico that would be closer to the reservation lands. Detailed tabulations of the analysis are shown in Appendix D.1. None of the parcels in the Navajo Watershed had a positive residual payment capacity. Table D.3 summarizes the results of the analysis.

TABLE D.2
PRELIMINARY CROPPING PATTERN

Climatic Zone	Elevation Range,ft.	Crop Mix 1/	Maximum Net Agricultural Return 2/ $/ac/yr
A	<5,000	Corn, Soybeans	375
B	5,000-5,400	Corn, Soybeans	330
C	5,400-5,800	Corn, Soybeans	285
D	5,800-6,200	Alfalfa, Malt Barley	270
E	6,200-6,600	Alfalfa, Malt Barley	240
F	6,600-7,000	Alfalfa, Malt Barley	210
G	7,000-7,400	Alfalfa, Malt Barley	185
H	7,400-7,800	Alfalfa, Malt Barley	160
I	7,800-8,200	Grass Hay, Pasture	85
J	>8,200	Grass Hay, Pasture	70

1/ Cropping mix and maximum net agricultural return provided by Western Research Corporation, April 11, 1986.

2/ Maximum net agricultural returns do not include on-farm irrigation costs.

TABLE D.3
SUMMARY OF PRELIMINARY RESIDUAL PAYMENT CAPACITY
(Considering pumping only)

Parcel No.	Gross Acres	Prelim. Residual Payment Capacity ($/ac/yr) Hndmve.1/	Sdroll.2/	Grav.3/
N1	35	-233	-264	-310
N2	7	-273	-409	-336
N3	20	-181	-220	-244
N4	6	-211	-364	-267
N5	10	-171	-254	-232
N6	16	-168	-224	-229
N7	19	-188	-231	-251
N8	8	-249	-366	-310

1/ Hndmve - Handmove sprinkler, on-farm irrigation system.

2/ Sdroll - Sideroll sprinkler, on-farm irrigation system.

3/ Grav - Gravity on-farm irrigation systems.

APPENDIX D.1

PRELIMINARY PIA ANALYSIS

APPENDIX D.1
LEGEND

Parcel I.D.: S11-N-01, "S11" = Southern Ute Sheet 11; "N" = Navajo Watershed; "01" = parcel number.

Field Size: Gross size of parcel in acres.

Reduction Factor: Acreage reduction factor discussed in Task A Report.

Net Acreage: The product of field size times reduction factor.

Elevation High and Low: The maximum and minimum elevation within the parcel.

Climatic Zone: Discussed in Task A Report and determined by the parcel's elevation.

Irrigation System Type: Type of on-farm irrigation system.

- HNDMVE - Handmove sprinkler
- SDROLL - Side roll sprinkler
- GRAV - Gravity
- CNTRPVT- Center pivot sprinkler
- CPVT/HMV- Center pivot with handmove

Net Feet: The unit net average irrigation water requirement for the parcel in acre-feet per acre.

Irrigation Efficiency: Irrigation efficiency discussed in Task A Report.

Applied: The unit gross on-farm average irrigation water requirement in acre-feet per acre.

Preliminary Net Ag Return: The preliminary net agricultural return not including the on-farm irrigation system or off-farm irrigation water transmission/distribution system.

Capital: The amortized capital cost per acre per year for the on-farm irrigation system (at 8 3/8% for 50 years) from Task B Report.

Maintenance: The per acre per year maintenance cost of the on-farm irrigation system from the Task B Report.

Labor: The per acre per year labor cost for operation of the on-farm irrigation system from the Task B Report.

Pumping: The per acre per year cost of providing additional on-farm pumping to meet the higher pressure requirements of the center pivot irrigation system.

Preliminary Payment Capacity: The preliminary net ag. returns minus the on-farm irrigation capital, maintenance, labor, and pumping cost in dollars per acre.

Water Source Elevation: The water source diversion point nominal elevation.

Static Lift: The difference in elevation of the parcel's high elevation and and water source elevation in feet.

Annual Power Cost/Acre: The cost of electrical energy per acre per year to serve the parcel considering only the static lift in the case of gravity irrigation or the static lift plus 139 ft. (60 psi) for all types of sprinkler irrigation.

Residual Preliminary Payment Capacity: The result of the preliminary payment capacity minus the annual power cost for pumping at the water supply source in dollars per acre.

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PRELIMINARY PIA ANALYSIS
Navajo Watershed

PARCEL I.D.	***** ACREAGE ***** FIELD SIZE (ACRES)	REDUCTION FACTOR	NET ACREAGE	ELEVATION HIGH	ELEVATION LOW	CLIMATIC ZONE	**** WATER REQUIREMENTS PER ACRE **** IRRIG. SYSTEM TYPE	NET FEET	IRRIG. EFF	APPLIED	****** PRELIMINARY ANNUAL PAYMENT CAPACITY PER ACRE ****** PRELIMINARY NET AG. RETURN	*** ON-FARM IRRIG COSTS *** CAPITAL	MAINT	LABOR	PUMPING	PRELIM PAYMENT CAPACITY	PRELIM WATER SOURCE ELEV.	OFF-FARM WATER COST STATIC LIFT	ANNUAL POWER COST/ACRE	RESIDUAL PRELIM PAYMENT CAPACITY
515-N-001	35	1	35	9160	9080	J	HNDMVE	.82	.7	1.17	$ 70	$ 35	$ 4	$ 14	$ 0	$ 14	7040	2120	$ 247	$-233
515-N-001	35	1	35	9160	9080	J	SDROLL	.82	.7	1.17	$ 70	$ 59	$ 17	$ 10	$ 0	$-16	7040	2120	$ 247	$-264
515-N-001	35	1	35	9160	9080	J	GRAV	.82	.65	1.26	$ 70	$ 109	$ 5	$ 14	$ 0	$-59	7040	2120	$ 250	$-310
515-N-002	7	1	7	9040	9000	J	HNDMVE	.82	.7	1.17	$ 70	$ 80	$ 12	$ 15	$ 0	$-39	7040	2000	$ 234	$-273
515-N-002	7	1	7	9040	9000	J	SDROLL	.82	.7	1.17	$ 70	$ 172	$ 60	$ 11	$ 0	$-174	7040	2000	$ 234	$-409
515-N-002	7	1	7	9040	9000	J	GRAV	.82	.65	1.26	$ 70	$ 144	$ 12	$ 12	$ 0	$-99	7040	2000	$ 236	$-336
515-N-003	20	1	20	8640	8580	J	HNDMVE	82	.7	1.17	$ 70	$ 40	$ 5	$ 14	$ 0	$ 9	7040	1600	$ 190	$-181
515-N-003	20	1	20	8640	8580	J	SDROLL	.82	.7	1.17	$ 70	$ 69	$ 19	$ 10	$ 0	$-29	7040	1600	$ 190	$-220
515-N-003	20	1	20	8640	8580	J	GRAV	.82	.65	1.26	$ 70	$ 104	$ 5	$ 14	$ 0	$-55	7040	1600	$ 189	$-244
515-N-004	6	1	6	8400	8340	J	HNDMVE	.82	.7	1.17	$ 70	$ 86	$ 14	$ 15	$ 0	$-46	7040	1360	$ 164	$-211
515-N-004	6	1	6	8400	8340	J	SDROLL	82	.7	1.17	$ 70	$ 190	$ 67	$ 11	$ 0	$-199	7040	1360	$ 164	$-364
515-N-004	6	1	6	8400	8340	J	GRAV	.82	.65	1.26	$ 70	$ 150	$ 13	$ 12	$ 0	$-106	7040	1360	$ 160	$-267
515-N-005	10	1	10	8320	8240	J	HNDMVE	82	.7	1.17	$ 70	$ 62	$ 9	$ 14	$ 0	$-16	7040	1280	$ 155	$-171
515-N-005	10	1	10	8320	8240	J	SDROLL	82	.7	1.17	$ 70	$ 119	$ 38	$ 10	$ 0	$-98	7040	1280	$ 155	$-254
515-N-005	10	1	10	8320	8240	J	GRAV	82	.65	1.26	$ 70	$ 127	$ 9	$ 14	$ 0	$-81	7040	1280	$ 151	$-232

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PARCEL I.D.	***** ACREAGE ***** FIELD SIZE (ACRES)	REDUCTION FACTOR	NET ACREAGE	ELEVATION HIGH	ELEVATION LOW	CLIMATIC ZONE	**** WATER REQUIREMENTS PER ACFE **** IRRIG. SYSTEM TYPE	NET FEET	IRRIG. EFF	APPLIED	****** PRELIMINARY ANNUAL PAYMENT CAPACITY PER ACRE ****** PRELIMINARY NET AG RETURN	*** ON-FARM IRRIG. COSTS *** CAPITAL	MAINT	LABOR	PUMPING	PRELIM. PAYMENT CAPACITY	PRELIM OFF-FARM WATER COST WATER SOURCE ELEV	STATIC LIFT	ANNUAL POWER COST/ACRE	RESIDUAL PRELIM PAYMENT CAPACITY
S15-N-006	16	1	16	8430	8380	J	HNDMVE	.82	.7	1.17	$ 70	$ 49	$ 6	$ 14	$ 0	$ 0	7040	1390	$ 167	$-168
S15-N-006	16	1	16	8430	8380	J	SDROLL	.82	.7	1.17	$ 70	$ 89	$ 27	$ 10	$ 0	$-57	7040	1390	$ 167	$-224
S15-N-006	16	1	16	8430	8380	J	GRAV	.82	.65	1.26	$ 70	$ 113	$ 7	$ 14	$ 0	$-65	7040	1390	$ 164	$-229
S15-N-007	19	1	19	8680	8640	J	HNDMVE	.82	.7	1.17	$ 70	$ 42	$ 5	$ 14	$ 0	$ 7	7040	1640	$ 195	$-188
S15-N-007	19	1	19	8680	8640	J	SDROLL	82	7	1.17	$ 70	$ 74	$ 21	$ 10	$ 0	$-36	7040	1640	$ 195	$-231
S15-N-007	19	1	19	8680	8640	J	GRAV	.82	65	1.26	$ 70	$ 106	$ 6	$ 14	$ 0	$-57	7040	1640	$ 193	$-251
S15-N-008	8	1	8	8880	8800	J	HNDMVE	82	7	1.17	$ 70	$ 74	$ 11	$ 15	$ 0	$-32	7040	1840	$ 217	$-249
S15-N-008	8	1	8	8880	8800	J	SDROLL	82	7	1.17	$ 70	$ 154	$ 53	$ 11	$ 0	$-149	7040	1840	$ 217	$-366
S15-N-008	8	1	8	8880	8800	J	GRAV	.82	65	1.26	$ 70	$ 138	$ 11	$ 12	$ 0	$-93	7040	1840	$ 217	$-310