# COST ANALYSIS AND WATER CONSERVATION POTENTIAL OF IRRIGATION TECHNOLOGIES IN THE TEXAS PANHANDLE WATER PLANNING AREA

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## Abstract

Six irrigation systems are analyzed considering cost and potential water savings. The investment cost of furrow and drip is $115,800 and $260,120, respectively. The cost of quarter mile pivot ranges from $59,000 to $64,000. Per acre-inch variable pumping cost ranges from $9.96 to $14.86 assuming natural gas price $7.00 per MCF. Converting current furrow acreage (60 percent application efficiency) to surge flow (75 percent) would save between 4.84 and 5.25 million acre-feet (MAF) of water over the 50-year time frame. Shifting irrigated acre to LESA results in estimated total water savings of 8.13-8.57 MAF. Converting all less efficient acreage to LEPA or drip increases estimated water saving to 12.59-12.96 MAF and 13.83-14.28 MAF, respectively. The total adoption of LEPA or drip would result in 18-20 percent reduction in water used for irrigation while maintaining crop production at current levels. Adoption of LEPA on acres currently under furrow irrigation will save approximately $22 million annually in fuel costs. Additional benefits can also be derived from savings in field operations performed and chemigation.

The current mix of irrigation equipment used in the Texas Panhandle suggests that there is a significant potential for water savings by adopting advanced irrigation technology. However, economic feasibility of adopting more expensive irrigation technology and water savings resulting from it needs to be thoroughly assessed.

**Key words:** water savings, irrigation technology, economic feasibility.

**JEL Classification Codes:** Q15; Q25

## Introduction

In Texas the Panhandle Water Planning Area, Region A, is one of the 16 distinct regions established by the Texas Water Development Board. The Panhandle area is one of the largest water consuming regions in the state with agricultural use accounting for over 90 percent of water use. Region A consists of a 21-county area of the Panhandle that includes: Armstrong, Carson, Childress, Collingsworth, Dallam, Donley, Gray, Hall, Hansford, Hartley, Hemphill, Hutchinson, Lipscomb, Moore, Ochiltree, Oldham, Potter, Randall, Roberts, Sherman, and Wheeler Counties.

Irrigated agriculture utilizes more than ten million acre-feet of water in Texas every year. Farmers of the Texas High Plains produce 60 percent of the state's irrigated crops with water pumped from the Ogallala Aquifer. Irrigated crop producers account for 89 percent of the water use in the Texas High Plains. Increasing pressure from population growth, rising pumping costs due to high energy prices, and declining water tables coupled with low commodity prices have forced farmers to consider more advanced and efficient irrigation technologies.

Six irrigation systems are identified and analyzed with respect to cost and potential water savings. Irrigation systems are selected on the basis of use in the Texas High Plains or having the potential to improve water use efficiency. The alternative irrigation systems analyzed include conventional furrow (CF), surge flow (SF), mid-elevation sprinkler application (MESA), low elevation spray application (LESA), low energy precision application (LEPA) and subsurface drip irrigation (DRIP). It is assumed that each irrigation system is installed on a "square" quarter section of land (160 acres).

The general objective of this study is to assess the cost and potential water savings of alternative irrigation technologies. The specific objectives are to:

1. Determine capital investment and operating cost information of alternative irrigation systems.
2. Assess the impact of changes in fuel price and pumping lift on the cost structure of alternative irrigation systems and pumping cost of water from the Ogallala Aquifer.
3. Estimate potential water savings through adoption of the latest irrigation technologies.

## Background

Irrigation technology adoption trends in the past, current status of irrigation technology in the Panhandle Water Planning Area (Region A), and potential water savings by shifting to improved and efficient irrigation systems are discussed in the following section. Total irrigated acres in Region A and crop mix are assumed to be constant during the planning period for the purpose of estimating potential water savings. The estimates of water savings are based on two approaches, indexed water use approach and equal water use approach. A comparison of the water savings from both the approaches is also presented.

### Current Status of Irrigation Technology in Region A

Irrigation in the Texas High Plains began as early as 1911 developing slowly until both the drought of the 1950s and the availability of improved equipment stimulated large number of irrigated acres. This growth continued into the late 1970s with irrigated acres peaking in 1980 at 1.755 million acres in Region A (Table 1). During the

1980s factors such as continuing groundwater depletion of the Ogallala Aquifer, escalating pumping energy costs, low farm profits, and government set-aside programs stimulated a decline in irrigated area in Region A until the early 1990s. This decline continued until the mid-1990s (TWDB, 2001)

Labor shortage, strict laws and liability associated with hired labor encouraged the producers to move from conventional to mechanized irrigation systems. With the adoption of more efficient irrigation technology at a large scale, the producers are able to irrigate more acres with the same amount of water pumped. Therefore, irrigated acres in Region A increased in 1997, Table 1. However, the increase in total irrigated acres is less than the increase in acres under sprinkler irrigation. This means that the producers are not only adopting sprinkler irrigation for newly irrigated acres but also are converting the existing irrigated acres under conventional surface irrigation systems.

The estimates of irrigated acres in Region A in 2008 under furrow and sprinkler are 304,666 and 913,998 respectively (New, 2009). The acres under sprinkler irrigation are further subdivided into three systems, MESA, LESA and LEPA. The irrigated acres by irrigation system, application efficiency, efficiency indices and estimated water use by each system for 2008 are presented in Table 2. The low application efficiency of furrow irrigation is a significant reason for the higher estimated water use i.e., 36.75 percent. The major share of the estimated water use, 59.05 percent, is distributed through the more efficient LESA to irrigate 71 percent of the irrigated acres.

The ratio of estimated water use to acre irrigated for furrow is 1.72 while for LESA the ratio is 0.98. The difference in these ratios is due to the application efficiency of the irrigation system. This efficiency varies due to the intricate design, maintenance, and management of the distribution system as described in the previous section. Other factors such as soil, stage of crop development, time of the year, and climatic conditions also affect the application efficiency. The selection of a system depends on availability and value of water for irrigation. Thus, economic factors influence the irrigation efficiency obtained in a specific production system. In the light of the prevailing climatic conditions in the region and previous research on the subject in this area, the application efficiency percentages and indices have been calculated for these systems.

**Methodology**

Three cost components are analyzed for each of the irrigation systems. First, the initial investment costs for the well, pump, engine and distribution system are examined (New, 2009). Costs of various components of the irrigation systems were obtained from the irrigation equipment dealers during the summer of 2009. Additional cost information was obtained from suggested retail price lists provided by different manufacturers of irrigation equipment. Second, the annual fixed costs associated with depreciation, interest, taxes and insurance are analyzed. Third, the variable costs of fuel, maintenance, lubrication, repairs (LMR) and labor are determined (Amosson, 2009).

Two scenarios were developed to estimate the potential water savings from adopting more efficient irrigation in the Panhandle Water Planning Area (PWPA). The planted irrigated crop acres for each of the counties included in PWPA were based on Texas Agricultural Statistics

(TASS, 2008) and Farm Service Agency of USDA (USDA, 2008) data (Marek et al., 2009). Estimates of water usage by irrigated crops were calculated by determining the optimal water use level via the North Plains Potential Evapotranspiration (NPPET) Network (Amosson et al., 1999, Marek et al., 2000). The current distribution of irrigated acres under each system was used as the base from which potential water savings are estimated.

It is assumed in Scenario I that the crop distribution is the same for each system, i.e., if 25 percent of the acreage is under furrow irrigation then 25 percent of the irrigated corn, cotton, hay, pasture, peanuts, sorghum, soybeans and wheat utilized furrow irrigation. This scenario set the upper bound on what the potential water savings could be. It is assumed in Scenario II that the amount of water pumped through the irrigation systems is the same as the percentage of acreage under that system. Therefore, if 25 percent of the acreage is under furrow irrigation then 25 percent of irrigated water use is through furrow irrigation. This implies that the crop mix under each system adjusts to the application efficiency, i.e., a greater proportion of the high water use crops such as corn are grown under the more application efficient pivot systems than are under furrow. This scenario is used to estimate the lower end of the potential water savings. In reality, potential water saving from adoption of more efficient irrigation systems is between Scenario I and Scenario II.

The acres irrigated with conventional furrow in each county of Region A are distributed among crops assuming a constant crop mix. These crop acres are multiplied by acre-inches of water saved when shifting furrow irrigated acres to LESA. The product is converted into acre-feet by dividing it with 12.

Description of Irrigation Systems

Furrow and surge flow systems are the two surface irrigation systems considered in this analysis. Each system is assumed to irrigate 160 acres. Furrow is assumed to have an application efficiency of 60 percent and a discharge pressure of 10 pounds per square inch (psi). This low efficiency is attributed to the non-uniform distribution, evaporation from the wetted area and deep percolation of water. Surge flow has an application efficiency of 75 percent with a discharge pressure of 10 psi. The major difference between furrow and surge flow is the utilization of a surge valve. The surge value enhances furrow irrigation effectiveness by intermittently applying water and taking advantage of the reduced infiltration parameter associated with soil surface tensions with time.

Three center pivot systems, MESA, LESA, and LEPA are analyzed. Each center pivot is assumed to cover 125 acres. MESA is defined as having 145 drops mounted on top of the center pivot's main line. The sprinkler heads are positioned approximately midway between the mainline and ground level. Water is applied over the crop canopy with MESA resulting in greater water loss due to evaporation and wind drift. MESA has an efficiency rate of 78 percent with a discharge pressure of 25 psi. The application efficiency of MESA is relatively low compared to LESA and LEPA.

LESA is the predominant system within the Panhandle Water Planning Region (New, 2009) and has an average application efficiency of 88 percent with a lower operating pressure of 15 psi. The 261 drops are positioned 12 to 18 inches above ground level. LEPA has an application efficiency of 95 percent with an operating pressure of 15 psi.

Water is applied with either a bubble applicator that applies water in a bubble pattern or drag sock or a hose that releases water on the ground. This concept, by definition, must also utilize furrow diking due to high, concentrate application rates. The application efficiency is improved because this method of application reduces evaporation and wind drift losses.

The drip system is designed to irrigate 160 acres with an application efficiency of 97 percent. This is another low-pressure system operating at 15 psi. Drip tubes are placed 6 to 24 inches below the soil surface depending on the soil type and crop irrigated. These tubes have built-in emitters at a variable spacing and rate of water application. Again, this application efficiency is much higher due to method of application because of elimination of evaporation and wind drift.

## Results and Discussion

The results and discussion section is divided into two major sub-sections. The cost analysis of alternative irrigation systems is presented in the first sub-section while the second sub-section describes the potential water savings through adoption of the efficient irrigation technologies. Potential water savings are estimated based on water use efficiency of the respective alternative irrigation systems. Total potential water savings for the 50 year planning period by adopting more efficient irrigation are also included in the analysis to emphasize the importance of irrigation technology from a water conservation perspective.

### Investment Cost of the Irrigation Systems

Cost analysis for each irrigation system is comprised of fixed investment and operating costs. The pumping costs are estimated for each system at four pumping lifts. Five pumping lifts of 150 feet, 250 feet, 350 feet, 450 feet, and 550 feet are assumed for the pumping cost calculations. Natural gas is the most commonly used fuel to pump water in the region. Therefore, fuel costs to pump water from the Ogallala Aquifer are based on natural gas price at the rate of $6.75 per MCF (Amosson et al., 2009).

The investment costs for the alternative irrigation systems at four pumping lift levels including the well, pump, engine and distribution systems are presented in Table 3. Conventional Furrow requires the least capital investment, $115,800 ($723.75 per acre), at 250 feet lift but is considered the most labor-intensive method of irrigation, as the pipes are often moved manually. A furrow system can easily be converted to surge flow by adding surge valves to the system. Surge flow requires an investment of $119,800 ($748.75 per acre) for a 250 feet lift. Additional investment to change from furrow to surge flow is only $25 per acre but application efficiency is improved from 60 percent to 75 percent.

The investment costs required for MESA, LESA, and LEPA are $138,000 ($1104.00 per acre), $141,900 ($1,135.20 per acre), and $143,000 ($1,144.00 per acre), respectively for a 250 feet lift. MESA can be converted to LESA with an additional investment of $31.20 per acre. Converting LESA to LEPA requires an additional investment of $8.80 per acre. Drip requires the highest capital investment; however, it is considered the least labor-intensive method of irrigation due to automation. At a pumping lift of 550 feet, the furrow system requires an investment of $202,300 ($1,264.38 per acre) for the well, pump, engine and distribution system on 160 acres where the subsurface drip requires an investment of $346,620 ($2,166.38 per acre) to irrigate the same number of acres.

### Operating Costs of Alternative System

Operating costs have two components, fixed and variable costs. The fixed costs include depreciation, taxes, insurance and interest charges associated with the investment (Pflueger, 2009). The variable costs are comprised of fuel charges, lubrication, maintenance, repair charges and labor costs.

The annual fixed costs are calculated for corn using an average water requirement of 18.52 acre-inches per acre. The fixed costs range from $0.84 per acre-inch to $3.98 per acre-inch for conventional furrow to drip, respectively when growing high water use crop. The fixed costs to pump and distribute an acre-inch of water with MESA, LESA, and LEPA for high water use crop are $1.44, $1.84, and $2.05, respectively. Per acre-inch fixed costs for low water use crop with MESA, LESA, and LEPA increase to $3.60, $4.60, and $5.12, respectively because total water pumped in acre-inches is lower than high water use crop assumption.

The variable costs per acre-inch of water pumped at four pumping lifts under each alternative irrigation system are calculated. Variable costs include fuel, lubrication, maintenance, and repair (LMR) charges and labor costs. The variable costs for four pumping lifts are presented in Table 4. The variable costs range from $9.96 per acre-inch at 250 feet to $14.23 per acre-inch at 550 feet for furrow. The variable costs range from $10.01 at 250 feet to $14.20 at 550 feet for drip.

### Impact of Fuel Prices and Pumping Lift on Operating Costs

The price of fuel and pumping lift are some of the major factors that influence pumping cost for irrigated crops. The analysis is conducted by varying fuel price and pumping lift to determine the impact of these variables on irrigation costs under each irrigation system. The results of the analysis help in determining how the decision to invest in irrigation technology will be influenced by the changes in these variables.

Impact of Fuel Prices on Pumping Cost

The impact on fuel costs per acre is analyzed using natural gas prices ranging from \$7.00/MCF to \$12.00/MCF with increments of \$1.00 to determine the impact of fuel price change on the fuel costs under different irrigation systems. The water requirement of corn with LESA is assumed at 20.00 acre-inches. The water in acre-inches pumped is adjusted for other irrigation systems using a relative application efficiency of each system compared to the application efficiency of the LESA system. The estimated fuel costs at an operating lift of 350 feet for corn are presented in Table 5.

At a price of \$7.00/MCF of natural gas, the fuel cost for LEPA is \$6.76 and at \$12.00/MCF this cost rises to \$11.59, an increase of \$4.83. For the same quantity of effective water to be pumped, the fuel cost for furrow is \$10.37 at \$700/MCF and \$17.77 at \$12.00/MCF. This is an increase of \$7.40. The increase in fuel cost on the LEPA system equates to \$0.54 per bushel increase in the cost of producing 180 bushel per acre corn yield and the increase in fuel cost on the furrow system equates to \$0.82 per bushel. Generally, the less efficient irrigation system has greater impact of a change in fuel cost on the cost of production of an irrigated crop.

Impact of Lift on Pumping Cost

The fuel costs for effective water applied equivalent to an acre-inch under LESA with pumping lift levels ranging from 250 feet to 550 feet at incremental changes of 100 feet are calculated to determine the impact of pumping lift levels on the fuel costs under six alternative irrigation systems. The relative efficiency of each system is incorporated into these calculations. These costs at four lift levels are presented for each irrigation method in Table 6. The fuel cost for LEPA at 250 feet is $5.56 and at 550 feet this cost rises to $7.99, an increase of $2.43 per equivalent acre-inch. The fuel cost increases by 44 percent as the lift increases from 250 feet to 550 feet in case of LEPA. The pumping cost for furrow is $8.43 at 250 feet and $12.38 at 550 feet. This is an increase of $3.95 that is $1.52 more than LEPA. The fuel cost increase is 47 percent in the case of furrow as the lift increases from 250 feet to 550 feet. The less efficient the irrigation system, the greater the impact of a change in pumping lift to the cost of production of an irrigated crop.

The fuel cost at 350 feet of lift under furrow and LEPA are $207.40 and $135.20, respectively, for each irrigated acre of corn. At 350 feet lift level, producers will be able to save $72.20 in fuel costs for each irrigated acre by switching to more efficient irrigation technologies. The fuel cost saving from shifting furrow to LEPA increases to $87.80 for every irrigated acre of corn at the 550 feet pumping lift.

The comparison indicates that an increase in lift favors adoption of improved and efficient irrigation methods. With the latest irrigation technologies, the producers will not only save on production costs for themselves but also conserve water for future generations.

Water Saving Potential of Alternative Irrigation Technologies

The investment cost for each system and estimated water savings using the indexed water use approach in Region A are presented in a matrix form in Table 7. Shifting all of the current irrigated acres under furrow to LESA will save 207,132 acre-feet each year due to the use of more efficient irrigation technology. Converting current irrigated acres under furrow and MESA to LESA, the annual water saving is estimated at 209,423 acre-feet. This indicates that by adopting LESA, a more efficient irrigation technology, 10.486 MAF can be saved over the next 50 years. Annual water savings of 302,186 acre-feet can be achieved by converting current irrigated acres under furrow, MESA, and LESA to LEPA. Similarly, 326,174 acre-feet of water can be saved if current irrigated acres under furrow, MESA, LESA and LEPA were converted to drip. However, additional water saving of 23,988 acre-feet per annum with an additional investment of $458.80 per acre does not appear economically feasible.

The water savings estimate by shifting from less efficient to more efficient irrigation distribution system based on equal water use approach and the investment cost for each irrigation system in Region A are presented in a matrix form in Table 8. Shifting 304,666 furrow irrigated acres to MESA results in water savings of 121,274 acre-feet each year and 6.063 MAF over the next 50 years. By shifting irrigated acres under furrow and MESA to LESA annual water saving is estimated at 171,458 acre-feet and 8.573 MAF for next 50 years planning period. Similarly, shifting all irrigated acres under furrow, MESA, and LESA to LEPA could save 258,330 acre-feet of water annually and 12.966 MAF over the next 50 years. Converting 1,218,644 acres to drip irrigation results in additional annual water saving of 26,242 acre-feet. The saving in water is probably not economically feasible at an investment cost of $837.68 per acre.

The estimated water savings from both the approaches are compared. The estimated water savings using an equal water use approach exceed the savings utilizing an indexed water use approach under all alternatives. Water savings from MESA is 8.00 percent. Converting to LEPA, water savings are 18.00 percent and to drip irrigation the savings range from 19.00 to 20.00 percent of the base requirement over the next 50 years.

It is anticipated that the water savings calculated with an indexed water use approach are overestimated because of the assumption that the crop mix and number of irrigated acres in the region will remain constant during the next 50 years. The validity of this assumption seems unrealistic. The water saving estimates need to be verified through future research. Producers making investments in more efficient irrigation technology will definitely thrive for cultivating those crops with higher marginal value per acre-inch of water pumped.

## Summary

Six irrigation systems are identified and analyzed with respect to cost and potential water savings. Irrigation systems analyzed include furrow, surge flow, mid-elevation spray application (MESA), low elevation sprinkler application (LESA), low energy precision application (LEPA) and subsurface drip.

Converting current furrow acreage (60 percent application efficiency) to surge flow (75 percent) would save between 4.84 and 5.25

million acre-feet (MAF) of water over the 50-year time frame. Shifting irrigated acre to LESA results in estimated total water savings of 8.13-8.57 MAF. Converting all less efficient acreage to LEPA or drip increases estimated water saving to 12.59-12.96 MAF and 13.83-14.28 MAF, respectively. The total adoption of LEPA or drip would result in 18-20 percent reduction in water used for irrigation while maintaining crop production at current levels. Adoption of LEPA on acres currently under furrow irrigation will save approximately $22 million annually in fuel costs. Additional benefits can also be derived from savings in field operations performed and chemigation.

The current mix of irrigation equipment used in the Texas Panhandle suggests that there is a significant potential for water savings by adopting advanced irrigation technology. However, economic feasibility of adopting more expensive irrigation technology and water savings resulting from it needs to be thoroughly assessed.

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Table 1. Historical Irrigated Acres in Panhandle Water Planning Region (Region A).

| Year | Furrow | Sprinkler | Total Acres |
|---|---|---|---|
| 1950 | 19,315 | 0 | 19,315 |
| 1960 | 549,884 | 20,397 | 570,281 |
| 1970 | 1,379,878 | 137,139 | 1,517,017 |
| 1980 | 1,353,443 | 401,117 | 1,754,560 |
| 1990 | 676,051 | 515,195 | 1,191,246 |
| 1997 | 509,267 | 854,171 | 1,363,438 |
| 2000 | 545,461 | 889,962 | 1,435,423 |
| 2008 | 304,666 | 913,998 | 1,218,664 |

Table 2. Irrigated acres (2006-08 Average) and Estimated Water Use by irrigation systems, Region A.

| Irrigation System | Acres Irrigated | Acres by System (%) | Application Efficiency (%) | Efficiency Index | Estimated Water Use (acre-feet) | Estimated Water Use (%) |
|---|---|---|---|---|---|---|
| F | 304,666 | 25.00 | 60 | 1.47 | 525,521 | 36.75 |
| SF | 0 | 0.00 | 75 | 1.17 | 0 | 0.00 |
| MESA | 29,248 | 2.40 | 78 | 1.13 | 38,610 | 2.70 |
| LESA | 865,251 | 71.00 | 88 | 1.00 | 844,408 | 59.05 |
| LEPA | 19,499 | 1.60 | 95 | 0.93 | 21,450 | 1.50 |
| DRIP | 0 | 0.00 | 97 | 0.91 | 0 | 0.00 |
| Total | 1,218,664 | | | | 1,429,989 | 100.00 |

Table 3. Investment costs for six irrigation systems at five lift levels,Texas Panhandle (Region A).

| Irrigation System/ Pumping Lift | Well | Pump | Engine | Distribution System | Total Investment | Acres Irrigated | Investment Cost |
|---|---|---|---|---|---|---|---|
| | Dollars | | | | | Acres | ($/acre) |
| CF | | | | | | | |
| 150’ | 27,500 | 26,500 | 6,000 | **36,800** | 96,800 | 160 | **605.00** |
| 250’ | 36,500 | 36,000 | 6,500 | **36,800** | 115,800 | 160 | **723.75** |
| 350’ | 45,500 | 46,000 | 9,000 | **36,800** | 137,300 | 160 | **858.13** |
| 450’ | 54,500 | 56,000 | 9,000 | **36,800** | 156,300 | 160 | **976.88** |
| 550’ | 64,000 | 66,500 | 35,000 | **36,800** | 202,300 | 160 | **1,264.38** |
| SF | | | | | | | |
| 150’ | 27,500 | 26,500 | 6,000 | **40,800** | 100,800 | 160 | **630.00** |
| 250’ | 36,500 | 36,000 | 6,500 | **40,800** | 119,800 | 160 | **748.75** |
| 350’ | 45,500 | 46,000 | 9,000 | **40,800** | 141,300 | 160 | **883.13** |
| 450’ | 54,500 | 56,000 | 9,000 | **40,800** | 160,300 | 160 | **1,001.88** |
| 550’ | 64,000 | 66,500 | 35,000 | **40,800** | 206,300 | 160 | **1,289.38** |
| MESA | | | | | | | |
| 150’ | 27,500 | 26,500 | 6,000 | **59,000** | 119,000 | 125 | **952.00** |
| 250’ | 36,500 | 36,000 | 6,500 | **59,000** | 138,000 | 125 | **1,104.00** |
| 350’ | 45,500 | 46,000 | 9,000 | **59,000** | 159,500 | 125 | **1,276.00** |
| 450’ | 54,500 | 56,000 | 9,000 | **59,000** | 178,500 | 125 | **1,428.00** |
| 550’ | 64,000 | 66,500 | 35,000 | **59,000** | 224,500 | 125 | **1,796.00** |
| LESA | | | | | | | |
| 150, | 27,500 | 26,500 | 6,000 | **62,900** | 122,900 | 125 | **983.20** |
| 250’ | 36,500 | 36,000 | 6,500 | **62,900** | 141,900 | 125 | **1,135.20** |
| 350’ | 45,500 | 46,000 | 9,000 | **62,900** | 163,400 | 125 | **1,307.20** |
| 450’ | 54,500 | 56,000 | 9,000 | **62,900** | 182,400 | 125 | **1,459.20** |
| 550’ | 64,000 | 66,500 | 35,000 | **62,900** | 228,400 | 125 | **1,827.20** |
| LEPA | | | | | | | |
| 150, | 27,500 | 26,500 | 6,000 | **64,000** | 124,000 | 125 | **992.00** |
| 250’ | 36,500 | 36,000 | 6,500 | **64,000** | 143,000 | 125 | **1,144.00** |
| 350’ | 45,500 | 46,000 | 9,000 | **64,000** | 164,500 | 125 | **1,316.00** |
| 450’ | 54,500 | 56,000 | 9,000 | **64,000** | 183,500 | 125 | **1,468.00** |
| 550’ | 64,000 | 66,500 | 35,000 | **64,000** | 229,500 | 125 | **1,836.00** |
| DRIP | | | | | | | |
| 150, | 27,500 | 26,500 | 6,000 | **181,120** | 241,120 | 160 | **1,507.00** |
| 250’ | 36,500 | 36,000 | 6,500 | **181,120** | 260,120 | 160 | **1,625.75** |
| 350’ | 45,500 | 46,000 | 9,000 | **181,120** | 281,620 | 160 | **1,760.13** |
| 450’ | 54,500 | 56,000 | 9,000 | **181,120** | 300,620 | 160 | **1,878.88** |
| 550’ | 64,000 | 66,500 | 35,000 | **181,120** | 346,620 | 160 | **2,166.38** |

Table 4. Variable pumping costs using natural gas as fuel to pump water from the Ogallala aquifer at four levels of pumping lifts for six irrigation systems, Region A.

| System/Lift | 250’ | 350’ | 450’ | 550’ |
|---|---|---|---|---|
| | Dollars/acre-inch | | | |
| CF | 9.96 | 12.05 | 12.95 | 14.23 |
| SF | 9.79 | 11.88 | 12.78 | 14.06 |
| MESA | 10.91 | 12.80 | 13.86 | 14.86 |
| LESA | 10.06 | 12.11 | 12.98 | 14.25 |
| LEPA | 10.02 | 12.07 | 12.94 | 14.21 |
| DRIP | 10.01 | 12.06 | 12.93 | 14.20 |

Table 5. Fuel costs in dollars for effective water applied equivalent to one acre-inch under LESA at alternative gas prices for six irrigation systems at 350’ pumping lift.

| Gas Prices ($/MCF) | | 7.00 | 8.00 | 9.00 | 10.00 | 11.00 | 12.00 |
|---|---|---|---|---|---|---|---|
| Irrigation System | Equivalent to one ac-in of LESA | Dollars | | | | | |
| CF | 1.47 | 10.37 | 11.85 | 13.33 | 14.81 | 16.29 | 17.77 |
| SF | 1.17 | 8.25 | 9.43 | 10.61 | 11.79 | 12.96 | 14.14 |
| MESA | 1.13 | 8.71 | 9.95 | 11.20 | 12.44 | 13.68 | 14.93 |
| LESA | 1.00 | 7.27 | 8.31 | 9.35 | 10.39 | 11.42 | 12.46 |
| LEPA | 0.93 | 6.76 | 7.73 | 8.69 | 9.66 | 10.62 | 11.59 |
| DRIP | 0.91 | 6.62 | 7.56 | 8.51 | 9.45 | 10.40 | 11.34 |

Table 6. Fuel costs in dollars for effective water applied equivalent to one acre-inch under LESA at alternative pumping lift levels for six irrigation systems.

| Pumping Lift | | 250' | 350' | 450' | 550' |
|---|---|---|---|---|---|
| Irrigation System | Eq. to ac-in of LESA | Dollars | | | |
| CF | 1.47 | 8.43 | 10.37 | 11.20 | 12.38 |
| SF | 1.17 | 6.71 | 8.25 | 8.91 | 9.86 |
| MESA | 1.13 | 7.30 | 8.71 | 9.24 | 10.10 |
| LESA | 1.00 | 5.98 | 7.27 | 7.80 | 8.59 |
| LEPA | 0.93 | 5.56 | 6.76 | 7.26 | 7.99 |
| DRIP | 0.91 | 5.44 | 6.62 | 7.10 | 7.82 |

Table 7. Water savings when shifting from conventional irrigation method to more efficient irrigation technologies using indexed water use approach, Region A.

| System | CF | SF | MESA | LESA | LEPA | SDI |
|---|---|---|---|---|---|---|
| | ----------------------------------$/acre---------------------------------- | | | | | |
| Investment Cost | 212.35 | 235.47 | 348.63 | 372.22 | 378.88 | 837.68 |
| | -----------------------------------acre-feet-------------------------------- | | | | | |
| CF | 0 | 96,820 | 111,477 | 159,110 | 184,759 | 192,087 |
| SF | | 0 | 0 | 0 | 0 | 0 |
| MESA | | | 0 | 3,434 | 5,897 | 6,600 |
| LESA | | | | 0 | 60,520 | 77,378 |
| LEPA | | | | | 0 | 469 |
| DRIP | | | | | | 0 |
| Annual Water Savings | | 96,820 | 111,477 | 162,544 | 251,176 | 276,534 |
| Water Savings for 50 years | | 4,841,000 | 5,573,850 | 8,127,200 | 12,558,800 | 13,826,700 |
| Water Savings (%) of Base[1] | | 7 | 8 | 11 | 18 | 19 |

[1] Base irrigation water demand for 50 years in Region A is 71,499,450 acre-feet.

Table 8. Water savings when shifting from conventional irrigation method to more efficient irrigation technologies using equal water use approach, Region A.

| System | F | SF | MESA | LESA | LEPA | SDI |
|---|---|---|---|---|---|---|
| | ---------------------------------$/acre-------------------------------- | | | | | |
| Investment Cost | 212.35 | 235.47 | 348.63 | 372.22 | 378.88 | 837.68 |
| | -------------------------------acre-feet------------------------------ | | | | | |
| CF | 0 | 105,104 | 121,274 | 168,024 | 192,913 | 201,125 |
| SF | | 0 | 0 | 0 | 0 | 0 |
| MESA | | | 0 | 3,434 | 5,897 | 6,600 |
| LESA | | | | 0 | 60,520 | 77,378 |
| LEPA | | | | | 0 | 469 |
| DRIP | | | | | | 0 |
| Annual Water Savings | | 105,104 | 121,274 | 171,458 | 259,330 | 285,572 |
| Water Savings for 50 years | | 5,255,210 | 6,063,704 | 8,572,886 | 12,966,489 | 14,278,616 |
| Water Savings (%) of Base[1] | | 7 | 8 | 12 | 18 | 20 |

[1] Base irrigation water demand for 50 years in Region A is 71,499,450 acre-feet.

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