Applied Risk Analytics

Hay Producers Evaluate Pivot Irrigation Alternatives

Alfalfa hay producers Steve and Teri Smith* have been struggling with drought and regulation of their groundwater irrigation system. Their farm is in a groundwater control area and, therefore, limited to 15 acre-inches per year. The Smiths are finding that, especially in drought years, it is increasingly difficult to maintain a profitable alfalfa crop at this level of applied irrigation water.

They have considered several options, such as idling acres to conserve water and switching crops, but have determined that those options lack adequate long-term revenue. In addition, a change would put their customer sales base in jeopardy. One solution, that seems to show the most promise, is to convert their existing 120-acre center pivot irrigation system to a Mobile Drip (drip-tape) system.

Steve and Teri know an effective way to evaluate this potential change is to use a partial-budgeting approach. However, they would like to evaluate this change on a long-term basis to better account for the costs and returns over the life of the system. This bulletin examines the potential irrigation system switch using the Multi-Temporal Risk Analyzer (MTRA) tool, available at RightRisk.org.

RightRisk Analytics
Tools and guides are available at no cost at the website https://RightRisk.org

Change to Pivot-Based Drip Irrigation

Center pivots are one of the most common irrigation systems used in agriculture today; a mechanized moving sprinkler that rotates around a central point in a field. The Smiths are considering installing a Mobile Drip system on their center pivots to save water. Drip tape systems typically involve being placed on or under the ground to provide water to crops, while minimizing evaporation loss. The Mobile Drip system involves combining aspects of both sprinkler and drip systems

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by removing the sprinkler nozzles and installing varying lengths of drip irrigation tape.

Tape length is varied, based on the amount of applied water desired. Minimal water is applied closest to the pivot point and increases as it moves out toward the end tower. Water is delivered through the tape, applying it directly to the ground with much less evaporation than typical sprinklers. The idea is to make the existing system more efficient by cutting the total water required. In general, less water is needed and at a lower pressure than sprinklers require. The result is fewer total gallons pumped.

Table 1. Smith Example Mobile Drip Irrigation System Upgrade Costs and Returns

Proposed Change:	Interest Rate:	10.00%		~ Check the boxes below for year(s) affected by the propo												
Convert 120 acre center pivot to drip-drag system	Most Likely VALUE	Expected Low/High Value		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	
Added Returns																
Increased alfalfa production (1 T/A at $200/ton)	$ 24,000	$ - Low	All	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
		$ 30,000 High	None													
	$ -	$ - Low	All													
		$ - High	None													
	$ -	$ - Low	All													
		$ - High	None													
	$ -	$ - Low	All													
		$ - High	None													
Reduced Costs																
Reduced irrigation electricity costs	$ 6,000	$ 2,000 Low	All	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
		$ 6,000 High	None													
Grazing maintenance costs	$ 1,200	$ 1,000 Low	All	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
		$ 1,500 High	None													
		Low	All													
		High	None													
	$ -	$ - Low	All													
		$ - High	None													
Added Costs																
Drip line installation	$ 36,000	$ 24,000 Low	All	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
		$ 48,000 High	None													
Drip line maintenance	$ 7,500	$ 3,000 Low	All	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
		$ 9,000 High	None													
Additional alfalfa cutting (3rd) harvest costs	$ 6,000	$ 4,200 Low	All	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
		$ 7,500 High	None													
	$ -	$ - Low	All													
		$ - High	None													
Reduced Returns																
Fall grazing	$ 3,000	$ 2,500 Low	All	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
		$ 4,000 High	None													
		$ - Low	All													

The Smiths currently pump 750 gallon per minute (gpm). Other producers in the region utilizing Mobile Drip systems report that they have experienced water savings of 250 gpm, while producing crops with better yields by extending the length of the irrigation season. Ideally, this would allow the Smith's to harvest a 3rd cutting, as currently they are limited to only 2 cuttings by the water allotment limit. Previously, they had been able to harvest two cuttings and leased what would have been the third cutting for grazing to a neighbor.

Steve and Teri assume a yield increase of 1 ton per acre by adding a 3rd cutting, providing $24,000 (at $200/ton) in additional revenue. For reduced costs, the Smiths hope to achieve an irrigation pumping and pivot electric bill cost savings of $50/acre; their current average electric bill is $150/acre. This savings estimate is based on reduced horsepower required and fewer trips with the pivot. In addition, the Smiths have had minor maintenance costs associated with grazing of $10/acre or $1,200 per year. The drip tape and installation is expected to cost $300 per acre or $36,000 in total, with a yearly maintenance cost of $7,500 per year. The extra cutting of alfalfa is expected to cost $50/acre or $6,000 in total to harvest.

Taking a Long Term View

Standard partial budgeting can be useful when evaluating a change in infrastructure, like the one outlined in this example. However, it can be quite challenging to describe all of the planned changes on an annual basis, as the approach does not take into account the long-term effects. It is extremely important for producers to think long term when making major and potentially costly changes in infrastructure, and not simply look at only the short-term payoffs.

Using standard approaches such as assigning a conservative rate of return or opportunity cost in an attempt to capture the time value of money may not accurately reflect the potential risk over a longer timeframe.

The Multi-Temporal Risk Analyzer tool (MTRA) from RightRisk.org is a partial budgeting tool designed to give producers a long-term view of the uncertainty associated with potential changes being considered. The tool allows users to enter the positive effects (increased returns and decreased costs) and negative effects (decreased returns and increased costs) over a time span of up to 20 years. This allows the user to incorporate the long-term expectations tied to the proposed changes.

Table 2. Smith Example Mobile Drip System Upgrade MTRA Tabular Results, Cash- and Net Present Value-basis Analysis

Interest Rate: 0.00%

CASH-basis analysis

YEAR	*Projected* Total Added Returns	*Projected* Total Reduced Costs	*Projected* Total Added Costs	*Projected* Total Reduced Returns	*Projected* NET ANNUAL Return
1	22,499	6,683	51,685	3,492	-25,995
2	20,351	6,159	10,629	3,045	12,835
3	19,505	7,006	14,012	3,549	8,950
4	20,250	6,920	14,791	3,294	9,085
5	16,679	7,045	14,572	3,171	5,981
6	18,750	7,108	13,502	3,329	9,028
7	28,238	6,849	13,283	3,217	18,587
8	26,591	5,204	14,359	3,809	13,626
9	27,392	7,235	13,703	2,880	18,044
10	27,224	7,146	13,303	2,937	18,130
11	-	-	-	-	0
12	-	-	-	-	0
13	-	-	-	-	0
14	-	-	-	-	0
15	-	-	-	-	0
16	-	-	-	-	0
17	-	-	-	-	0
18	-	-	-	-	0
19	-	-	-	-	0
20	-	-	-	-	0

Net Return:	**88,270**
MIN Rtn:	-25995
AVG. Rtn:	4413
MAX Rtn:	18587

Interest Rate: 10.00%

PRESENT VALUE-basis analysis

YEAR	*Projected* PV-Total Added Returns	*Projected* PV-Total Reduced Costs	*Projected* PV-Total Added Costs	*Projected* PV-Total Reduced Returns	*Projected* PV-NET ANNUAL Return
1	22,499	6,683	51,685	3,492	-25,995
2	18,501	5,599	9,663	2,768	11,668
3	16,120	5,790	11,580	2,933	7,397
4	15,214	5,199	11,112	2,475	6,825
5	11,392	4,812	9,953	2,166	4,085
6	11,642	4,414	8,384	2,067	5,606
7	15,940	3,866	7,498	1,816	10,492
8	13,645	2,671	7,368	1,955	6,993
9	12,779	3,375	6,393	1,343	8,418
10	11,545	3,031	5,642	1,246	7,689
11	-	-	-	-	0
12	-	-	-	-	0
13	-	-	-	-	0
14	-	-	-	-	0
15	-	-	-	-	0
16	-	-	-	-	0
17	-	-	-	-	0
18	-	-	-	-	0
19	-	-	-	-	0
20	-	-	-	-	0

Net Return:	**43,176**
MIN Rtn:	-25995
AVG. Rtn:	2159
MAX Rtn:	11668

MTRA also allows the user to incorporate risk for any one of these potential inflows or outflows by entering estimated maximum, minimum, and most likely values for each. Using a range of potential values can help account for the inherent uncertainty involved over a longer time horizon. A unique feature of this tool is the ability to turn on or off each of these inflow/outflow items over the period of interest. MTRA is capable of generating several tabular and graphical outputs, allowing users to evaluate the risk probabilities as well as implications of alternative interest rates on computed results.

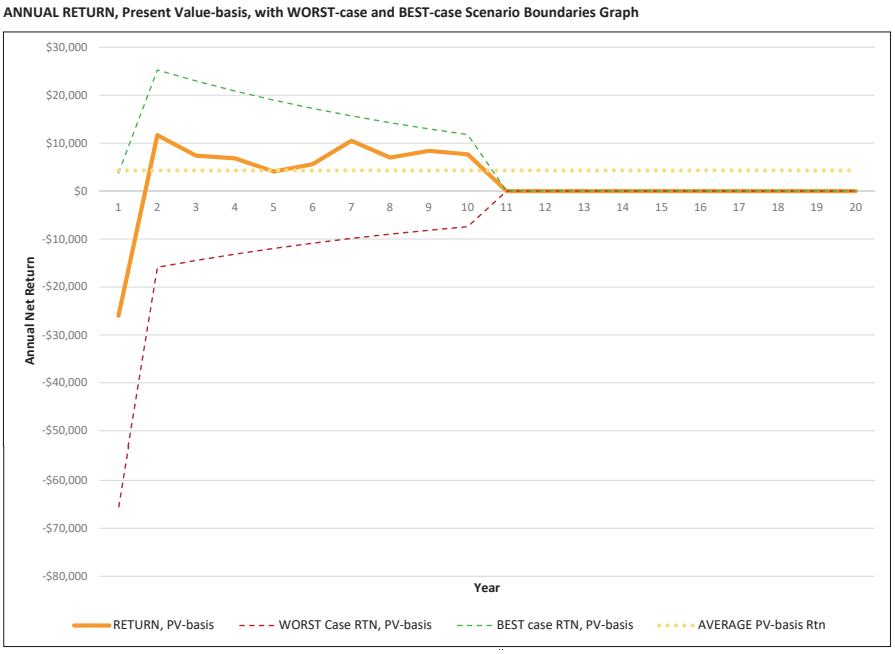
MTRA Data Input

MTRA takes input using a partial budget framework: dividing revenues and expenses into four broad categories. The Smith's added returns include a gain of 1 T/A resulting from installation of the drip system. At $200/ton this would equate to a total value of $24,000 per acre, entered as the most likely value. In addition, we assume a potential high of $30,000 (1.5 T/A at $200/ton) and low of zero (if no yield gain is achieved). Under reduced costs, the Smiths hope to achieve an irrigation pumping and pivot electric bill cost savings of $50/acre (their current average totals $150/acre). We enter this $6,000 total as the most likely value, with a high of $6,000 (they don't believe they will save much more than that) and a low of $2,000. Finally, the Smiths previously expected minor maintenance costs associated with grazing of $10/acre, or $1,200 total, that should also be entered as a reduced cost. These costs varied from $1,000 to $1,500 per year.

Under added costs, we enter the drip line installation charges for year one. The Smiths assume a cost of around $300/acre for the drip line and installation or $36,000 in total. They also estimate that the cost could be as high as $48,000 or as low as $24,000, based on soil type and other factors requiring more or less tape. Other added costs include yearly maintenance of the drip lines at $7,500 per year ($3,000 low and $9,000 high) and for harvesting a 3rd cutting of hay, totaling $6,000 per year, with a projected low of $4,200 and a high of $7,500. The only reduced return included is the elimination of fall grazing for a total of $3,000 and a range from $2,500 to $4,000.

We enter an interest rate of 10 percent accounting for expected borrowing and opportunity cost of capital. We also assume a 10-year timeframe, the useful life of the Mobile Drip system. The MTRA input page is shown in Table 1.

Figure 1. Smith Example Mobile Drip System Estimated Annual Returns, Present Value-basis, with Worst- and Best-case Boundaries



MTRA Results and Analysis

Clicking RUN initiates thousands of random draws representing possible outcomes of the Mobile Drip system upgrade over the course of the 10 years. The results are provided under the output tab, including both cash and present value tables. The tool also provides results via probability graphs of projected net returns for the proposed Mobile Drip upgrade. Tabular results for a single draw (one set of possible outcomes) are reported on the output tab, Table 2.

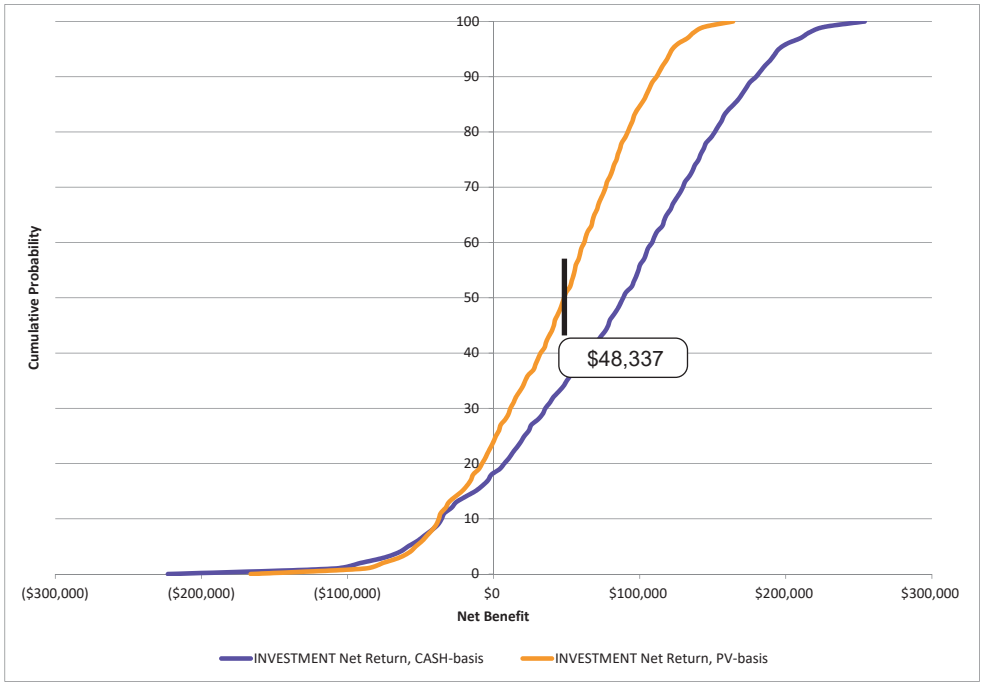
Single draw results suggest that the Smiths could expect the switch to Mobile Drip irrigation to result in a total net return of $43,176 on a net present value basis, with a minimum expected return of ($25,995) and a maximum of $11,668. Note that year one results in a significant net present value loss due to the high up-front cost of the drip system. These results are also depicted graphically in Figure 1, as a stream of annual returns on a net present value basis. It is important to remember that these results are just one set of possible results; by clicking RUN again the tables and graphs are updated to show another set of possible net returns.

MTRA Risk Analytics

One of the useful features of the MTRA tool is the probability analysis it provides. The tool summarizes probabilities for various outcomes, on a cash and net present value basis via eight different charts. Clicking the button to view Investment Net Return for Cash- and PV-basis results provides the cumulative probabilities for the Smith's potential switch to Mobile Drip irrigation, Figure 2. This graph summarizes the thousand random draws from simulation results. The probability estimates on a cash basis (blue line) are somewhat illustrative (they assume a zero interest rate), the crucial curve is depicted in gold as the probabilities and estimated net returns on a NPV basis. From this curve, we can see that Steve and Teri should expect a 50 percent probability of a net return of $48,337 total over the ten years, or $4,834 per year on average. The range of possible outcomes spans from a maximum of $163,901 (100 percent chance of not exceeding) and a minimum of ($166,214) with a zero percent chance of a lower return.

The Smiths now have a much clearer picture of what the long-term implications of making this change to Mobile Drip irrigation might be. While they most likely will not see a large total net return from the switch, it offers at least a 75 percent chance of providing a positive return. In other words, they could expect the change to meet their goal of improved long-term profitability through water savings, while adding another cutting of alfalfa over the initial ten years.

Figure 2. Smith Example Mobile Drip System Investment Net Return: Cash- and Net Present Value-basis Cumulative Probability Distribution Graph



In order for cumulative net returns to be higher over this time horizon, one of several factors would need to improve. The system would need to last longer than ten years, maintenance costs would need to be consistently lower, and/or the initial cost would need to be lower. Conversely, if hay prices were to significantly decrease over the lifespan of the system, to $100-150 per ton for example, the system would most likely become infeasible.

** The Steve and Teri Smith operation is a case study example created to demonstrate RightRisk tools and their applications. No identification with actual persons living or deceased, places, or agricultural operation is intended nor should be inferred.*