Cost Analysis for the Adoption of Water Truck and Solid-Set Sprinkler Systems for Feedlot Dust Control

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Selected Paper prepared for presentation at the Southern Agricultural Economics Association (SAEA) Annual Meeting, Orlando, Florida, 3-5 February 2013

Cost Analysis for the Adoption of Solid-Set and Water Truck Sprinkler Systems for Feedlot Dust Control

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Feedlot dust control is an important issue in the Texas High Plains. Water application, with either a solid-set or a water truck sprinkler system, is the most common method of dust control. An analysis conducted suggests the economically optimal system depends on length of ownership, inflation, and cost-share availability.

Key Words: air quality, cost analysis, dust control, feedlot, sprinkler, water application

JEL Classifications: Q10, Q16, Q52

Dust emission from feedlots is an important environmental issue in the Texas High Plains. This area accounts for approximately 85% of all fed beef produced in Texas (Almas et al., 2004) and has some of the largest feedlots in the state. Sweeten et al. (2012) reported that approximately 42% of the national fed beef cattle production, representing 7.2 million head/year, is produced within a 200-mile radius of Amarillo. Such a vast amount of beef generates large quantities of manure (more than 5 million tons/year). At a high level of moisture content, manure exhales odors. Dried manure, especially prevalent in summer months, is blown away as dust by the wind. The consequences can be analyzed from the social, economic, and public health perspectives. Socially speaking, the neighboring residents are often bothered by dusty air and odors emitted by feedlots. From the public health perspective, cattle as wells as humans may experience some respiratory irritations and other related diseases. Economically, the resulting animal mortality may erode profitability; the economic value of properties around feedlots may also be adversely affected.

Corral-surface sprinkling is one of the most recommended dust control options for feedlots with adequate water supplies. It consists of watering the manure to keep its moisture level within an optimum range. Lorimor (2003) estimated that optimum range to be between 25% and 40% during the critical times of the day. The reason is because at approximately 40% moisture and above, manure gets smelly and lures flies while at 25% and below, dust emission gets high. Previous studies from the Texas A&M AgriLife Research and Extension Center evaluated three types of sprinkler systems: solid-set (Guerrero et al., 2012), water truck (Amosson et al, 2008), and traveling-gun (Amosson et al., 2007) to help feedlot operators budget for related gross investment and operational costs. A recent survey indicated that only about 5% of feedlots utilize the traveling-gun sprinkler system due to its complexity and labor intensity (Amosson, 2007). Moreover, cost-share rates and inflation, which were not previously evaluated, can affect the feedlot manager's decision on system adoption. Thus, the overall objective of this study was to compare the costs of adopting either a solid-set or a water truck sprinkler system over time under alternative inflation and cost-share scenarios.

Data and Methods

It was necessary to estimate the total costs of owning and operating each type of system over time in order to make comparisons. First, the cost data including gross investment and operational costs from previously conducted studies on solid-set (Guerrero et al., 2006) and water truck sprinkler systems (Amosson et al, 2008) for a 30,000 head capacity feedlot were adjusted for inflation to 2012 dollars using the Producer Price Index (Bureau of Labor Statistics, 2012). Then, the cost stream over the 25 year life of each system was determined using the net investment in conjunction with annually accruing operational costs.

Net investment *(NI)* was computed as gross investment *(GI)* less the discounted salvage value *(DSV)* and the discounted net tax benefits *(DNTB)*.

(1) $NI = GI - DSV - DNTB$

The salvage value *(SV)* of each system was estimated to be 10% of the gross investment. A discount rate *(d)* of 4% was used to obtain present value in 2012 dollars.

(2) $DSV = GI \times .1 \times (1 + d)^{-L}$

where L is the useful lifetime of the system. *DNTB* were determined by subtracting the tax on the discounted salvage value *(TDSV)* from the discounted tax benefits *(DTB)*.

(3) $DNTB = DTB - TDSV$

Discounted tax benefits *(DTB)* were calculated using a tax life of five years and a marginal tax rate *(r)* of 15%.

(4) $DTB = \sum_{t=1}^{5} \frac{GI \times r}{5} \times (1 + d)^{-t}$

(5) $TDSV = DSV \times r$

Total costs for year zero were represented by the net investment alone. To estimate the total costs for each subsequent year (year 1, year 2, year 3, year 4, …, year 25), the operational costs for the current year T were added to the total costs for the previous year. Total costs for each year were calculated as follows:

(6) $TC_T = NI + \sum_{t=0}^{T} OC_t \times (1 + d)^{-t}$

where T=0 ,…, L.

A sensitivity analysis was conducted to assess the potential effects of inflation and cost-share on the cost stream of each system. A baseline, in which no inflation and cost-share were assumed, and four alternative scenarios were analyzed. The influence of inflation was measured in Scenarios 1 and 2 by applying a three percent and six percent rate, respectively. The impact of governmental assistance on the investment of a solid-set sprinkler system was measured by assuming a cost-share of 25% in Scenario 3 and 50% in Scenario 4. Currently, cost-share programs only apply to solid-set sprinkler systems and do not cover operational costs.

Results

Guerrero et al. (2006) and Amosson et al. (2008) reported that a solid-set sprinkler system had twice the gross investment of a water truck. However, the water truck had four times the annual operational costs of the solid-set. The investment costs by system were adjusted for inflation and are presented in 2012 dollars in Table 1. The updated costs indicate the same relationship in investment and operational costs between the two systems. The gross investment for a water truck was $355,985 while the solid-set sprinkler was $785,260. The comparison in investment costs remains the same regarding net investment for a water truck and solid-set sprinkler system at $297,091 and $655,347, respectively. Net investment takes into consideration the salvage value at the end of the useful life and the net tax benefits of owning the system. The annual operational costs were four times higher for the water truck ($59,943) than the solid set sprinkler system ($14,699).

Table 1. Estimated gross investment, net investment, and operational costs for water truck and solid-set sprinkler systems, 2012

	Water Truck	Solid-Set
Gross Investment	$355,985	$785,260
Net Investment[1]	$297,091	$655,347
Annual Operational Costs	$59,943	$14,699

[1]Assumes a marginal tax rate of 15%, discount rate of 4%, and salvage value of 10%.

This information alone is not sufficient to determine which sprinkler system is the economically optimal investment choice. Thus, a baseline comparison of annually accruing total costs over the useful lifetime (25 years) was conducted in this study to provide more insight. In addition, two major factors including inflation and cost-share availability were analyzed to determine which sprinkler system is more economically optimal under alternative conditions and therefore, likely to be recommended to feedlot operators for dust control. The scenarios analyzed were useful in estimating the required length of ownership, where the total costs of the two systems breakeven. Detailed operational costs and total costs by scenario, system, and year are presented in the Appendix, Tables A1 and A2.

Baseline

The goal of the baseline scenario was to compare total costs between the two sprinkler systems regardless of inflation and cost-share availability over time. In the baseline scenario, the total costs of the two systems breakeven between years nine and 10 (Figure 1). After that point, the total costs of the water truck surpass the solid-set and remain more expensive for the remainder of useful lifetime. An alternative baseline scenario utilizing a marginal tax rate of 28 percent is presented in the Appendix, Figure A1.

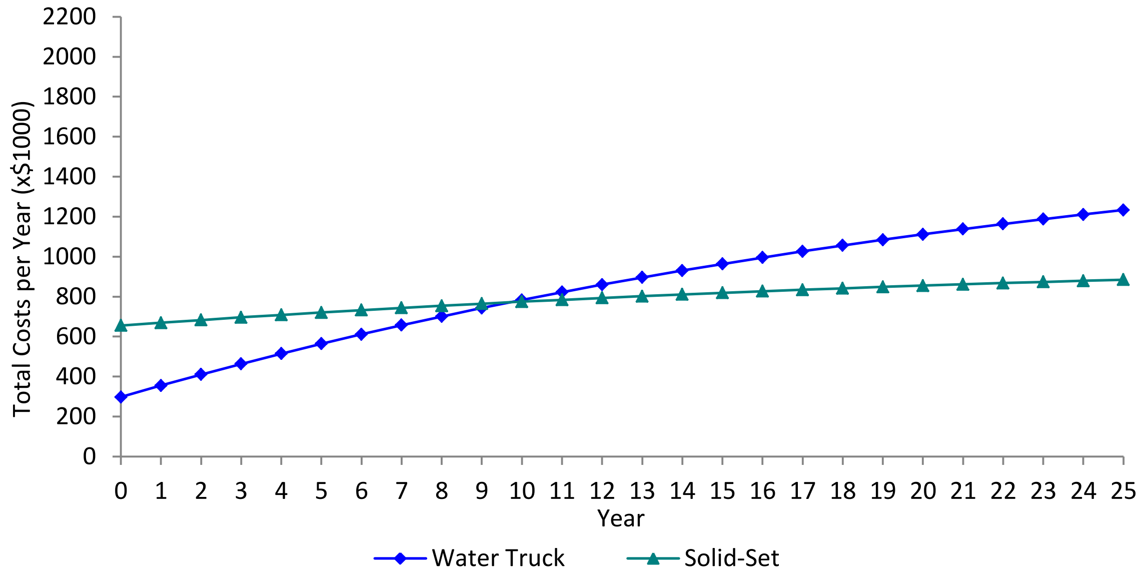

Figure 1. Total costs of water truck and solid-set sprinkler systems, baseline scenario

Scenario 1: 3% Inflation

The addition of 3% annual inflation results in the breakeven point being reached between years eight and nine (Figure 2). This indicates that under this scenario it is better to choose a solid-set system when ownership is going to be at least nine years and a water truck otherwise. Compared to the baseline scenario, the required ownership period of a solid-set system decreases approximately one year.

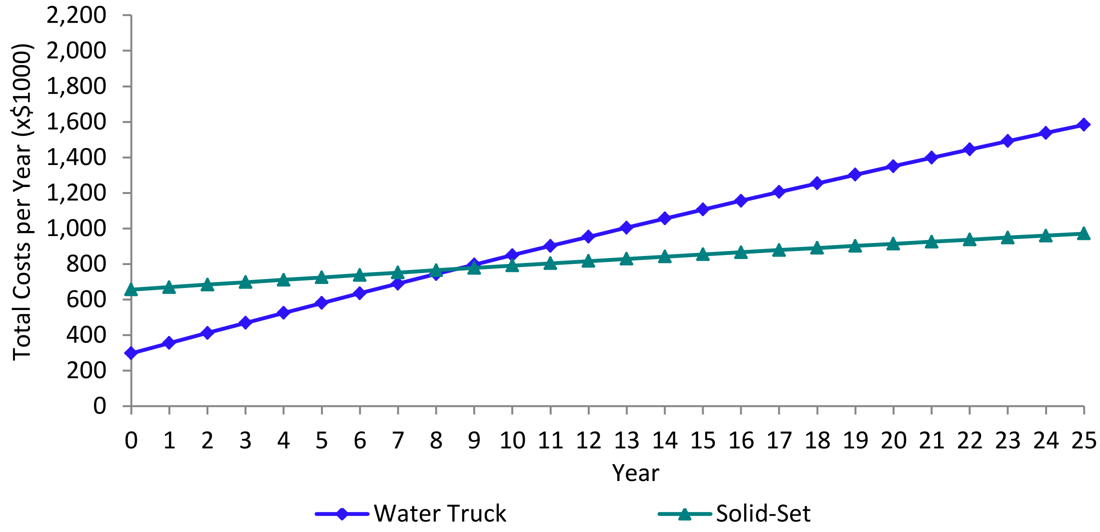

Figure 2. Total costs of water truck and solid-set sprinkler systems with 3% inflation, Scenario 1

Scenario 2: 6% Inflation

The application of 6% inflation increased operational costs significantly and consequently, made total costs even higher. In this scenario, the breakeven point occurs between years seven and eight (Figure 3). This indicates that inflation increases the economic feasibility of owning and operating a solid-set system over the water truck. Required ownership of the solid-set system decreases approximately two years relative to the baseline scenario.

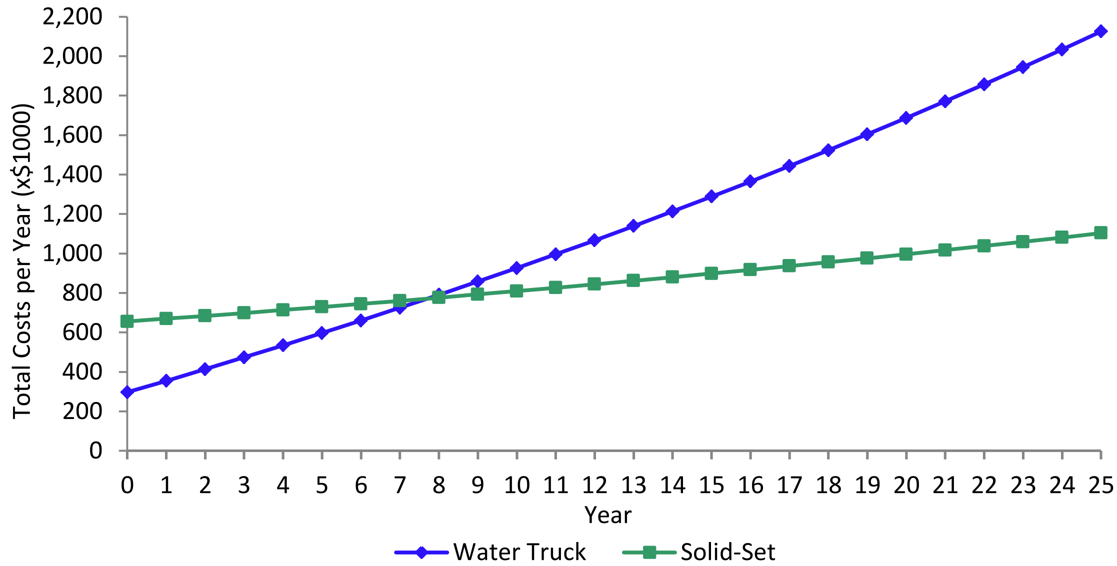

Figure 3. Total costs of water truck and solid-set sprinkler systems with 6% inflation, Scenario 2

Scenario 3: 25% Cost-Share

A cost-share rate of 25 percent was applied to the solid-set sprinkler system in Scenario 3. This results in the breakeven point occurring between years four and five (Figure 4). Thus, the required ownership period of the solid-set system is reduced by five years relative to the baseline scenario. In addition, the difference in net investment between the two systems drops from $358,000 to $194,000 under this scenario.

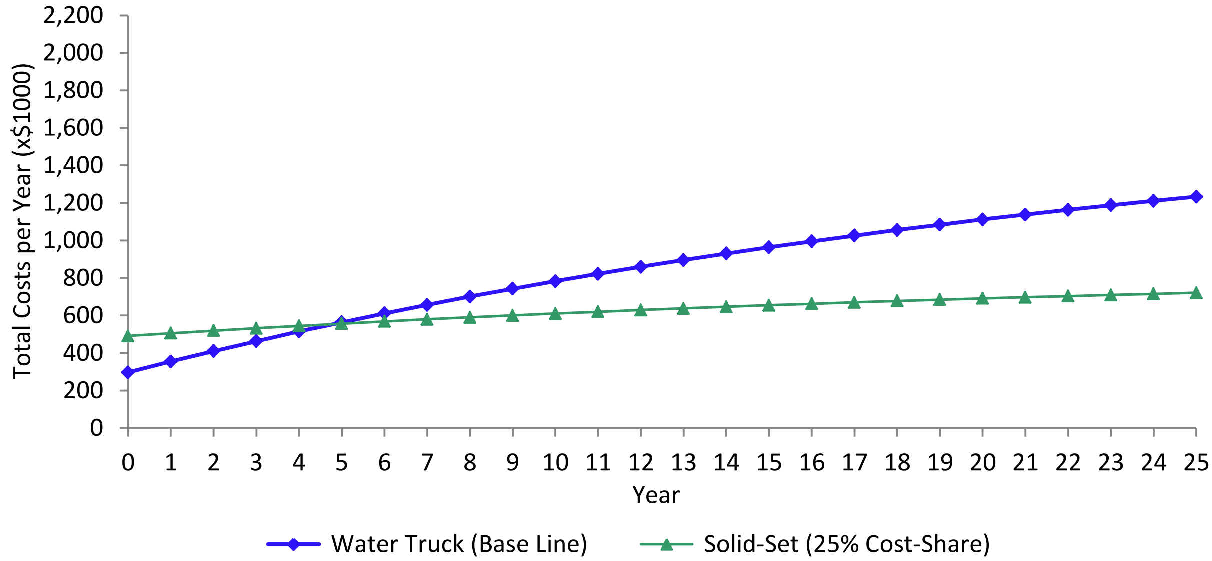

Figure 4. Total costs of water truck and solid-set sprinkler systems with 25% cost-share, Scenario 3

Scenario 4: 50% Cost-Share

A cost-share rate of 50 percent was applied to the solid-set sprinkler system in Scenario 4. In this scenario, the breakeven point occurs within the first year (Figure 5). Thus, the required ownership period of the solid-set system is decreased by nine years relative to the baseline scenario. In addition, the difference in net investment between the two systems drops from $358,000 to $31,000 under this scenario.

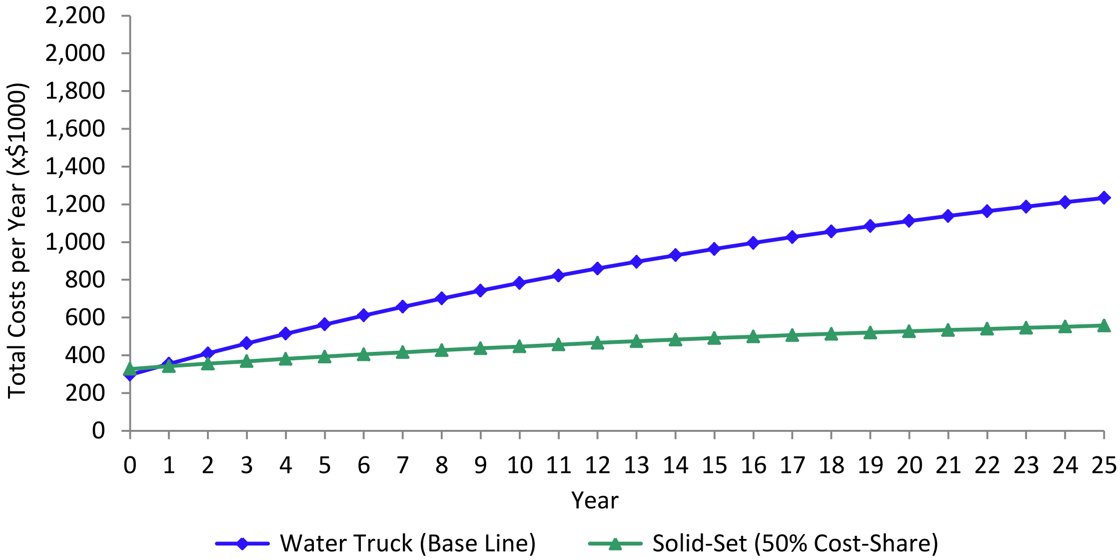

Figure 4. Total costs of water truck and solid-set sprinkler systems with 50% cost-share, Scenario 4

Summary

Results indicate that under the baseline scenario, it will take between nine and 10 years for the total costs of the solid-set sprinkler system to breakeven with the costs of the water truck (Table 2). Thus, it is economically beneficial for feedlot managers to invest in the system if ownership is expected to extend longer than 10 years.

Inflation impacted the total costs of each sprinkler system in terms of reduction of the required ownership time with nine years under 3% inflation and eight years under 6% inflation (Table 2). This is due to the magnitude of the effects of inflation on the operational costs, especially for the water truck. Since inflation affects operational costs but not net investment, the total costs of water truck accrued faster over time and overtook those on solid-set in a shorter time than in the baseline scenario.

In Scenarios 3 and 4 it was assumed that government assistance would cover 25% and 50% of the gross investment on the solid-set sprinkler system, respectively. The cost-share rates did not apply to the water truck or any operational costs. Thus, the cost stream for the solid-set sprinkler system under alternative cost-share scenarios was compared with the baseline graph for the water truck. The major effect of cost-share was that it considerably reduced the gap in net investment between the water truck and the solid-set sprinkler system as well as the time to a breakeven point in total costs. In the baseline scenario, the gap was approximately $358,000. With 25% and 50% cost-share on the solid-set sprinkler system, it dropped to $194,000, and then to $31,000, respectively. Consequently, the total costs for the solid-set sprinkler decreased substantially relative to the baseline scenario while they remained unchanged for the water truck. The required ownership period for the solid-set sprinkler system decreased to 5 years at 25% cost-share and less than a year at 50% cost-share (Table 2).

Table 2. Breakeven years for the total costs of water truck and solid-set sprinkler systems

	Assumptions	Breakeven Year
Baseline	No inflation, no cost-share	Year 9 - Year 10
Scenario 1	3% inflation, no cost-share	Year 8 - Year 9
Scenario 2	6% inflation, no cost-share	Year 7 - Year 8
Scenario 3	No inflation, 25% cost-share	Year 4 - Year 5
Scenario 4	No inflation, 50% cost-share	Year 1

Conclusion

The goal of this study was to compare the costs of adopting either a solid-set or water truck sprinkler system over time under a baseline and alternative inflation and cost-share scenarios. It was determined that the solid-set sprinkler system had twice the net investment of the water truck system; however, the water truck had four times the annual operational costs. Under the baseline, the total costs of the two systems are approximately equal by year 10 of the analysis. Then, the water truck surpasses the solid-set and remains more expensive for the remainder of useful lifetime (25 years). Incorporating scenarios that analyzed potential impacts of inflation and/or cost-share decreased the years necessary to break even by one to nine years, depending on the scenario. The sensitivity analyses conducted through these four alternative scenarios determined that even though the solid-set sprinkler system demands a higher net investment, over time it appears to be more cost-efficient than the water truck. Consequently, feedlots that are planning to use dust control methods in their operation should consider investing in the solid-set sprinkler system as it appears to be the most cost efficient if their ownership is going to last longer than 10 years. If cost-share is available or inflation is anticipated, then the required ownership period decreases substantially. Overall, the economically optimal system depends on length of ownership, inflation, and cost-share availability.

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Appendix

Table A1. Discounted operating costs of water truck and solid-set sprinkler systems ($)

Year	Baseline		3% Inflation		6% Inflation	
	Water Truck	Solid-Set	Water Truck	Solid-Set	Water Truck	Solid-Set
1	57,638	14,134	57,638	14,134	57,638	14,134
2	55,421	13,590	57,084	13,998	58,746	14,405
3	53,290	13,067	56,535	13,863	59,876	14,682
4	51,240	12,565	55,991	13,730	61,028	14,965
5	49,269	12,081	55,453	13,598	62,201	15,253
6	47,374	11,617	54,920	13,467	63,397	15,546
7	45,552	11,170	54,392	13,338	64,617	15,845
8	43,800	10,740	53,869	13,209	65,859	16,150
9	42,115	10,327	53,351	13,082	67,126	16,460
10	40,496	9,930	52,838	12,957	68,417	16,777
11	38,938	9,548	52,330	12,832	69,732	17,099
12	37,441	9,181	51,826	12,709	71,073	17,428
13	36,000	8,828	51,328	12,586	72,440	17,763
14	34,616	8,488	50,835	12,465	73,833	18,105
15	33,284	8,162	50,346	12,345	75,253	18,453
16	32,004	7,848	49,862	12,227	76,700	18,808
17	30,773	7,546	49,382	12,109	78,175	19,170
18	29,590	7,256	48,907	11,993	79,679	19,538
19	28,452	6,977	48,437	11,877	81,211	19,914
20	27,357	6,708	47,971	11,763	82,773	20,297
21	26,305	6,450	47,510	11,650	84,364	20,687
22	25,293	6,202	47,053	11,538	85,987	21,085
23	24,321	5,964	46,601	11,427	87,640	21,491
24	23,385	5,734	46,153	11,317	89,326	21,904
25	22,486	5,514	45,709	11,208	91,044	22,325

Table A2. Total costs of owning and operating a water truck and solid-set sprinkler system by scenario ($)

Year	Baseline		3% Inflation		6% Inflation		25% Cost-Share	50% Cost-Share
	Water Truck	Solid-Set	Water Truck	Solid-Set	Water Truck	Solid-Set	Solid-Set	Solid-Set
0	297,091	655,347	297,091	655,347	297,09	327,673	491,510	327,673
1	354,729	669,480	354,729	669,480	354,72	341,807	505,644	341,807
2	410,150	683,070	411,813	683,478	413,47	341,263	519,234	355,397
3	463,440	696,138	468,348	697,341	473,35	340,741	532,301	368,464
4	514,680	708,702	524,339	711,071	534,37	340,238	544,866	381,029
5	563,949	720,784	579,792	724,669	596,58	339,755	556,947	393,110
6	611,323	732,401	634,711	738,136	659,97	339,290	568,564	404,727
7	656,875	743,571	689,103	751,473	724,59	338,843	579,734	415,897
8	700,675	754,311	742,972	764,683	790,45	338,414	590,474	426,638
9	742,791	764,638	796,322	777,765	857,57	338,001	600,802	436,965
10	783,286	774,568	849,160	790,722	925,99	337,603	610,732	446,895
11	822,224	784,117	901,489	803,553	995,72	337,222	620,280	456,443
12	859,665	793,297	953,316	816,262	1,066,8	336,854	629,461	465,624
13	895,665	802,125	1,004,64	828,848	1,139,2	336,501	638,289	474,452
14	930,281	810,614	1,055,47	841,314	1,213,0	336,162	646,777	482,940
15	963,566	818,775	1,105,82	853,659	1,288,3	335,835	654,939	491,102
16	995,570	826,623	1,155,68	865,886	1,365,0	335,521	662,787	498,950
17	1,026,34	834,169	1,205,06	877,995	1,443,2	335,219	670,333	506,496
18	1,055,93	841,425	1,253,97	889,988	1,522,8	334,929	677,588	513,752
19	1,084,38	848,402	1,302,41	901,865	1,604,0	334,650	684,565	520,729
20	1,111,74	855,110	1,350,38	913,629	1,686,8	334,382	691,274	527,437
21	1,138,04	861,561	1,397,89	925,279	1,771,2	334,124	697,724	533,887
22	1,163,34	867,763	1,444,94	936,817	1,857,2	333,876	703,926	540,090
23	1,187,66	873,727	1,491,54	948,244	1,944,8	333,637	709,890	546,053
24	1,211,04	879,461	1,537,70	959,561	2,034,1	333,408	715,624	551,788
25	1,233,53	884,975	1,583,41	970,770	2,125,2	333,187	721,138	557,302

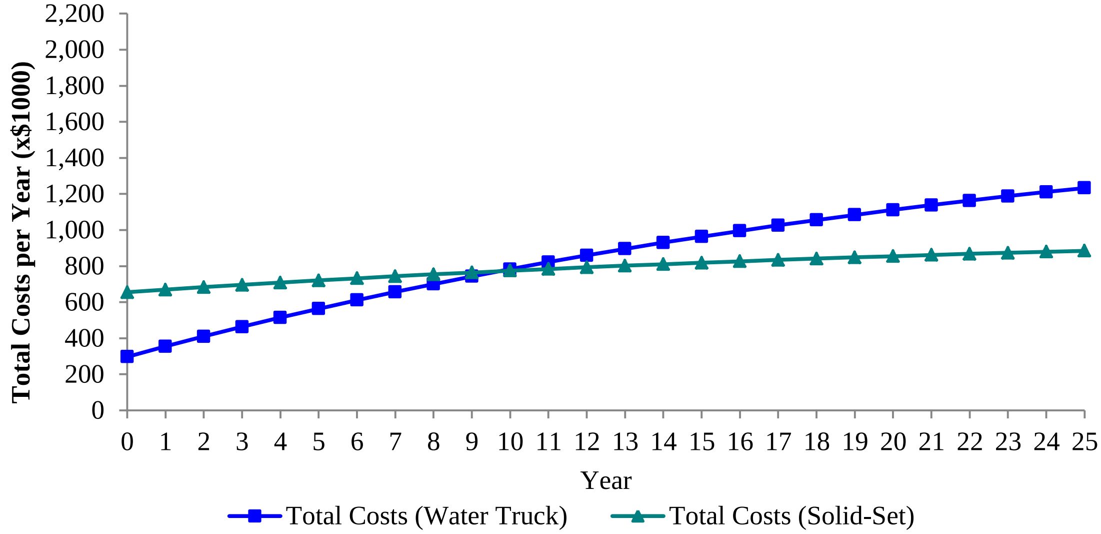

Figure A1. Total costs of water truck and solid-set sprinkler systems, alternative baseline scenario utilizing a 28% marginal tax rate