Low Energy Precision Application (LEPA) and Low Elevation Spray Application (LESA) Trials in the Pacific Northwest

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Abstract

LEPA and LESA are alterations on a center pivot where the sprinklers are moved much closer to the ground, the spacing between sprinklers is reduced (more sprinklers), and water is emitted at very low pressures. It saves water (18%), it saves energy (less water pumped and pumped at a lower pressure), and it helps growers get better yields especially in areas where water is limiting. However, it has an increased propensity for runoff, and the sprinklers operating below the top of the canopy can require some management changes. In many cases energy savings alone can pay for the increased costs of the additional sprinklers and drop hose. However, the largest profit potential lies in the ability to get improved yields in areas that are water short or have large water losses to wind drift and evaporation.

Background

Fresh water is limited and it will become a much more limiting resource in the future. This increased shortage will be driven by the municipal and industrial water needs for a growing population, the irrigation water requirements to grow food for these people, the irrigation water demands to grow biofuel crops, and the increased irrigation water requirement caused by a warmer environment due to climate change. Irrigation accounts for 80-90% of the consumptive use of water in the arid areas of the Pacific Northwest where water shortages are felt the keenest. Center pivots and linear-move irrigation systems account for well over half of the total irrigated acres in the Pacific Northwest, or 3.9 million irrigated acres (NASS Farm and Ranch Irrigation Survey, 2013). Because of this, even small changes in the efficiency of these systems will have a huge impact on total water conservation. Figures 1, 2, and 3 show the progression over time of sprinklers on center pivots from high-pressure impact sprinklers situated on the top of pivots to middle elevation sprinklers to low elevation spray application (LESA).

Figure 1. When center pivots were first introduced, they used high pressure impact sprinklers located on top of the pipe. These sprinklers needed 70-110 psi at the pivot point to operate properly, were spaced 20-30 ft apart, and the irrigation application efficiency was about 60% as measured by catch can tests without canopy. However, due to the large wetted radius, there is more time for the water to infiltrate into the soil as the pivot rolls past.

Figure 2. Currently most center pivots use mid elevation spray application (MESA). These sprinklers typically use 15-20 psi pressure regulators and thus need about 35-40 psi at the pivot point to operate properly. They are spaced about 10 ft apart, and the irrigation application efficiency is typically about 85% as measured with catch can tests without canopy. The smaller wetted radius does not allow as much time for the water to infiltrate into the soil as the pivot passes.

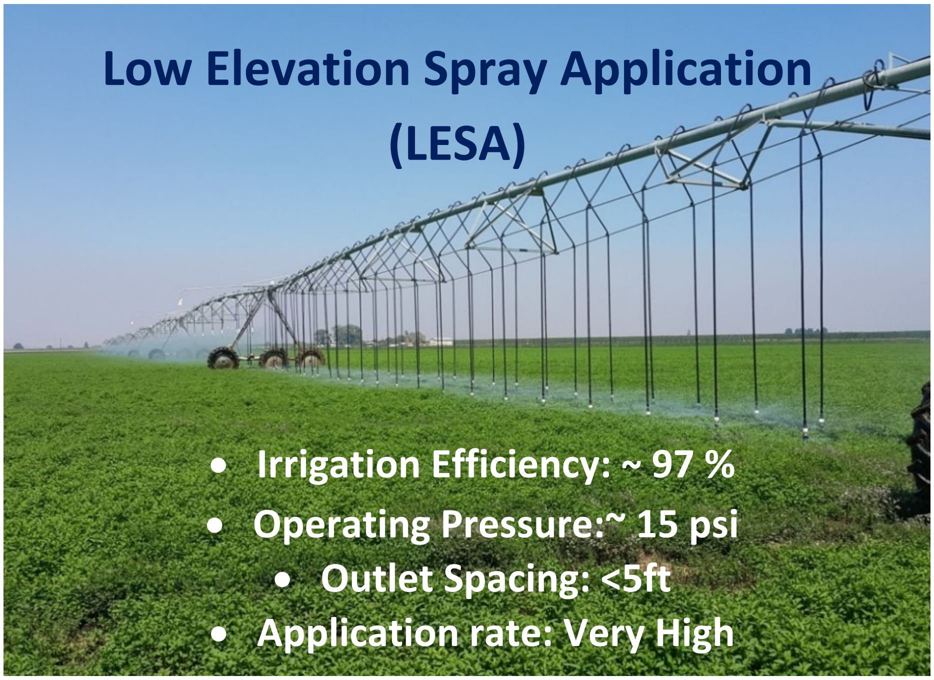

Figure 3. Low elevation spray application (LESA) and low energy precision application (LEPA) need much less pressure to operate properly and use 6-10 psi pressure regulators. The drops are spaced 5 ft or less apart, and the irrigation application efficiency is typically about 97% as measured by catch can tests without crop canopy. Because of the small wetted radius, ponding and runoff can be an issue on certain soils, slopes, and soil surface conditions.

What is LEPA? Low energy precision application (LEPA) is a modification to the typical sprinkler configuration on center pivots or linear-move machines that minimizes evaporation and wind drift losses by running the water directly onto the soil surface at very low pressure (Figures 4, 5 and 6). Because much less water is lost to wind drift and evaporation, and less of the soil surface is wetted there is less evaporation of water from the soil surface making it much more efficient (Lyle and Bordovsky, 1983). It operates at much lower pressures and consequently saves significant pumping energy. However, because water is applied to the soil in much less time, ponding and runoff can become a greater issue unless the field is tilled and the irrigation system is operated in such a way to limit this runoff. This may include using furrow diking and drag socks to limit the erosion of these dikes (Figure 4), using a dammer/diker to increase the soil surface water storage (Jones and Baumhardt, 2003), or speeding up the irrigation system to apply smaller application depths in each pass.

What is LESA? Low elevation spray application (LESA) is a similar modification to the typical sprinkler head configuration on center pivots or linear-move machines that places the water application very close to the soil surface, but uses a suspended sprinkler or spray head (Figures 3, 7, 8 and 9). It also reduces water losses to wind drift and evaporation and is uses less energy since it runs at much lower pressures. However, because the water is spread out in a limited way by the sprinkler head, it applies water more uniformly than LEPA and gives the water more time to infiltrate into the soil. Because of this, it has fewer problems with non-uniformity, crop germination, or with ponding and runoff than LEPA on fields without furrow dikes and therefore can be more flexible with a wide variety of crops, row orientations, and tillage systems.

Figure 4. LEPA on a row crop using drag socks to minimize erosion to the furrow dikes that limit water movement in the furrows.

Figure 5. LEPA on mint. This setup allows conversion back to MESA for better crop germination if desired.

Figure 6: LEPA on alfalfa in Oregon where triple sprinkler drop goosenecks are used to increase the number of sprinkler drops (decrease the drop spacing) without requiring additional outlets in the pivot pipe or truss-rod hose clamps to position the hose correctly.

Figure 7. LESA operating in wheat with the sprinkler heads below the top of the canopy.

Figure 8. LESA system using boombacks to spread the water out and increase infiltration on a wheat field near Milton Freewater, Oregon.

Figure 9. Traditional MESA sprinkler head arrangement (left), and a LESA sprinkler placement about 1 foot above the ground (right).

Testing and Trials in the Pacific Northwest

Starting in 2013, and continuing into the 2014, 2015, 2016 and 2017 growing seasons, adjacent spans of LESA and conventional MESA sprinkler mounting were tested on six center pivots in Idaho, four in Nevada, eleven in Washington, and six in Oregon. Many of these comparison trials have been operating for multiple years. Typically the last span of the pivot was converted to LESA or LEPA because this is where runoff problems would be the most pronounced. These sites were primarily located in fairly flat fields without significant runoff issues. The crops grown included timothy hay, alfalfa, alfalfa seed, grass seed, beans, peas, peppermint, spearmint, silage corn, grain corn, barley, potatoes, and wheat.

Soil moisture sensors were installed in both the LESA/LEPA sections of the pivot as well as the MESA sections of the pivot and the differences were monitored over time. The purpose was to monitor the difference of water movement in the different soil layers under these systems. The sensors could also detect which system has more water in the deeper soil layers – a sign of water saving by the irrigation system since it indicated more total water was getting into the soil.

In addition, a paired pivot study using two adjacent full pivots, one LESA and the other MESA was also conducted near Eureka, Nevada on alfalfa beginning in the summer of 2014. A third LESA / conventional comparison were performed on timothy hay. Irrigation scheduling was managed by the grower using their own traditional practices and experiences.

The LESA systems in these studies had the following characteristics:

- All equipment used is currently available "off the shelf" from most agricultural irrigation equipment retailers.
- Sprinkler heads were set to be about 12 inches above the soil surface when the pipe is full of water (Figure 10).
- Sprinkler drop spacing was about 4-5 feet apart. This was typically double the number of drops used for MESA. This is often done by replacing single gooseneck fittings on outlets spaced 9 feet apart with double goosenecks in each outlet, running the hose drops over the outside of the pivot truss rods, and using truss-rod hose clamps to position the sprinkler properly (Figures 11 and 12).
- Spray nozzles with grooved plates were used that apply water in an approximate 15-foot wetted diameter.
- 6 to 10 psi pressure regulators were used with the regulator located near the sprinkler head (Figure 13).

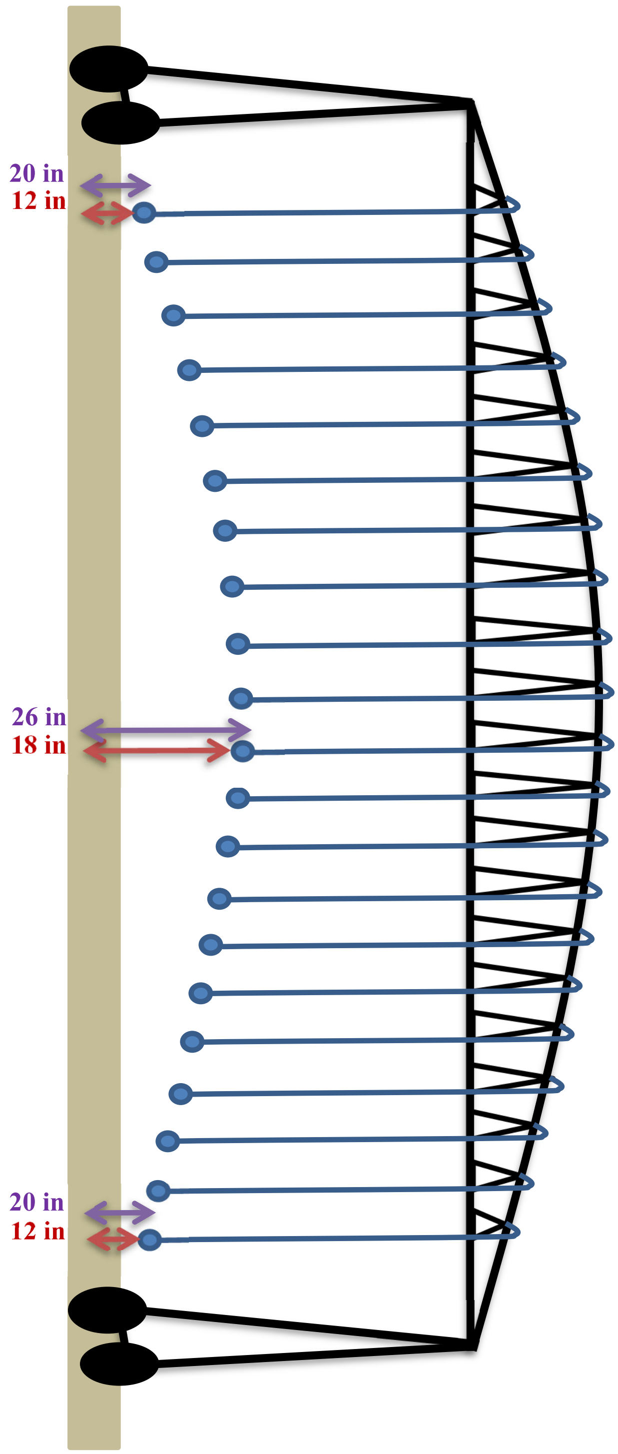

Figure 10. Schematic of one span of a center pivot without water in the pipe. 6 inches of deflection is planned for when the pipe is much heavier when it is full of water. In fields with varying topography some additional height may be added to the sprinklers in the middle of the span to prevent the sprinkler heads from dragging on the ground. The purple number is the height of hose from the ground and the red number is the height of sprinkler from the ground (assuming that the length of the adapter/pressure-regulator/sprinkler configuration is about 8 inches).

Figure 11. Double goosenecks and truss-rod hose clamps to position the sprinkler correctly are used to increase the number of sprinkler drops (decrease the drop spacing) without requiring additional outlets in the pivot pipe.

Figure 12. Double Goosenecks and truss-rod hose slings to position the hoses help spread the water out to offset shorter infiltration times.

Observations and Lessons Learned from the Trials

It is acknowledged that additional research needs to be done to replicate, validate, and quantify many of the observations noted below since there is a high degree of variability inherent in agriculture including soils, crops grown, weather conditions, possible sprinkler head configurations, and irrigation water management practices. However, sharing preliminary observations from these trials are deemed to be of benefit.

- Aside from removing old galvanized steel plugs in the top of some pivot pipes, conversion from MESA to LESA was simple and did not take very long.
- There were fewer runoff problems than anticipated.
- Almost all of the growers participating in this study expressed interest in expanding its use on their farms and many have already converted multiple pivots to LESA without prompting or cost share.
- The stationary grooved plate sprinklers used in LESA were inexpensive at less than $2 while the rotators or wobblers typically used in MESA retail for about $15-$20 each.
- When the pipe fills with water, the pivot pipe becomes heavy and deflects down slightly especially in the middle of the span between the towers due to the additional weight of the water. This can lower the sprinkler head height up to 6 inches and should be accounted for during installation when setting the LESA head height. The changing topography underneath each spans and wheel track depths should also be considered when setting the sprinkler heights if you wish to avoid sprinklers dragging on the ground. In some fields, it may be better to set the sprinklers in the center of the span higher than 12 inches based on the topography of the field (Figure 13).
- No observable damage was done to the crops by dragging the sprinkler heads through the crop (Figures 13).


Figure 13. In some instances, sprinkler heads bumped along the ground due to deepening wheel tracks or undulating topography. Although no damage was noted to either the crop or the sprinklers, it bothered the farmer so we increased the height of the sprinklers (shortened the hose) a few inches in the LESA section

- In the rare instances where the sprinkler heads bumped along the soil surface, it appeared to be a non-issue due to the closer sprinkler spacing (Figure 14). It did not do appreciable damage to the sprinkler or cause issues with the crop except in some cases where particular sprinkler bodies (Nelson D3030) were damaged when being drug through corn (Figure 15).
- LESA often showed better irrigation uniformity in corn than MESA. Corn can inhibit the sprinkler application pattern of MESA, while with LESA there is an additional sprinkler in that space (Figure 16).
- In one field of corn that was planted in straight rows, when the Nelson D3030 sprinkler body was used, then the body of the spray head, nozzles, and/or plates of LESA sprinklers were sometimes pulled off and had to be replaced (Figures 14, 15). Without the sprinklers, the hose whipped about causing physical damage to the corn. Because of this we don't recommend this sprinkler body type for LESA on corn.

Figure 14. LESA worked well in corn. The narrow spacing eliminates typical uniformity issues with MESA on a wider spacing due to the canopy disrupting the application pattern. Although the heads periodically were held up by the canopy, they made it through with few resultant uniformity issues. The growers did not plant in a circle and had no observable uniformity problems.

Figure 15: Examples of the sprinklers with the Nelson D3030 sprinkler bodies that drug through the corn. Possibly because of the sprinkler design, we found some losses of sprinkler spray plates,

nozzles, and even sprinkler bodies. This sprinkler body in corn was the only time we saw these kinds of issues.

- Later in the season, the top of the canopy stayed dry. This will likely result in greater differences in application efficiency than was measured using the catch can method on a bare soil surface (Figure 16).

Figure 16. Sprinklers operating within the canopy allow the wheat heads to stay dry. This may decrease lodging, and increase irrigation application efficiency due to less water lost to evaporation from wet canopy.

- LESA provided many benefits over LEPA including the ability to more uniformly irrigate the soil surface area, benefiting crop emergence and giving more flexibility for a wider variety of crops grown in rotation in the field, including a variety of crops, row spacing, and row orientations.
- A 4 to 5 foot nozzle spacing with LESA heads mounted at about 1 foot above the ground adequately distributed water on almost all of the crops tested.
- Crop production observations of a similar nozzle arrangement on an alfalfa field in northern Nevada in 2013 indicated no crop production uniformity advantage by reducing nozzle spacing from 5 feet to about 30 inches.
- The sprinkler spacing is close enough that sprinkler distribution uniformity issues have much less impact due to the soil's natural ability to move water laterally and the root's ability to grow towards water.
- Because of the increased application efficiency of LESA and less sprinkler distortion by the wind, there were fewer issues with dry field edges and fewer differences in applied water depths due to weather and climate changes including day/night, and windy vs. non-windy differences. This resulted in more consistent irrigation application efficiency and consequently an improved uniformity on a larger field scale (Figure 17).

- Some growers observed less lodging in their LESA fields (crop laying over which makes it difficult to harvest) due to the drier canopy. The dry canopy may also decrease disease pressure (Figure 18).
- There will likely be less loss of nitrogen to volatilization during fertigation due to the increased application efficiency.

Figure 17. The wind drift losses are fairly visible under the MESA section and practically non-existent in the LESA section where the spray heads are below the top of the wheat canopy. The majority of water losses from sprinklers is to evaporation though water vapor is not visible.

Figure 18. The sprinkler head can irrigate below the top of the canopy without problems. This may reduce disease problems and lodging. However, it may limit the ability to uniformly chemigate unless the nozzles are switched to chemigation nozzles that spray upwards.

- Sprinkler inspection and maintenance can be performed by walking among the sprinklers with just irrigation boots and without ladders (Figure 19).

Figure 19. Sprinkler maintenance is much easier and can be done while the system is running while simply wearing irrigation boots without getting overly wet.

- In some fields with restricted water, the differences in color of the hay in alfalfa were observable due to more water in the soil of the LESA section compared with MESA (Figures 20, 21).

Figure 20. Soil moisture sensors installed in an alfalfa field near Mud Lake Idaho. The foreground sensors are under MESA and the background sensors are under LESA. There are stark differences in crop health due to deficit irrigation on both showing the efficiency improvements under LESA.

Figure 21. Soil moisture sensors installed in an alfalfa field. The picture shows significant differences in crop health due to deficit irrigation on both showing the efficiency improvements under LESA.

- In a few instances, bands of under-irrigated seedlings were observed on newly seeded barley with LESA on sandy soils. These crops eventually "grew out of it" and the uniformity problems did not persist throughout the season as the root zones expanded. These problems are likely due to the very limited rooting zones of newly planted small grains, and the limited ability of sands to move water laterally. In instances such as these (sandy soils and small-seeded crops) it might be best to raise the sprinkler heads up a little higher off the ground and/or use a type of sprinkler or spray plate that increases the wetted radius and overlap of the LESA sprinklers.
- Some uniformity issues were also observed in deep furrowed crops such as potatoes when the row orientation was parallel or nearly parallel to the direction of the sprinkler movement through the field, when the sprinkler spacing was not evenly divisible by the row spacing, *and* when the crop canopy obstructed the sprinkler's water trajectory. For example, potatoes on 2.5 foot row spacing had uniformity issues with sprinklers on a 4-foot spacing when the sprinklers were in the canopy. Under this scenario, some rows got more water than others did. These issues were less of a problem when the rows were perpendicular to the sprinkler travel direction (sprinklers moved across the rows instead of with them) (Figure 22).

Figure 22. Irrigation uniformity issues (some rows get more water than others) related to row crops with a row spacing that is different from the sprinkler spacing when the sprinklers are below the top of the canopy *and* when the row direction is nearly parallel to the sprinkler movement direction. This is less of an issue when the sprinkler move direction is perpendicular to the rows. In this case the sprinklers should be raised slightly or spaced so that they are even multiples (1X or 2X) of the row spacing.

Potential Drawbacks

- Applying the same amount of water in less time due to the decreased wetted radius can increase ponding and runoff (Figure 23). If a grower is already experiencing problems with ponding and runoff due to tight (high clay content) soils or steep field slopes, then converting to LEPA or LESA is not recommended without using tillage practices that increase the soil surface water storage or improve infiltration.
- Slightly smaller nozzle sizes are used due to less water required per sprinkler drop. This can lead to an increased propensity for sprinkler nozzle plugging with dirty surface water sources. To compensate and prevent plugging, finer filter screens may be required. However, nozzle sizes are larger than many would expect due to the lower operating pressures. Many growers find that when pumping water from dirtier surface water sources that they get better results with a 10 psi pressure regulator instead of 6 psi (the additional pressure helps clear the debris through the nozzles).
- If the sprinkler spacing is decreased on the inside two spans of most pivots they would require impractically small nozzle sizes to avoid overwatering. It may be best for these one and a half to two spans to continue to operate on a larger spacing as MESA.
- LESA may cause issues with chemigation uniformity when the sprinklers are below the top of the canopy. Chemigation plates are available that spray water upwards (Figure 24),

but studies have not yet been done on how effective these are for pest and disease control when the sprinklers are below the tops of the canopy.

Figure 23. Due to its smaller wetted diameter, LESA allows less time for water to infiltrate into the soil. Therefore LEPA or LESA may not be suitable to tight soils or steep slopes where infiltration and runoff can be an issue.

Figure 24. Chemigation plates can be used to spray water upwards to improve canopy wetting for chemigation.

Measured Water Savings.

Catch can tests were performed using large cans (5-gallon buckets) to measure differences in irrigation application efficiency (water applied per unit time / water caught in the buckets) between

LESA and MESA. The cans were dug into the soil so that their openings were at or near the soil surface. No crop was planted during the tests. There were 24 cans in each section. This test was done on ten different dates and times to attempt to capture a variety of weather events. The materials, methods, and detailed results of this study are included in a manuscript titled "Evaluation of different types of Center Pivot Irrigation system under different weather conditions, WA, USA" (Mehanna and Peters, 2016).

In these experiments, an average of **96%** of the water that left the LESA nozzles was collected in the catch cans. By comparison, an average of **81%** of the water that left the MESA nozzles was collected in the catch cans. This translates to **18% more water reaching the ground with LESA when compared with MESA** (Figure 25). These differences were statistically significant ($p <= 0.05$). These differences are likely even higher when the LESA sprinklers operate below the top of a crop canopy. The efficiency measurements for LESA are comparable with those found by other researchers (Lyle and Bordovsky, 1983; Fipps and New, 1990; Rajan et al., 2015).

This improved irrigation application efficiency can result in large yield and crop quality increases to growers *especially* when there are water shortages and the marginal value of getting additional water into the soil is high. In other words, when there is not adequate water available there are very strong economic benefits to convert from MESA to LESA (additional yield due to more water in the soil). When there is access to an adequate amount of water and the costs of additional water is negligible, the primary economic benefits of converting to LEPA and LESA are derived from pumping energy savings because the pump requires less power (lower required pressures) and operating time to deliver an equivalent amount of water to the soil. Even if the only return to the growing operation is pumping power savings, it can still be cost effective to convert to LESA (see the cost estimate section below).

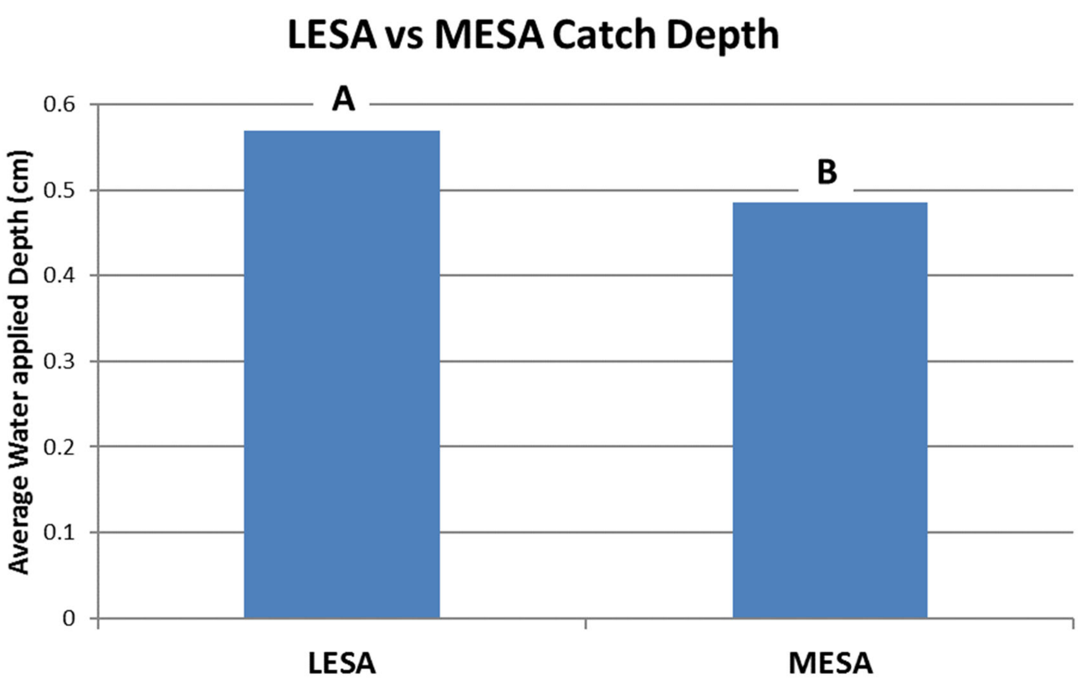

Figure 25. Catch can efficiency comparisons (10 replications) measured an average of 18% more water to the ground with LESA compared to MESA. Differences were statistically significant at the 0.05 level.

Anecdotal Corroboration of Water Savings Estimates

- In our trials during 2014 in Idaho, a grower managed a pair of pivots, one totally converted to LESA, and the other to MESA. The grower stated that the LESA-irrigated alfalfa pivots were able to be shut off for 1-2 days per week while the conventional MESA alfalfa pivots required continuous operation during the majority of the season to achieve similar yields.
- In 2015, the LESA pivot on one alfalfa field in Nevada had water supply reduced by about 20% due to well problems, but still yielded nearly the same as the MESA field with full water application.
- Similar results were obtained from another pair of pivots under alfalfa in Idaho. The grower plans to reduce capacity on the LESA pivot from 900 gpm to 750 gpm.
- On one trial the grower was deficit irrigating due to issues with his pump. The differences between MESA and LESA were highly visual (Figure 26).
- One grower converted his pivot from MESA to LEPA on a mint field and changed his sprinkler design flow rate from 7.5 gpm/acre to 6.5 gpm/acre with no loss of production.
- One MESA pivot at 850 gpm was converted to LESA at 700 gpm on an alfalfa field in Idaho with no loss of yield.
- In Idaho at 700 gpm on corn was adequate for the entire season.

With observed improvement in application efficiency, pivots that may have been under-designed are now able to meet peak crop water use rates (the pivot keeps up in very hot weather). However they may require more careful irrigation scheduling since they may need to be stopped periodically to avoid over-watering since it requires the grower to know when they can stop these pivots to realize these savings.

Figure 26. MESA (on the left) compared with LESA (on the right) on an alfalfa field in Idaho. The stark differences in crop health are partially due to 5% less gross water applied to the MESA due to inadequate pressures, and deficit irrigation on both showing the effects of improved irrigation application efficiency

differences. When both sides are over-irrigated, or the MESA section is adequately irrigated and the LESA section is over-irrigated, there is little noticeable difference.

Power Savings Analysis

Real power savings will depend on many aspects of the grower's particular situation including pump configuration, pump efficiency, depth to water source, incoming water pressure, and elevation differences. However, estimates were made for a typical ¼ mile long center pivot (120 acres) designed at 7.5 gpm/acre for a total of 900 gpm as shown in Table 1. A modest 10 psi pressure reduction was assumed from 35 psi required at the pump to 25 psi. A 15% decrease in the total run time of the LESA compared with the MESA was also assumed because LESA can get more water into the soil per hour of run time. This resulted in an estimated 172 kW-hr savings per acre, per irrigation season.

Table 1. Pumping power cost savings estimates for a typical center pivot with very little lift (surface water source).

Pumping Costs

	LESA	MESA	Units
Power Requirements	25	35	hp
Power Requirements	18.6	26.1	kW
Hours/season	1700	2000	hrs
Energy Use/Season	31620	52200	kWh
Cost/kwh	0.06	0.06	$
Demand Charge/month	5.00	5.00	$
Months/year	7	7	
Pumping Cost/Season	**$2,548**	**$ 4,046**	**$/year**

(LESA: 35 psi @ 900 gpm. MESA: 50 psi @ 900 gpm.)

Pumping Costs Saved with LEPA/Season..... $ 1,497.30

One of the large benefits from a power generation and supply perspective is that the power savings from LESA can be realized during the hot part of the summer when both water and power supplies are most limited. This helps make water available for alternative uses when it is most needed, and it can help directly reduce power generation capacity requirements.

How Much Does It Cost? Is It Worth It?

Assuming that it is time to replace the pressure regulators and sprinklers of a typical ¼ mile long pivot, a comparison was done of the costs the hardware of converting to LESA vs. replacing the existing MESA sprinklers and regulators on the pivot. The costs to replace MESA drops on a typical 10 ft spacing are compared with a LESA retrofit are shown in Table 2. The costs were annualized at a 4.0 percent interest rate for the number of years shown for each item. The additional labor costs to install the additional LESA drops are also annualized in Table 3.

Table 2. Equipment costs for converting to LESA compared with replacing worn MESA sprinklers.

	LESA Drop			MESA Drop			
Equipment Costs		**Years**	**$/Year**		**Years**	**$/Year**	**Notes**
Gooseneck	$ 2.59	10	$0.32	$ 3.55	30	$0.21	LESA $5.17/2 for two drops
Pinch Clamp	$ 0.68	10	$0.08	$ 0.34	10	$0.04	0.34/each
Drop Hose	$ 6.50	10	$0.80	$ 3.90	10	$0.48	0.65/ft x 6 ft.
Truss Rod Hose Sling	$ 2.27	10	$0.28	$ -		$0.00	
Pressure Regulator	$ 9.20	5	$2.07	$ 9.20	5	$2.07	Nelson
Weight	$ 7.46	30	$0.43	$ 7.46	30	$0.43	
nozzle	$ 1.56	5	$0.35	$ 1.56	5	$0.35	Nelson
Nelson R3000 vs D3000 Spray	$ 2.71	10	$0.33	$ 24.24	5	$5.44	Body, plate, and cap
Total/Drop	$ 32.97		$4.67	$ 46.70		$9.02	
Drops/1/4 mile pivot	206			116			1/5 of LESA remains MESA
Total Costs	**$ 7,491**		**$961**	**$ 5,417**		**$1,046**	per 1/4 mile pivot

(4% annual interest rate. LESA: D3000 spray head, 10ft hose. MESA: R3000 sprinkler, 6 ft hose).

Table 3. Labor cost comparisons for installing LESA compared to MESA.

Labor Costs	LESA Drop			MESA Drop		
LESA Drop	**Cost**	**Years**	**$/Year**	**Cost**	**Years**	**$/Year**
Labor Costs/Drop	$ 11.00			$ 11.00		
Drops/ 1/4 mile pivot	195			115		
Total Labor Costs	$ 2,145	5	**$481.83**	$ 1,276	5	**$286.62**

In order to achieve the maximum power savings from converting to LESA, the grower will need to use either a variable frequency drive, or a pump will often have to be reworked (the impeller trimmed) so that it will be most efficient at the decreased pressure requirement. These annualized costs at 4% interest rate over a 10 year life span are shown in Table 4 along with the costs of replacing the filter screen to filter out smaller particulates to avoid plugging the smaller nozzles. If the pump already has a variable frequency drive controller, then these additional pump rework costs are unnecessary.

Table 4. Annualized pump rework and replacement filter screen cost estimates.

Pump Rework Costs	**Cost/hp**	**Yrs**	**$/Year**
VFD&Filter or Rework	$ 150		
	$ 3,750	10	**462.341**
Water Filter (Fine Screen)	$ 400	10	**$49.32**
Total			**$ 462.34**

The total annualized cost estimates of deciding to convert to LESA vs. refit with MESA are shown in Table 5. This shows that although the upfront equipment costs of LESA is higher, over time this is repaid by power cost savings to create an estimated total cost *savings* of about $925 per year to convert to LESA. This results in about a 3.2 year simple payback using our assumptions.

Table 5. Total annualized cost difference estimates.

	LESA	MESA
Equipment	$ 961.26	$ 1,046.48
Labor/Maintenance	$ 481.83	$ 286.62
Annual Pumping Costs	$ 2,548.20	$ 4,045.50
Pump Rework	$ 462.34	$ -
Total/year	$ 4,453.63	$ 5,378.61
Difference/year	**$ 924.98**	

Each field will be slightly different depending on the water source, incoming pressures or depth to water table, power costs, and equipment costs. However the power cost savings alone will typically help pay for the conversion from LESA to MESA. However, these benefits are likely small compared to the financial benefits from getting more water to the crop when it needs it. These financial benefits to the grower will be especially apparent when water is limited and the ability to get more water into the soil per gallon of water pumped results in direct yield and crop quality increases.

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