Maximizing the Efficiency of Center Pivots

Beef Cattle & Forage Field Day

May 10, 2019

Guy Fipps, PhD, P.E.
Professor and Extension Agricultural Engineer
Biological and Agricultural Engineering Department
Texas A&M University, College Station

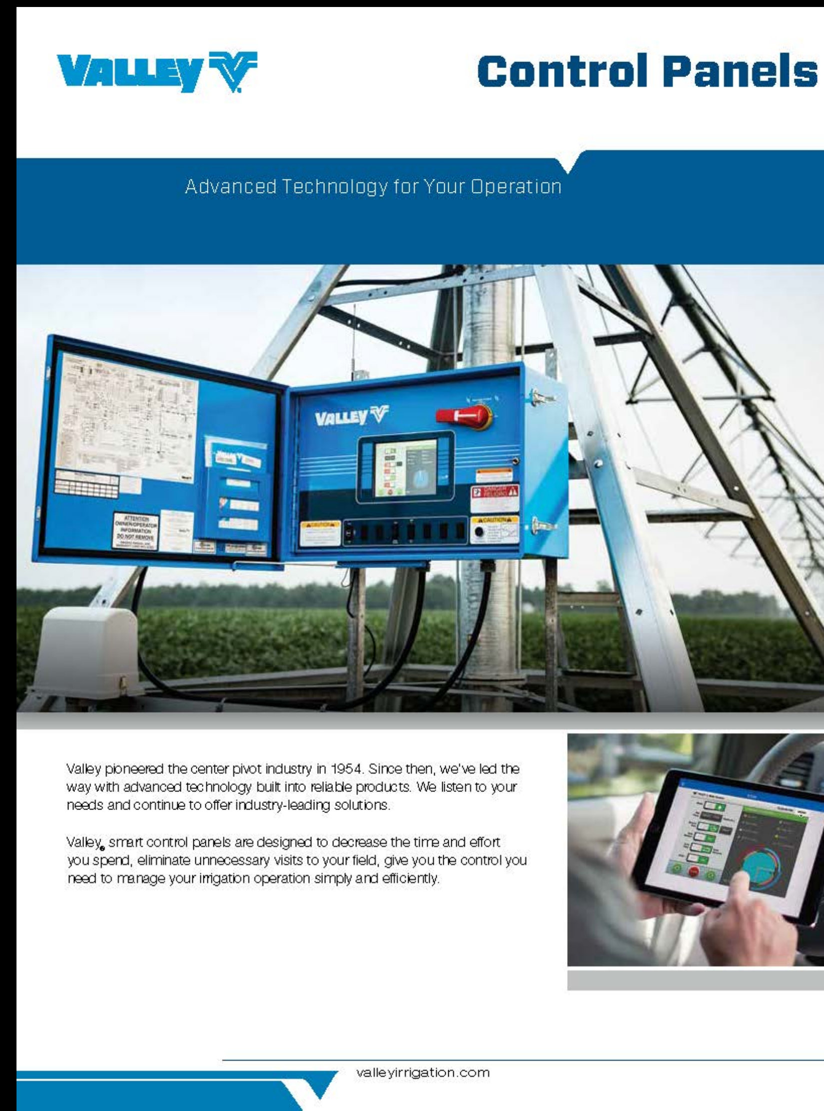
gfipps@tamu.edu

Topics:

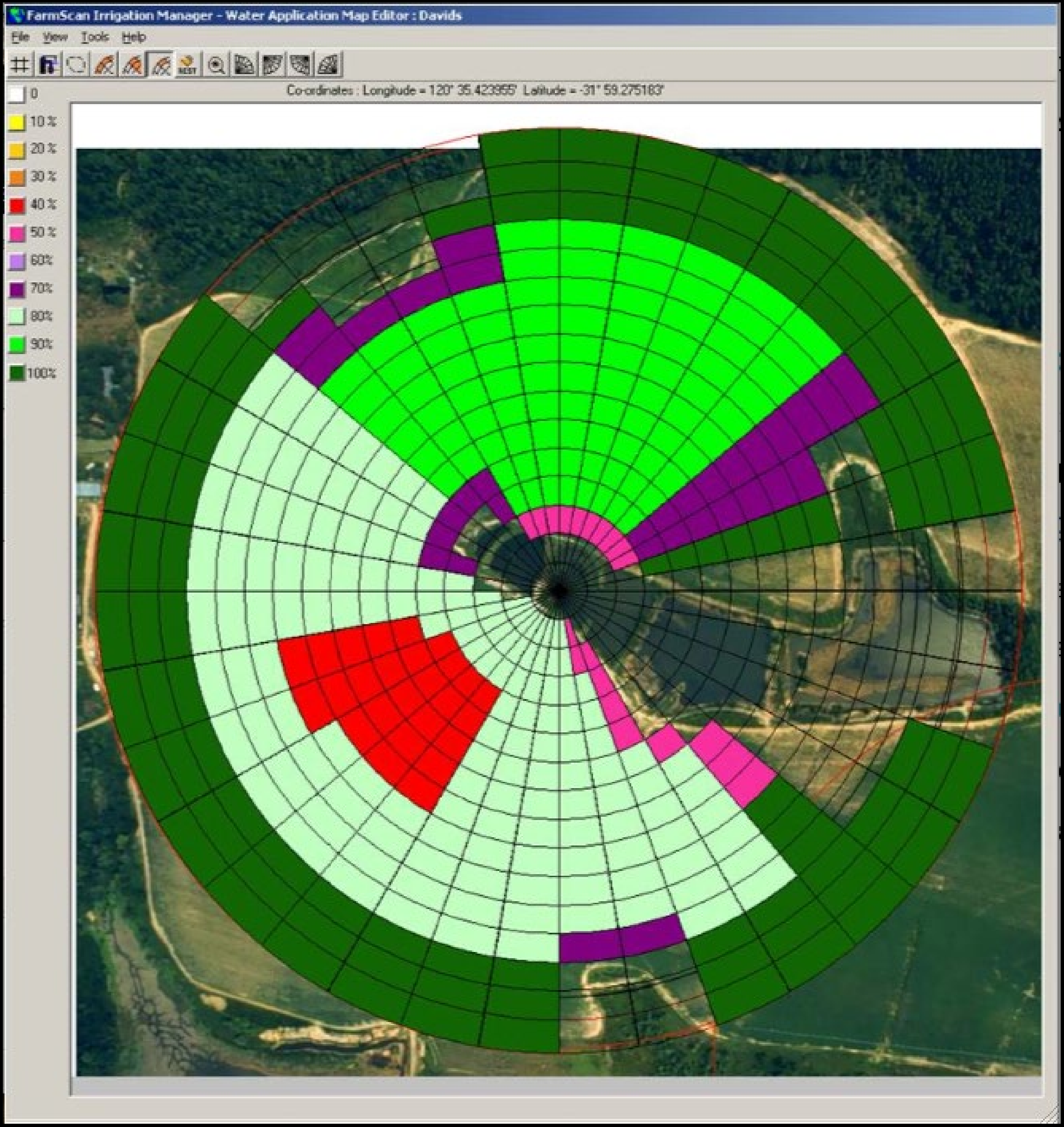
I. What's New in Center Pivots
II. Getting an Efficient New Pivot
III. Improving the Efficiency of Older Pivots
   - Switching to more efficient water applicators
   - Dealing with falling groundwater levels


177.4°
Status
Running
Repeats
Sector
End Gun
On
Fertilizer
Off
Aux 1
On
Aux 2
Off

Control and Management Systems



Off the shelve Variable Rate Irrigation



FarmScan Irrigation Manager - Water Application Map Editor : Davids
File View Tools Help
Co-ordinates : Longitude = 120° 35.423955' Latitude = -31° 59.275183'
0
10 %
20 %
30 %
40 %
50 %
60%
70%
80%
90%
100%

TRACKING SOLUTIONS

Continued evolution in water applicators

Drag line system ("*mobile drip*")

Drag-line evaluation at the Texas A&M University Farm – Fipps, 2016

Terminology – water application systems

On top of mainline

MESA

LESA

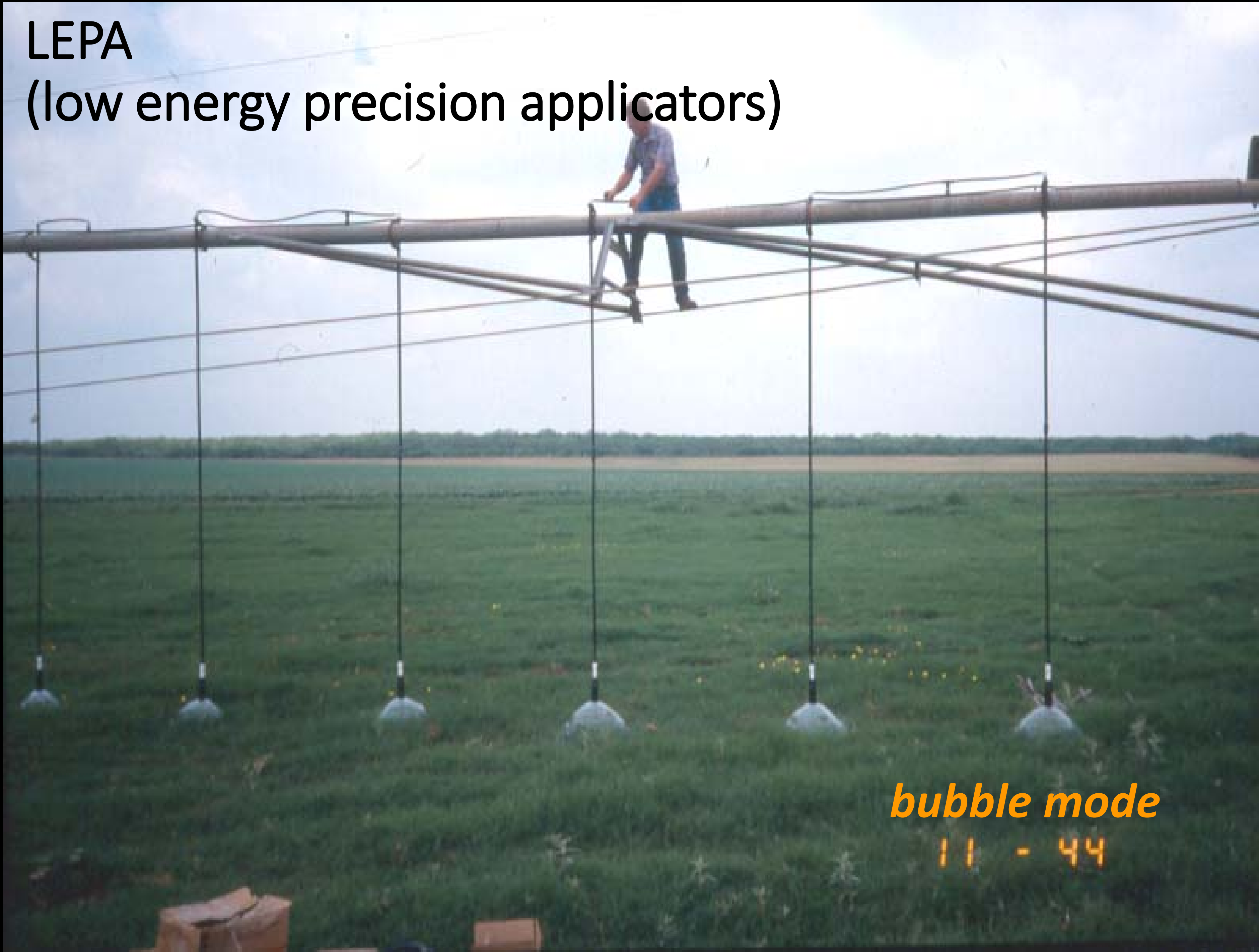
LEPA

On top of main line

MESA
(medium elevation spray applicators)

MESA
(medium elevation spray applicators)

Over-pressured MESA system


LEPA
(low energy precision applicators)
bubble mode
11 - 44


LEPA
with alternate row furrow dikes

LESA
(low elevation spry applicators)

Terminology – water application systems

On top of mainline

MESA

LESA

LEPA

On top of mainline

Above-canopy

In-canopy

Close drop spacing (with either LESA or LEPA)

Senninger®

LEPA CLOSE SPACING

Save Water, Use Less Energy and Increase Yield

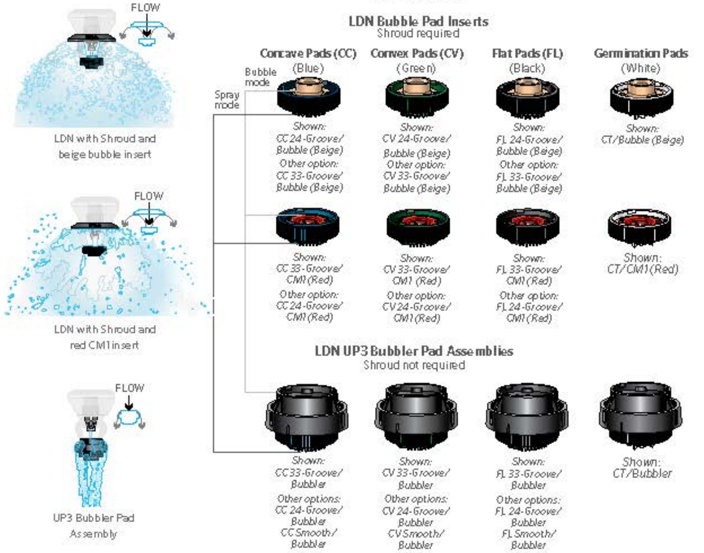
AGRICULTURAL IRRIGATION

Low Pressure - High Performance

RECOMMENDATIONS:

Flow: 0.27 to 18.35 gpm (61 to 4168 L/hr)

Pressure: 6 to 15 psi (0.41 to 1.03 bar)



Other spray pad surfaces available. Consult factory.
Small 12-grooved pads available (Used with UP3 Nozzles #2, #2.5, #3, #3.5).
120-Mesh Filtration Recommended.

Getting a new pivot with maximum efficiency

You just need to know what to ask for…

Pivot Design

1. Actual lowest and highest elevations in field with relation to the pivot point were used in the computer design printout.

2. Actual measured flow rate and pressure available from pump or water source was used in the computer design printout.

3. Friction loss in pivot mainline is no greater than 10 psi for quarter-mile long systems.

4. Mainline outlets are spaced a maximum of 60 to 80 inches apart or, alternately, no farther apart than two times the crop row spacing.

Pivot Design

5. For non-leveled fields, less than 20 percent pressure variation in system-design operating pressure is maintained when pivot is positioned at highest and lowest points in the field (computer design printout provided for each case).

6. Pressure regulators were evaluated for fields with more than 5 feet of elevation change from pad to the highest or the lowest points in the field.

7. Tower wheels and motor sizes were selected based on soil type and slope following manufacturers' recommendations.

8. Dealer has provided a copy of pivot design printout.

Water Applicators

No end gun.

Either LEPA or LESA applicators with:

- an operating pressure requirement of 6 psi,
- positioned 1 to 1.5 feet above the ground
- spaced at 2 times the crop row spacing, or 30-40 inches.

a. LEPA (low elevation precision application) - a LDN or similar model of water applicator that has easily switched plates for LEPA bubble mode.
b. LESA (low elevation spray application) – a LDN, supper spray or similar product

Accessories

Propeller flow meter or other type of flow measurement device having accuracy to ± 3 percent.

- Reads flow rate (i.e., gpm) and total gallions
- The flow meter should be installed in a long straight section of pipeline at least 10 pipe diameters upstream and 5 pipe diameters downstream from any changes in pipeline.

System includes two pressure gauges, one on the mainline near the pivot point and one in the last drop,

Figure 3. Sample design computer printout.

Pivot identification	J & J Farms	Overall length	1309.00 ft
Pivot location	Section 130	Drop tube length	12.50 ft
Design flow rate	625.00 GPM	Regulator position (from mainline)	12.00 ft
Design Pressure at the end	4.00 PSI	Design elevation of end tower	+7.0 ft, -8.0 ft
Pressure at pivot	13.67 PSI	End gun GPM	0

SPAN NO.	SPAN LENGTH (ft)	MAINLINE DIAMETER (inches)	NUMBER OF DROPS	DROP SPACING (ft)	DROP DIAMETER (inches)	1st DROP POSITION (ft)	REGULATOR SIZE (psi)	ACRES
1	160	6.38	19	6.67	0.75	36.60	6	1.84
2	160	6.38	24	6.67	0.75	3.335	6	5.53
3	160	6.38	24	6.67	0.75	3.335	6	9.23
4	160	6.38	24	6.67	0.75	3.335	6	12.92
5	160	6.38	24	6.67	0.75	3.335	6	16.61
6	160	6.38	24	6.67	0.75	3.335	6	20.30
7	160	6.38	24	6.67	0.75	3.335	6	23.99
8	160	6.38	24	6.67	0.75	3.335	6	27.68
9	29	5.78	5	6.67	0.75	3.335	6	5.41
Total	1309		192					123.51

1. Mainline outlet number from pivot point
2. Distances in feet between outlets or span length between towers
3. Distance in feet from pivot point to outlet or tower
4. GPM needed based on the area covered by the applicator
5. Actual GPM delivered by the applicator based on the applicator's nozzle size and operating pressure
6. Pressure in psi in the mainline at the outlet
7. Pressure at the nozzle (when pressure regulators are used, the pressure at the nozzle should be no less than the psi of the regulator's rating)
8. Brand name and/or type of applicator and nozzle size (nozzle size is reported either by number or actual size in inches)
9. Applicator number or position on mainline
10. Pressure regulator's brand name, psi rating, and flow capacity (GPM) often expressed as LF (low flow), HF (high flow), etc.
11. Plug number, if outlet is plugged
12. Distance from furrow arm to applicator, inches

(1) OUTLET NO.	(2) LAST OUTLET	(3) DISTANCE TO PIVOT	(4) GPM NEED	(5) GPM DEL.	(6) PIPE PSI	(7) NOZZLE PSI	(8) SPRINKLER LABEL & NOZZLE SIZE	(9) SPRK NO.	(10) REG SIZE	(11) PLUG NO.	(12) DROP LENGTH
1		6.08								1	
2	36.60	36.60	0.18	0.29	13.27	6.66	4.0	1	6LF		150
3	6.67	43.27	0.21	0.29	13.20	6.66	4.0	2	6LF		156
4	6.67	49.94	0.24	0.29	13.13	6.66	4.0	3	6LF		156
5	6.67	56.61	0.27	0.29	13.05	6.66	4.0	4	6LF		162
↓											
20	6.67	156.66	0.76	0.76	11.86	6.66	6.5	19	6LF		144

Figure 3. Sample design computer printout. (continued)

Tower 1	160.00	160.00								
21	6.67	163.33	0.79	0.76	11.79	6.66	6.5	20	6LF	144
22	6.67	170.00	0.82	0.88	11.72	6.66	7.0	21	6LF	144
23	6.67	176.67	0.85	0.88	11.65	6.66	7.0	22	6LF	150
24	6.67	183.84	0.89	0.88	11.58	6.66	7.0	23	6LF	150
25	6.67	190.01	0.92	0.88	11.50	6.66	7.0	24	6LF	156
↓										
44	6.67	316.67	1.53	1.61	10.20	6.66	9.5	43	6LF	144
Tower 2	160.00	320.00								
45	6.67	323.33	1.56	1.61	10.03	6.66	9.5	44	6LF	144
46	6.67	330.00	1.59	1.61	9.96	6.66	9.5	45	6LF	144

Figure 4. Sample precipitation chart.

IRRIGATOR – XXXXX

MOTOR SIZE (HP) = 1
LOADED MOTOR RPM = 1745
CENTER GEAR BOX RATIO = 58T01

WHEEL GEAR BOX RATIO = 50T01
TIRE SIZE = 11.2 X 24.0
LAST TOWER MAX. SPEED (FPM) = 5.90

Irrigation Precipitation Chart

1. Total amount of water applied in inches at this speed setting

2. Timer (or speed) setting on the control usually indicated as a percentage of the maximum speed

3. Time in hours to make a complete circle at this speed setting

PRECIPITATION – INCHES ①	TIMER SETTING – % ②	TIME – HOURS ③
0.25	100.00	22.70
0.32	80	28.38
0.36	70	32.44
0.42	60	37.84
0.51	50	45.41
0.64	40	56.76
0.85	30	75.68
1.02	25	90.82
1.27	20	113.53
1.42	18	126.14
1.70	15	151.37
2.12	12	189.22
2.55	10	227.06

Converting Older Pivot to a More Efficient Water Application Package

Case Study:

An On-Farm Irrigation Demonstration was conducted in Burleson County beginning in 2011.

The demonstration focused on converting spans of a center pivot currently equipped with conventional water applicators to LESA (Low Energy Spray Application).

iWOB
LDN
Quad SPray

Water Application Package	Average Yield
Conventional (i-Wob)	25 bu/ac
LESA	95 bu/ac

Converting an old pivot

You will need:

1. Pumping capacity (flow rate and pressure)
2. Elevation change between the pivot point and end of the pivot when parked at the highest and lowest points in the field
3. Existing pivot printout

(if you do not have your pivot printout, check with the dealer that installed the pivot or have another one run)

Converting an old pivot

Next:

1. Have your dealer run a new printout with the chosen water applicators (LESA or LEPA)
2. Install water applicators – each applicator will be numbered as shown in the design printout
3. Use double goosenecks/trust rods as needed to add additional drops for closer drop spacings
4. Use compression clamps for securing drop hose to water applicators and pressure regulators
5. Don’t forget to install a weight on each drop
6. Check for leaks
7. Have a cool one to celebrate!

Photos of some of the steps and components

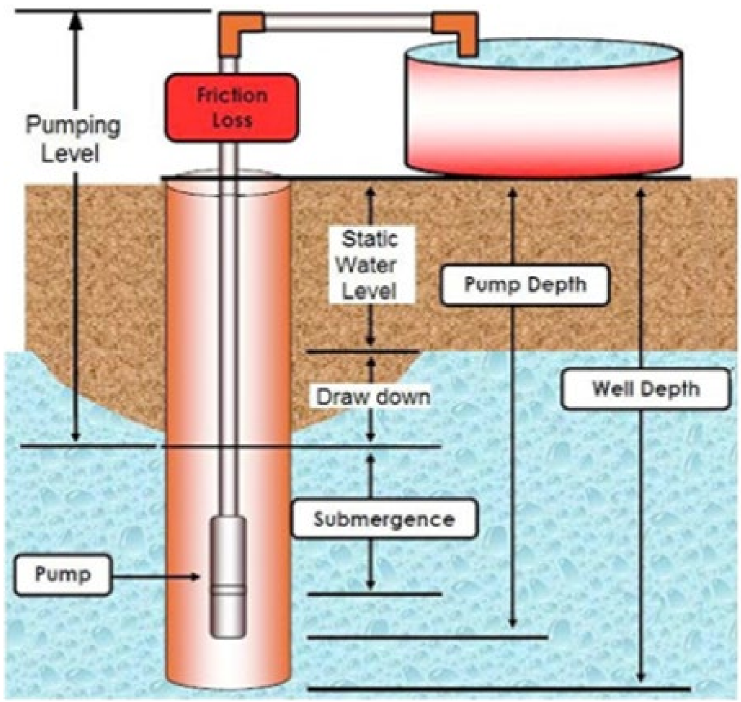
Dealing with falling water levels in wells

- Declining water levels in wells will negatively impact your irrigation efficiency
- Often this results in insufficient flows and pressures
- Its important to monitor flows with a flow meter and pressures with two pressure gauges (pivot point/last drop)
- For short term water declines (such as during the peak irrigation period), pivots can be renozzled based upon the current pumping capacity
  - Have new printout run based upon the current pumping capacity
  - Switch out the old nozzle sizes with the new nozzles following the design printout

Dealing with falling water levels in wells

- For long-term water declines, be sure to check your pump’s performance curve
- otherwise, excessive energy use may result

Reading pump curves



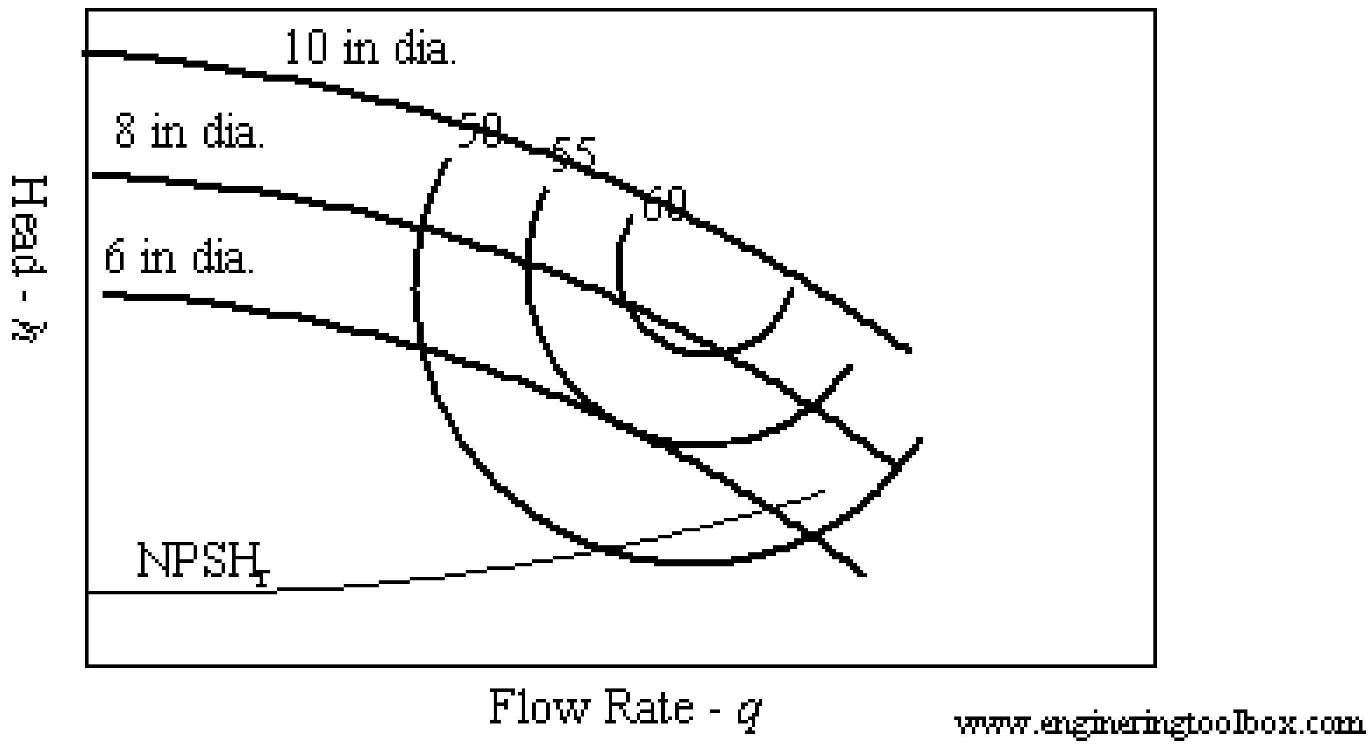
Pumping head

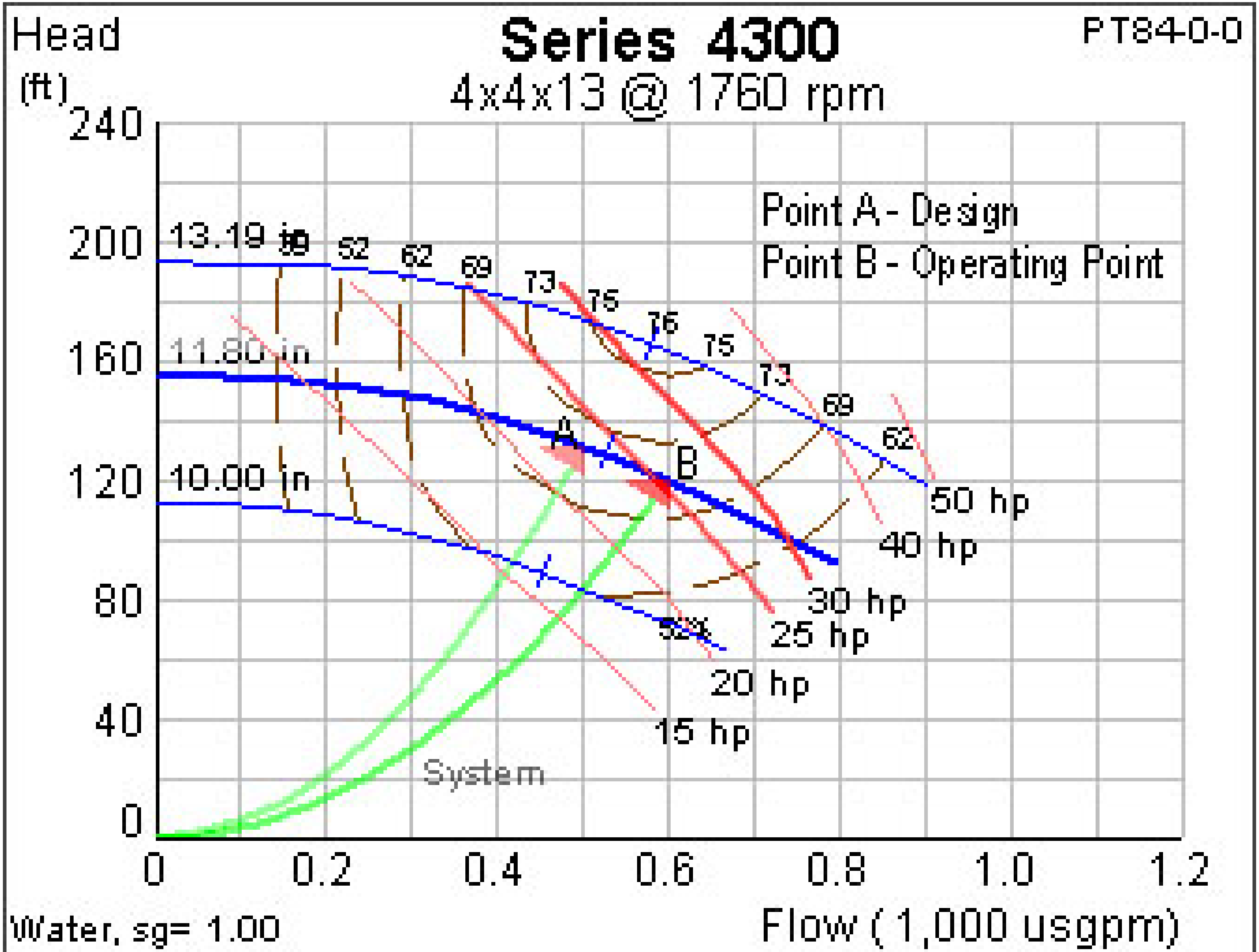
Pumping head includes:

1. How high water is lifted
2. Operation pressure of the irrigation system
3. Friction losses

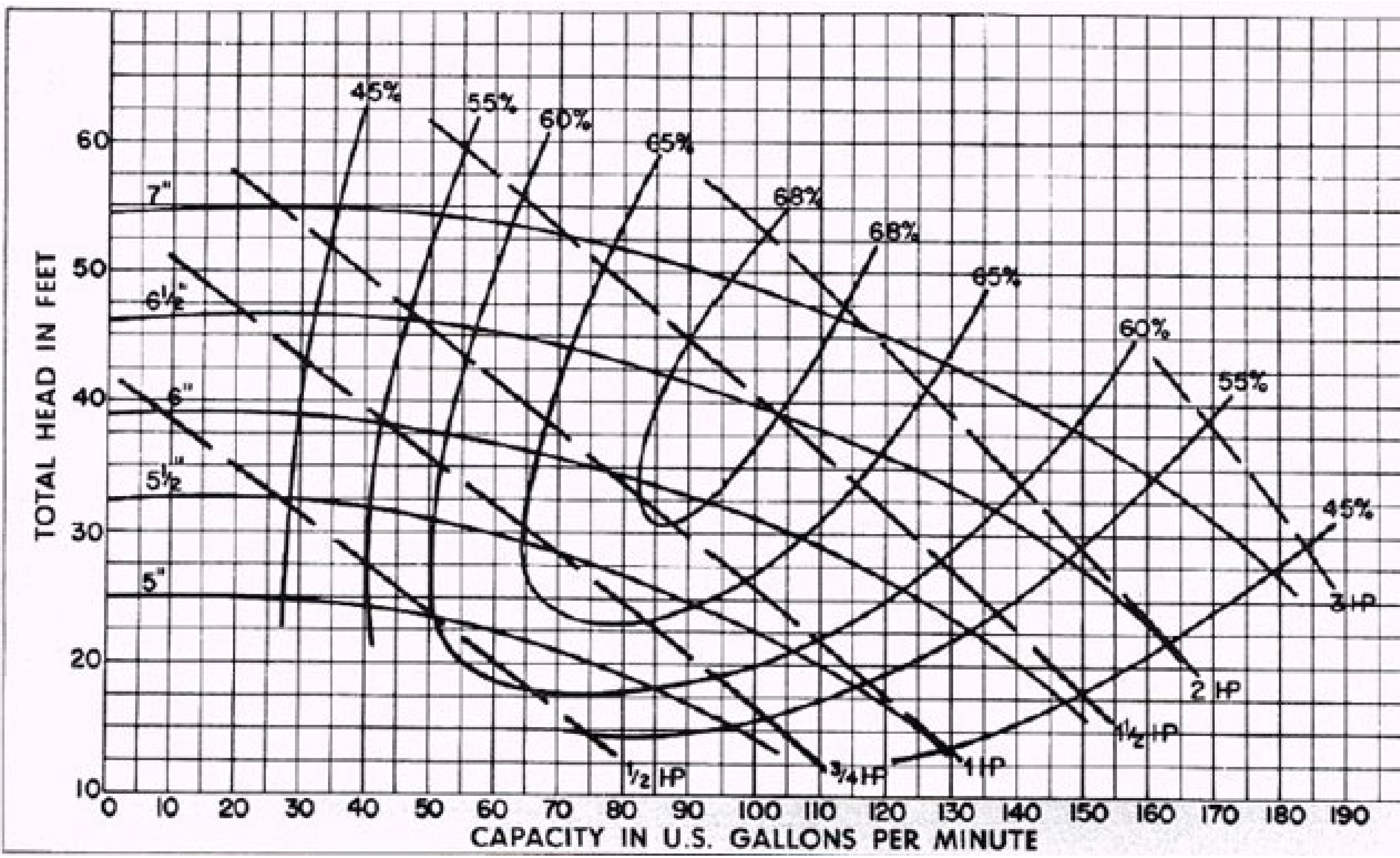
Reading pump curves

Total pumping head = lift + operating pressure + friction losses





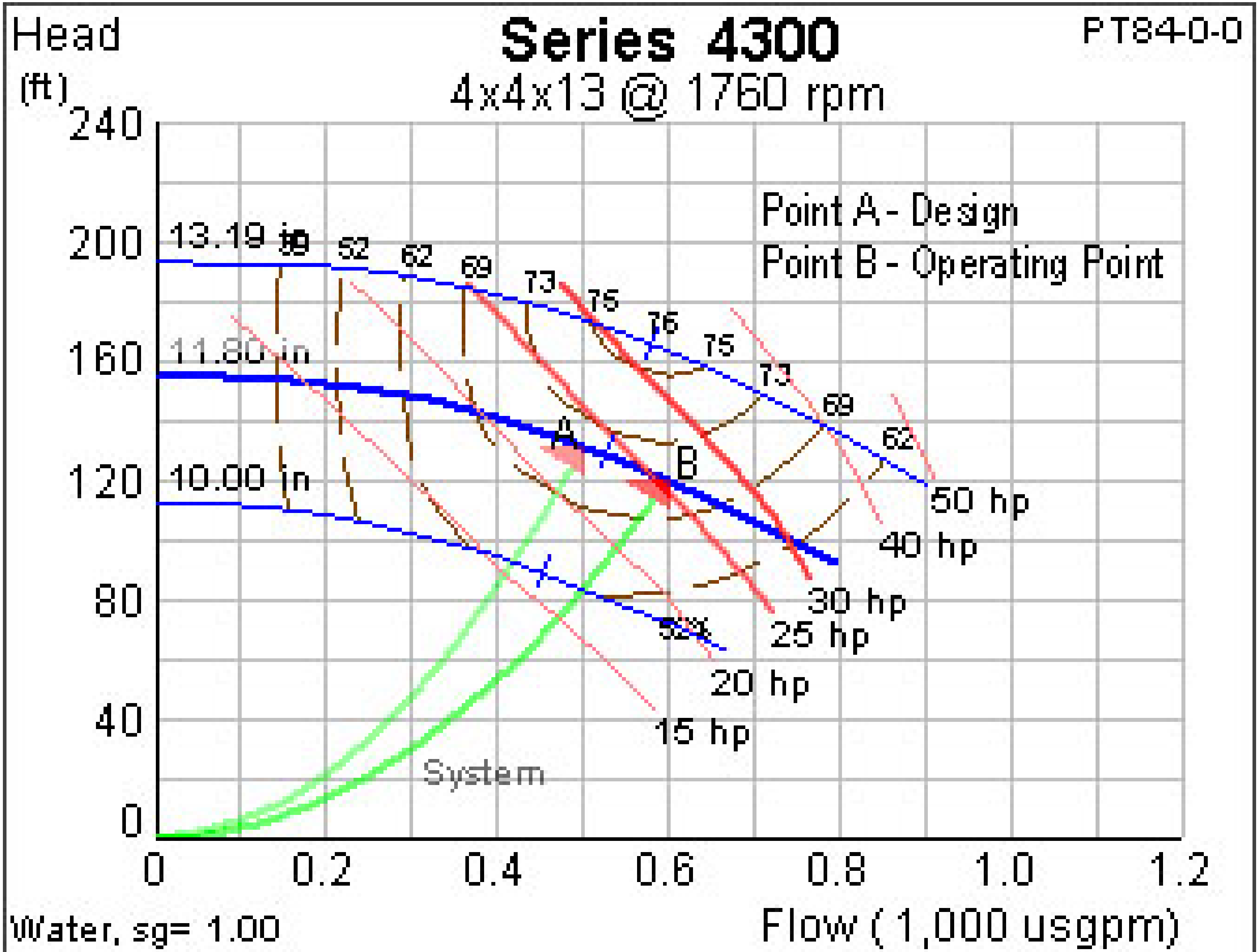
Series 4300
4x4x13 @ 1760 rpm
PT84-0-0
Head
(ft)
Point A - Design
Point B - Operating Point
13.19 in
11.80 in
10.00 in
52
62
69
73
75
76
75
73
69
62
52%
A
B
50 hp
40 hp
30 hp
25 hp
20 hp
15 hp
System
240
200
160
120
80
40
0
0
0.2
0.4
0.6
0.8
1.0
1.2
Water, sg= 1.00
Flow (1,000 usgpm)



45%
55%
60%
65%
68%
68%
65%
60%
55%
45%
7"
6½"
6"
5½"
5"
½ HP
¾ HP
1 HP
1½ HP
2 HP
3 HP
TOTAL HEAD IN FEET
10
20
30
40
50
60
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190
CAPACITY IN U.S. GALLONS PER MINUTE

Reading pump curves

Example – I have a 13.91” Series 4300 pump, with a flow rate of 600 gpm, and total head of 160 feet. What is my pumping efficiency?



Head
(ft)
Series 4300
4x4x13 @ 1760 rpm
PT84-0-0
Point A - Design
Point B - Operating Point
13.19 in
11.80 in
10.00 in
52
62
69
73
75
76
75
73
69
62
52%
50 hp
40 hp
30 hp
25 hp
20 hp
15 hp
A
B
System
240
200
160
120
80
40
0
0
0.2
0.4
0.6
0.8
1.0
1.2
Water, sg= 1.00
Flow (1,000 usgpm)

Reading pump curves

Example – I have a 13.91” Series 4300 pump, with a flow rate of 600 gpm, and total head of 160 feet. What is my pumping efficiency? 75.8%

<u>Example 2</u>

In the past 10 years, water level in my well has dropped 20 ft. How has this impacted my pumping capacity?

Reading pump curves

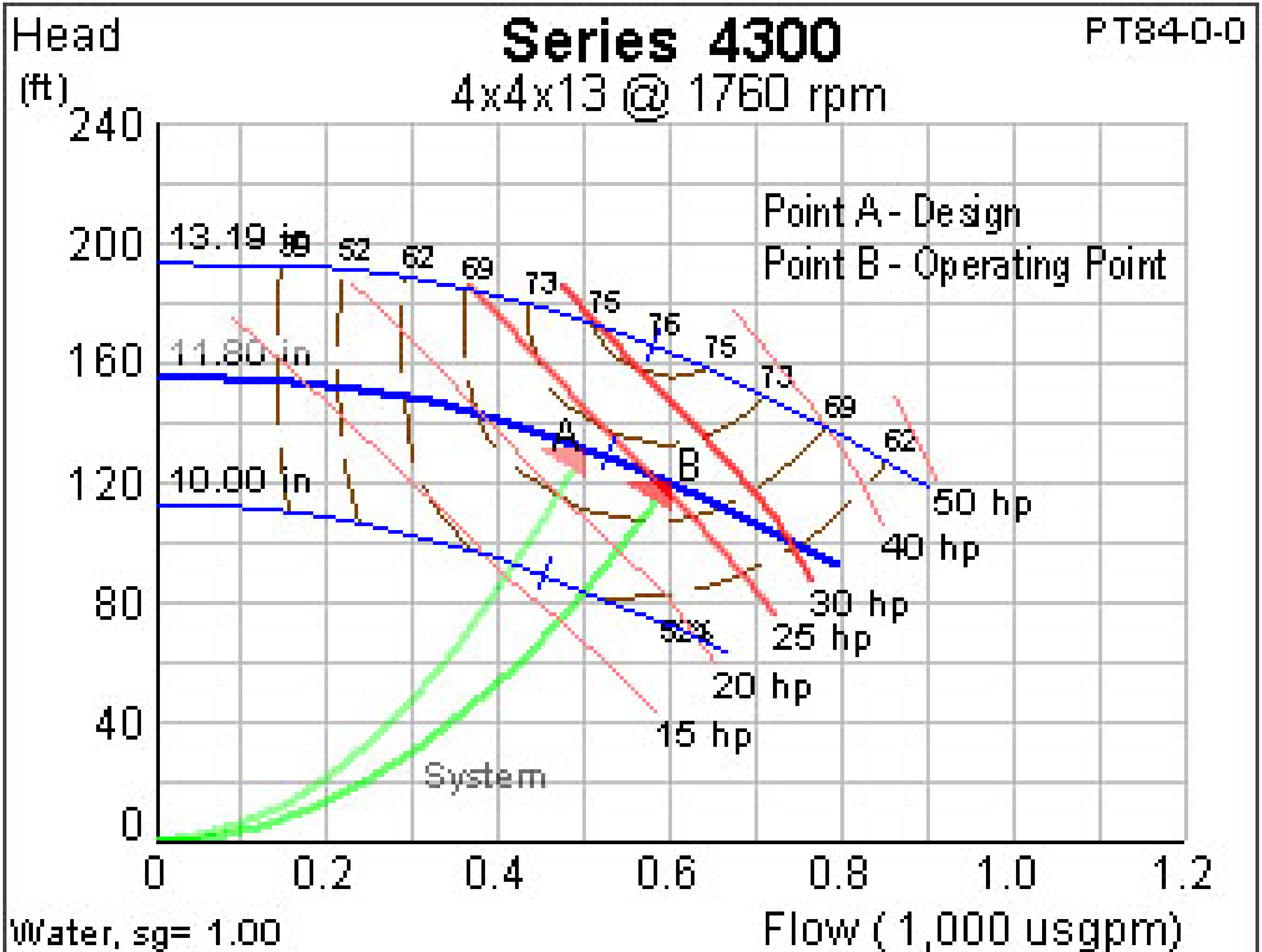
Example 2

In the past 10 years, water level in my well has dropped 20 ft. How has this impacted my pumping capacity?

As a result:

my pumping head has increased from 160 ft to 180 ft. Flow has been reduced from 600 gpm to 400 gpm

My pumping efficiency has fallen from 75.8% to 70%


Head
(ft)
Series 4300
4x4x13 @ 1760 rpm
PT84-0-0
Point A - Design
Point B - Operating Point
13.19 in
11.80 in
10.00 in
52
62
69
73
75
76
75
73
69
62
52%
A
B
50 hp
40 hp
30 hp
25 hp
20 hp
15 hp
System
240
200
160
120
80
40
0
0
0.2
0.4
0.6
0.8
1.0
1.2
Water, sg= 1.00
Flow (1,000 usgpm)

Reading pump curves

Example 2

In the past 10 years, water level in my well has dropped 20 ft. How has this impacted my pumping capacity?

As a result:

- my pumping head has increased from 160 ft to 180 ft
- flow has been reduced from 600 gpm to 400 gpm
- pumping efficiency has fallen from 75.8% to 70%

Questions….?

A copy of this presentation will be posted on Monday, May 13 at

http://gfipps.tamu.edu