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Center for Irrigation Technology

Pumps, Pump Tests, and VFDs

presented by Bill Green

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Upcoming Live Pump and VFD demonstrations at Taylor Farms 24228 Lincoln St. Chualar, Ca 93926 (10 miles south of Salinas on Hwy 101)

- March 7, 2023 9 am to noon- Grower and Farm Manager in English

https://docs.google.com/forms/d/e/1FAIpQLSdq2ecpmHJA-YUa8_W9H7R8Y7CEEoJANxSVx1EmJiLLDgWYWg/viewform?usp=sf_link

- March 8, 2023 9 am to noon- Farm worker pump and irrigation system management translated to Spanish by CIT staff

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Sign up- free lunch for all attendees each day, space limited

On-line PG&E Energy Classes, learn more and register at:
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Pumps deliver water to various irrigation systems such as flood, sprinklers, fanjets, center pivots, drip

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What is happening to our deep well pumps with the deeper Pumping Water Levels (PWL)?

- Over-drafting of the aquifer is occurring in California including the Salinas valley

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Because of the overdrafting of the aquifer, static and pumping water levels are greater

- Flow rates decrease
- Output discharge pressure decreases because more of the Total Lift of the pump is used for the deeper water levels
- Overall Pump Efficiency (OPE- wire to water) changes, usually with a negative result
- Cost to pump water increases

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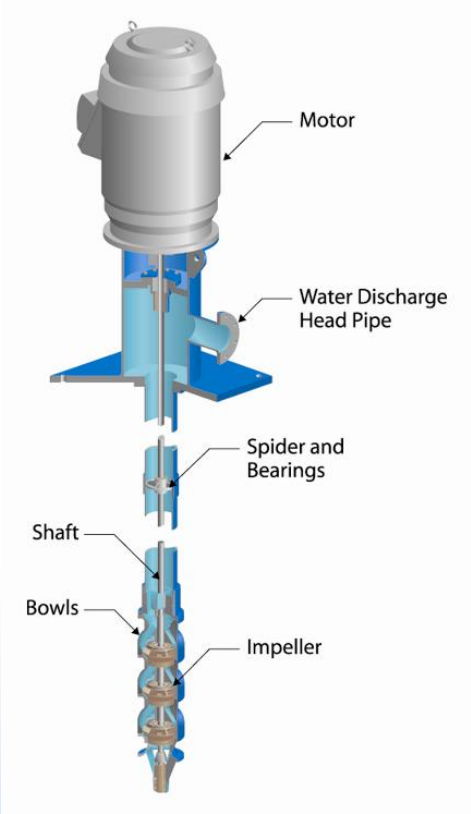
OPE (Overall Pump Efficiency) is a Combination of Efficiencies HPin/ HPout



Motor Efficiency – 88-96%
Transmission Efficiency – 90-97%
Bowl Efficiency – 60s – mid 80s
Thus, OPE = ME x TE x BE
Good OPE:
0.67 (67%) = 0.93 x 0.96 x 0.75
Poor OPE:
0.46 (46%) = 0.93 x 0.96 x 0.52

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Every pressurized irrigation system has a flow and pressure requirement. The pump needs to meet those conditions, how do we choose our pump?

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When aquifer water levels vary, so does the pump output, different flows and pressures

- In many cases, when flow rates and pressures vary, the irrigation system Distribution Uniformity (DU) can decrease leading to uneven applications of water and lowering Irrigation Efficiency (IE)

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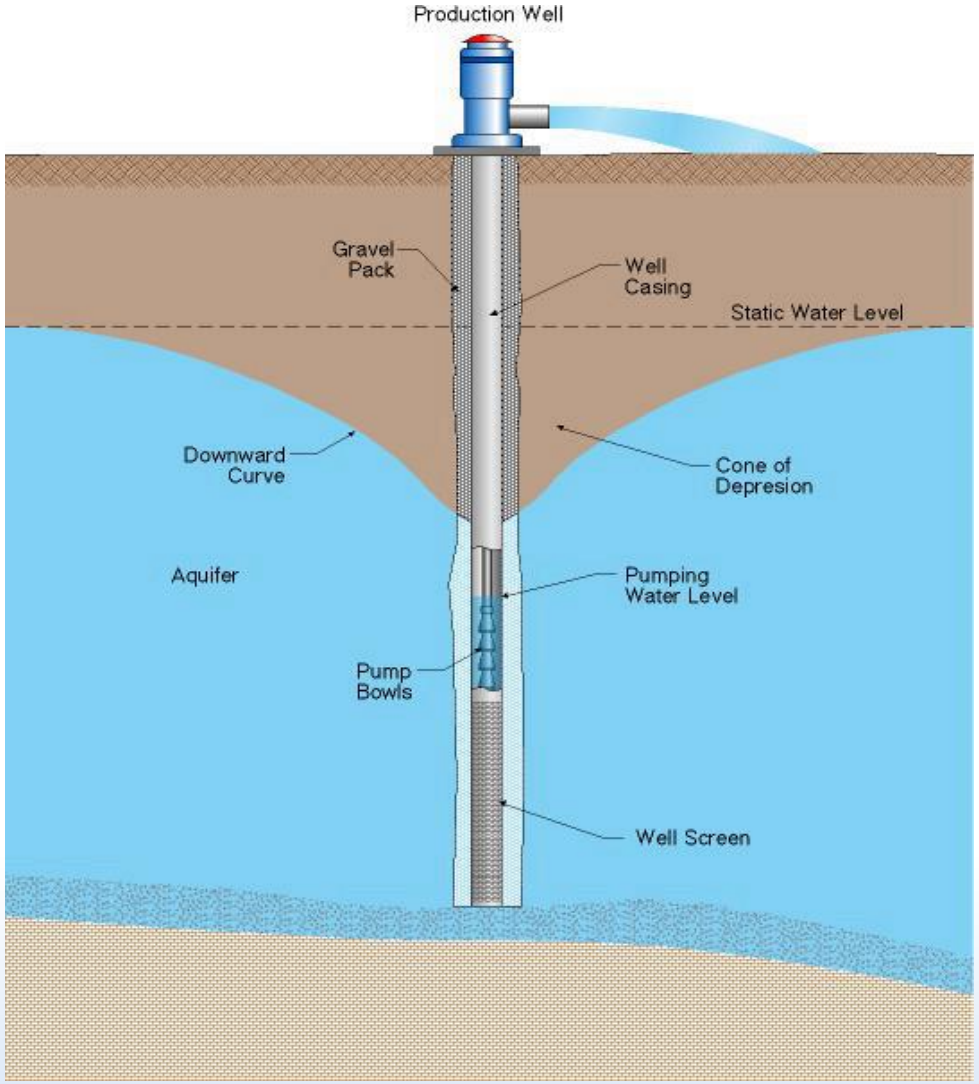
Deep Well Variable or Fluctuating Pumping Condition

1. Static or Standing Water Level (SWL)- varies as season progresses water table usually drops in summer or during drought conditions

2. Drawdown

3. Pumping Water Level (PWL) varies in fluctuating situation



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How do Pumps Work? The "Operating Condition" of a pump…

- HPin or "energy in" depends in part on the combination of flow and pressure (termed TDH- Total Dynamic Head/ Total Lift) developed to run the irrigation system.
- The combination of flow and pressure is termed the "Operating Condition".
- Every pump has a combination of flow and pressure as it operates…

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What is Flow?

- Flow is the volume of water pumped measured in Gallons per Minute or GPM
- Flow can also be measured in cubic feet/second or CFS
- Get a Flow meter!!! It's your first alert to changing flow rates and pumping conditions

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Doesn't a Pump Efficiency Test Give Me Flow?...

- The pump test is a snapshot, at the conditions tested.
- Especially with wells, flow rates may be significantly different throughout a season.
- Won't help if something starts to go wrong during a season.

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What is Pressure?

- Pressure is termed Total Dynamic Head (TDH) or Total Lift of the pump. This includes;
  - Lift of water from the source and delivered to the target crop
  - Friction losses (water moving through pipes) through the irrigation system
  - Pressure requirement to run the irrigation system (for drip and sprinklers, not flood)

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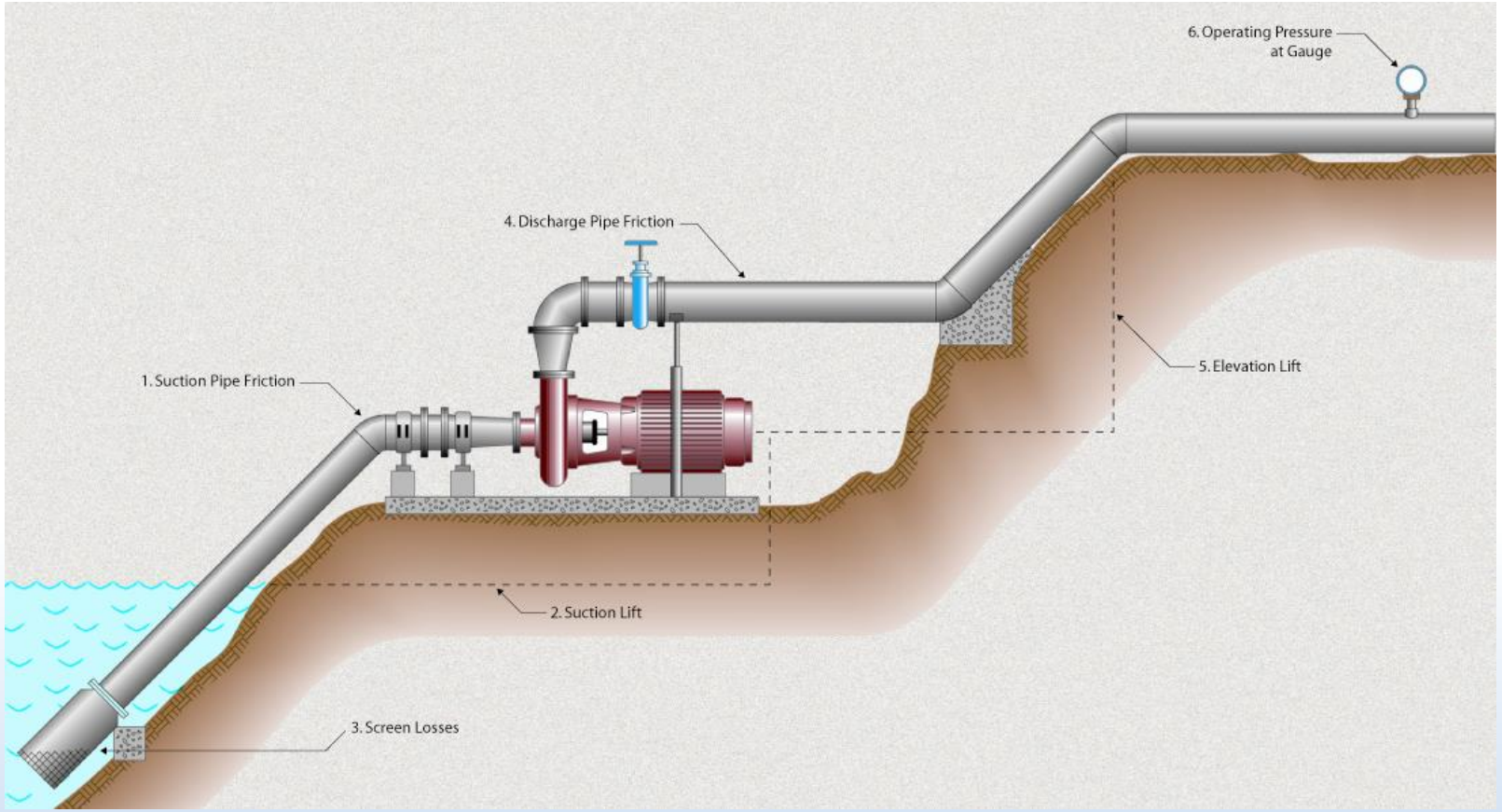
Diagram showing Total Dynamic Head (TDH) components



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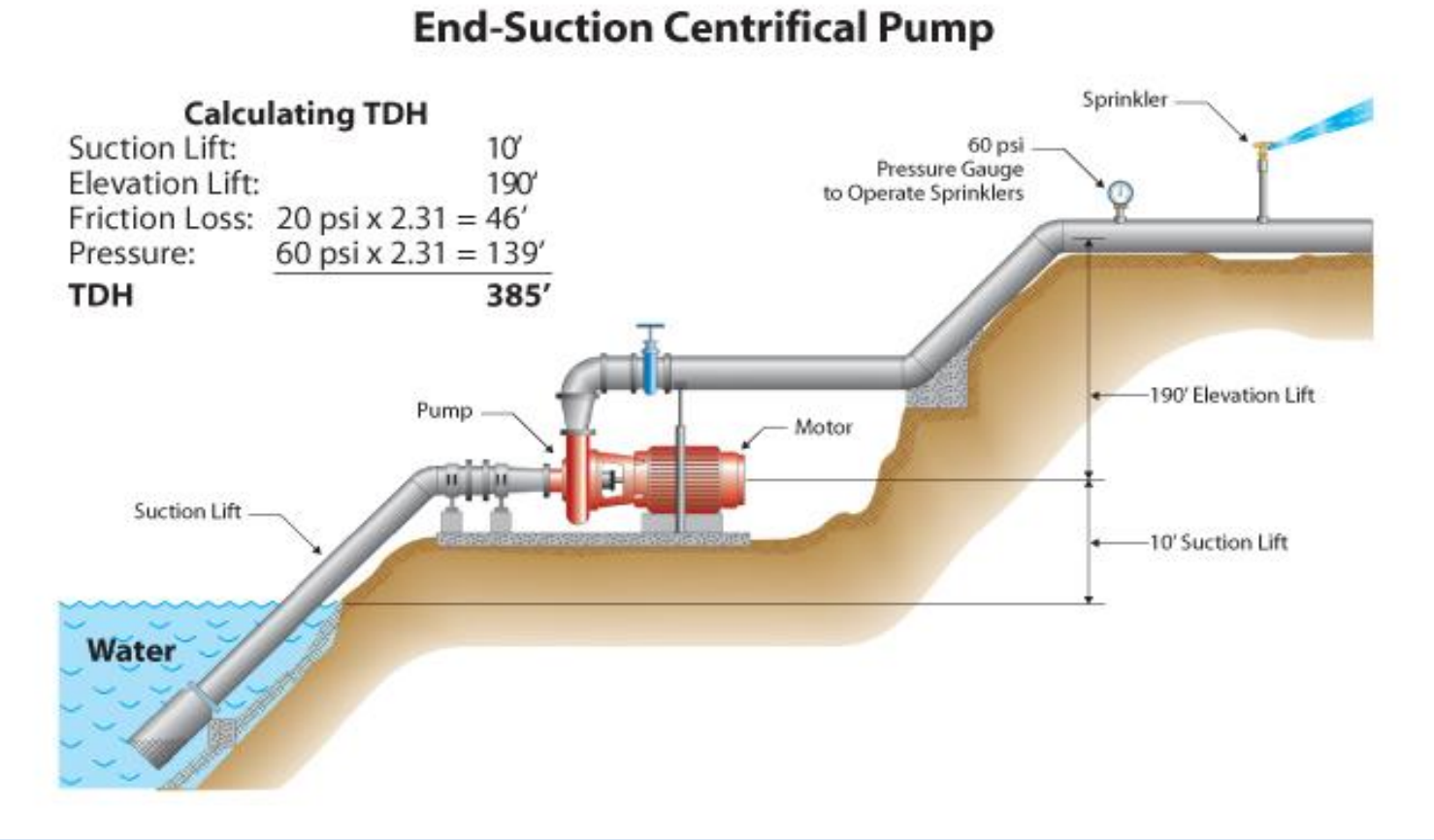
TDH example- Total Lift from the water source level (PWL) to the field level + Friction losses through the irrigation system + the pressure to operate the irrigation system



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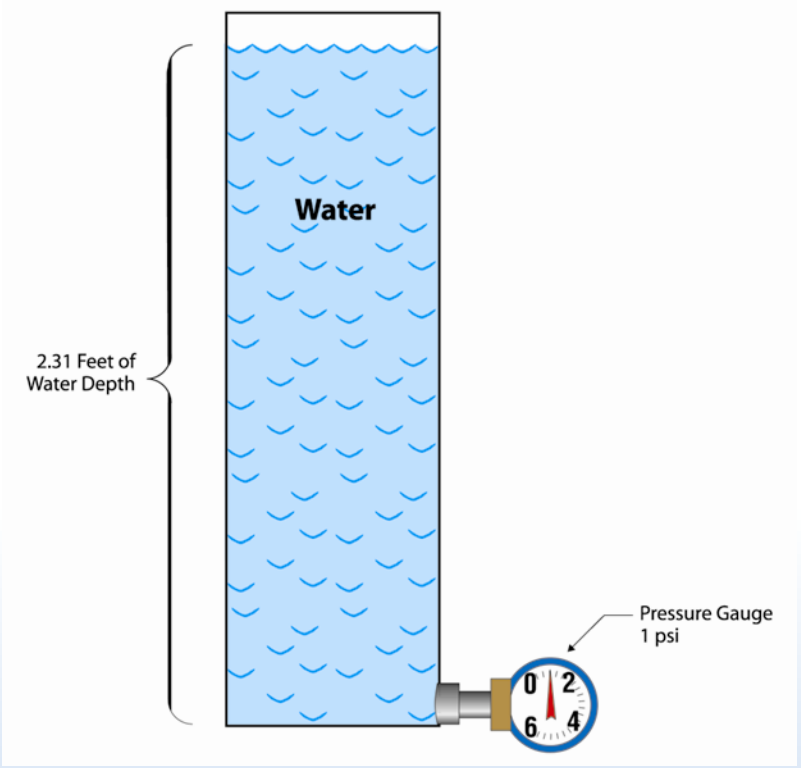
The constant to convert psi to feet of head

Every 2.31 feet of water depth equals 1 psi (at sea level).



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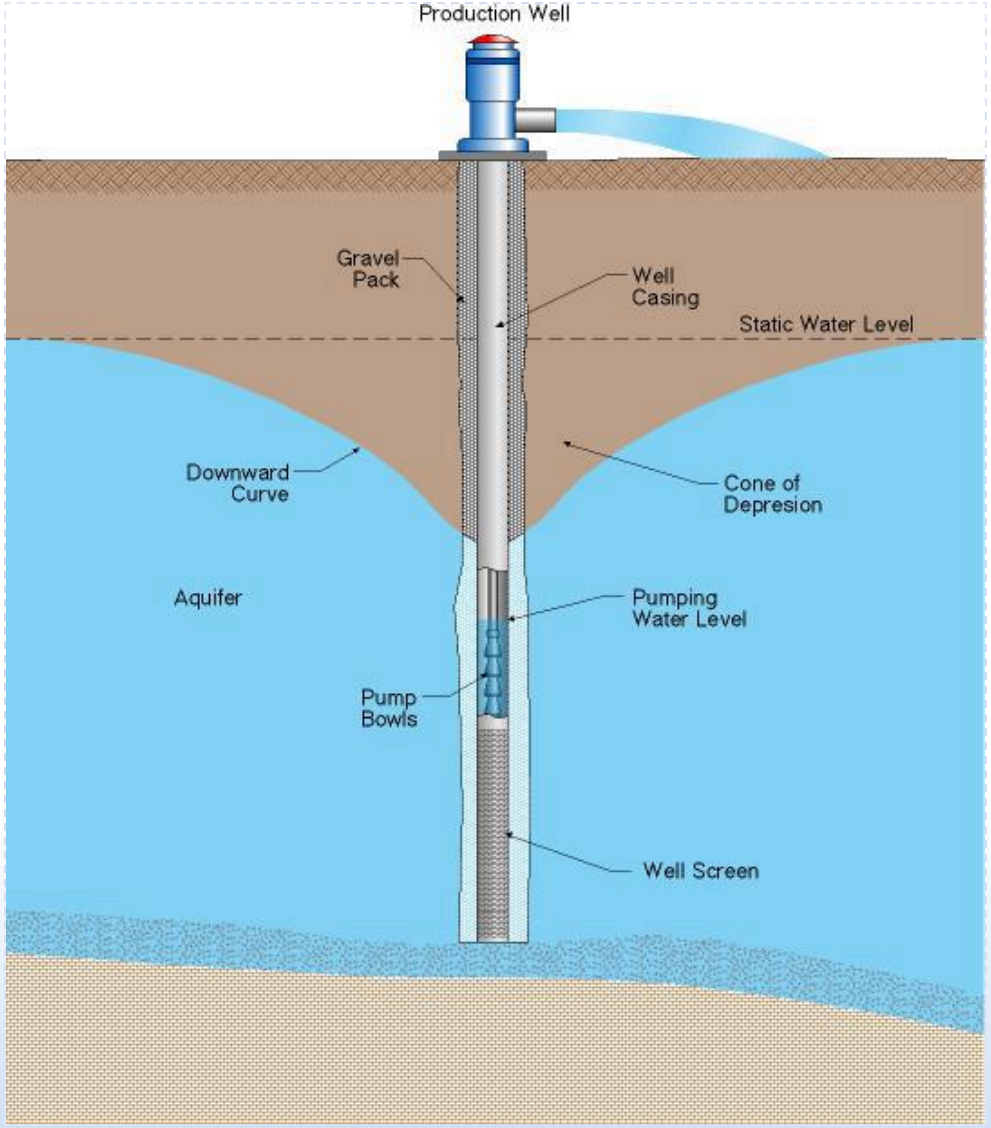
Deep Well Variable or Fluctuating Pumping Water Level Condition

1. Static or Standing Water Level (SWL)200'----------
2. Drawdown- 75'
3. Pumping Water Level (PWL) 275'----------
4. TDH (Total Lift) 275'



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Static Water Level lowers, so does Pumping Water Level, increasing TDH

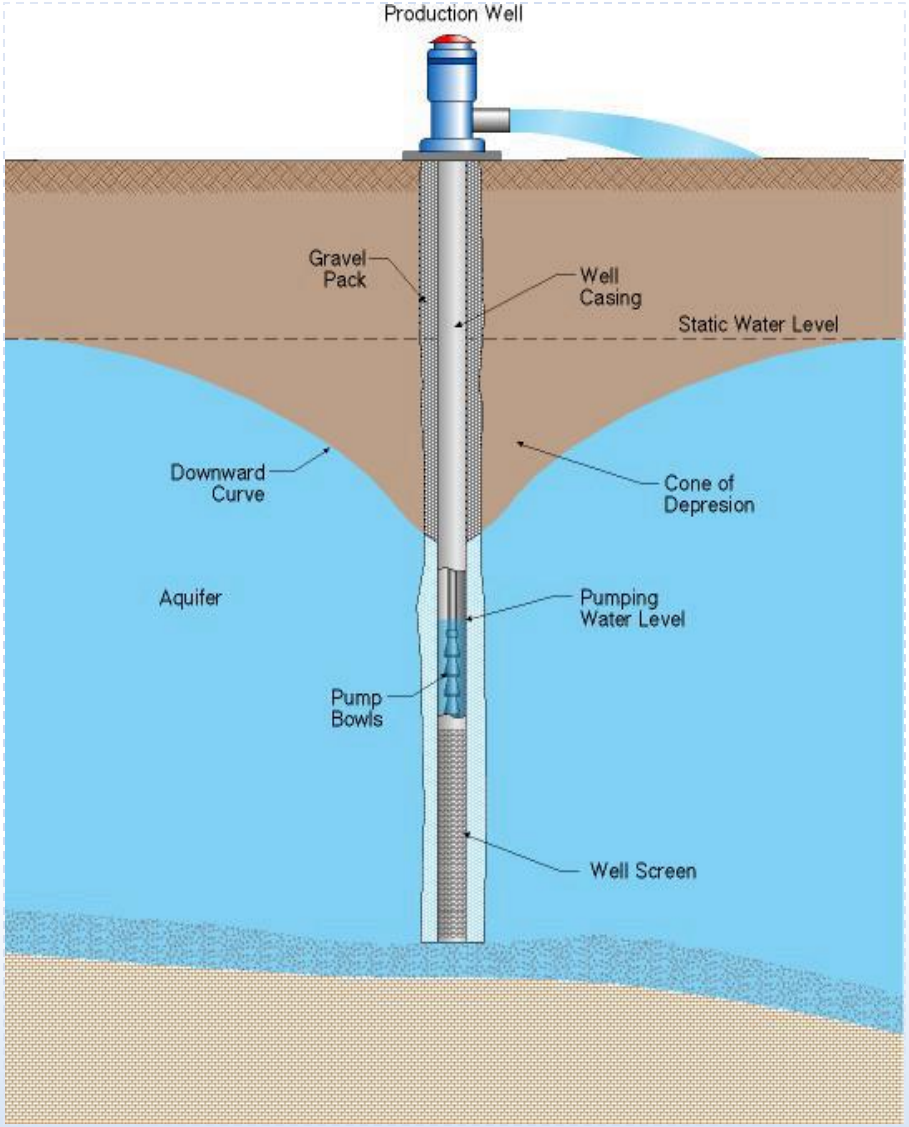
Static or Standing Water Level (SWL)200' to **250'------**

2.Drawdown- **75'**

3.Pumping Water Level (PWL) 275' to **325'----------**

4. TDH (Total Lift) **325'**

5. More horsepower is required to bring flow back- It always takes more horsepower to lift water from a greater PWL or create more pressure at the same flow



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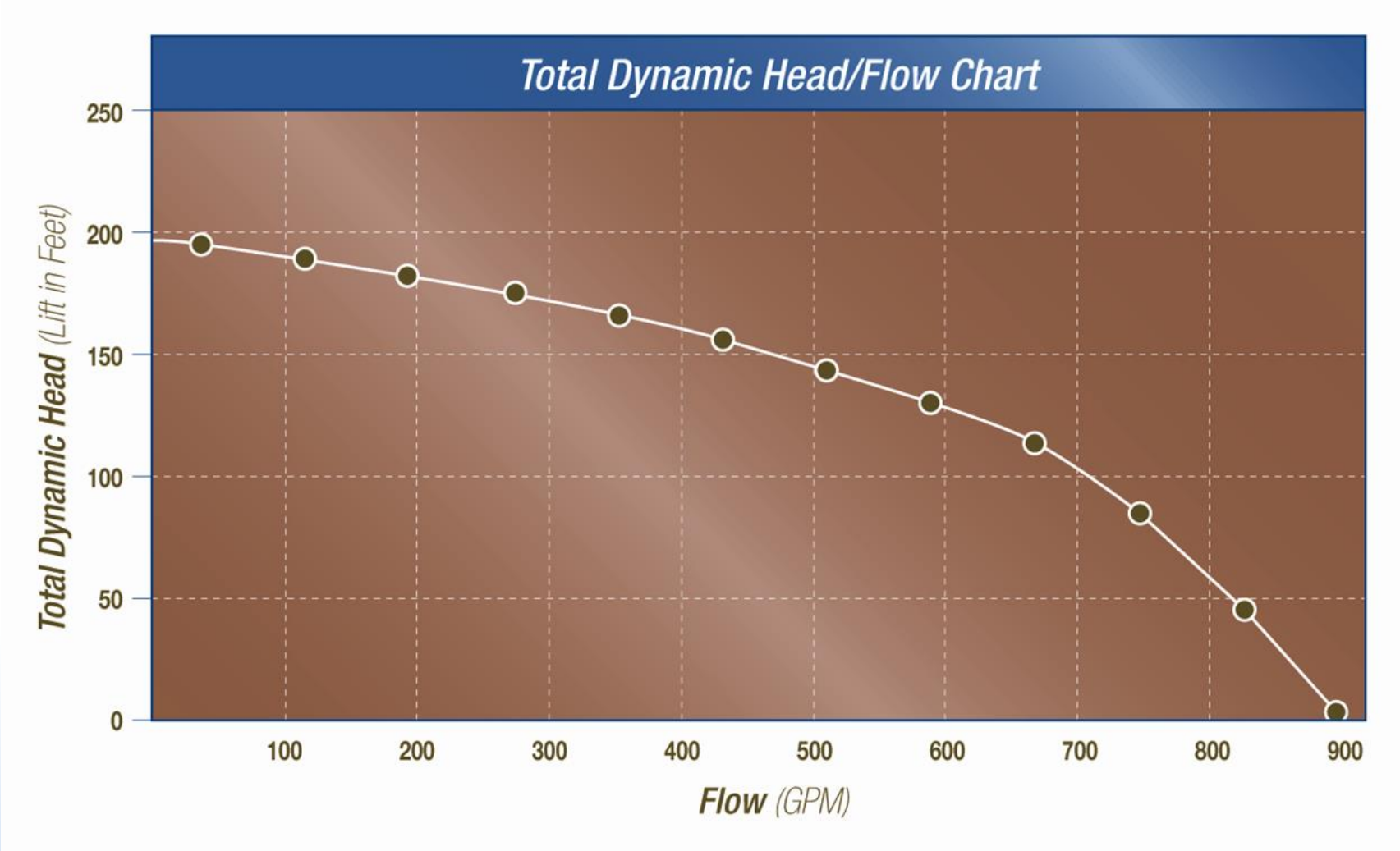
Simple Pump Performance Curve



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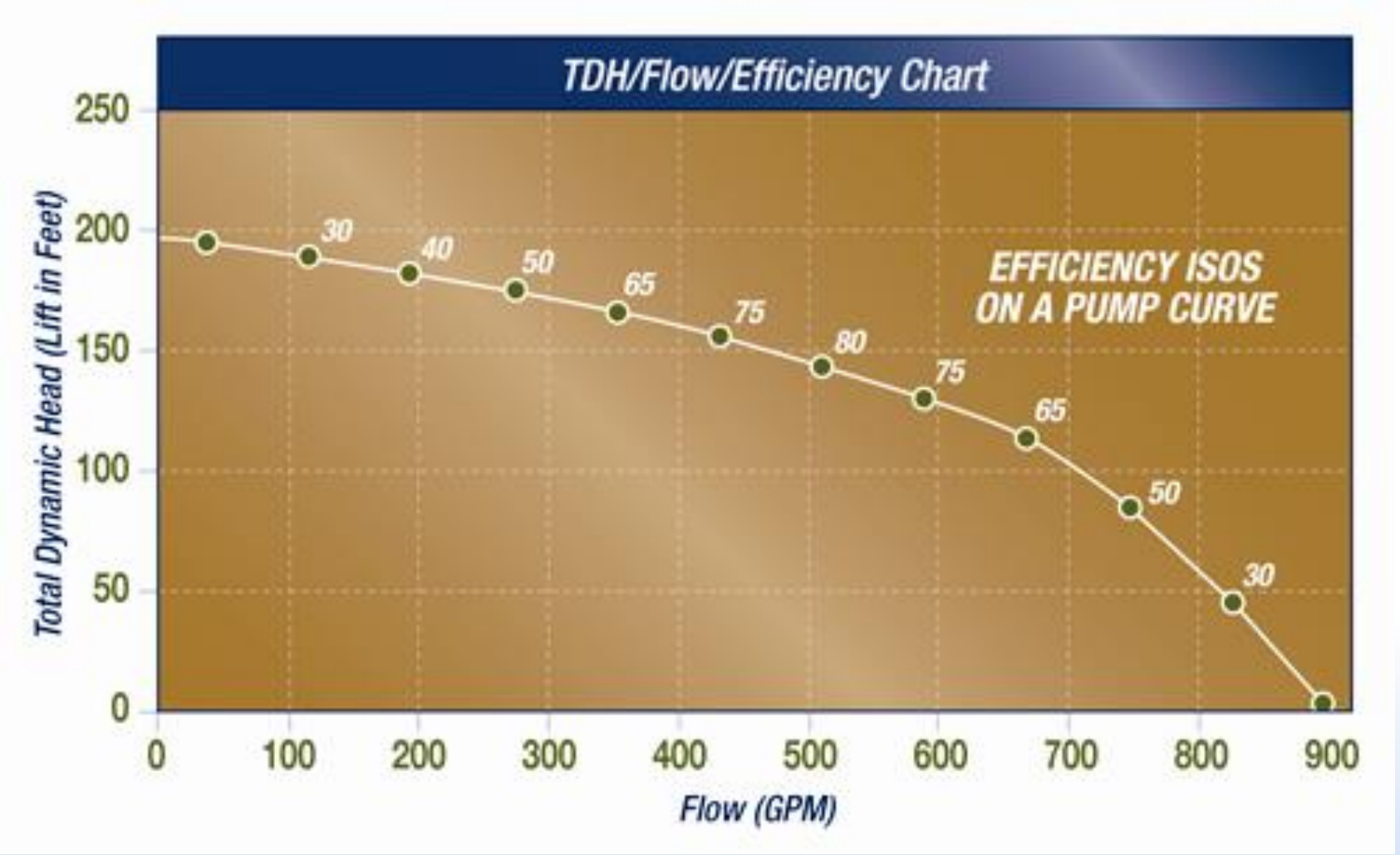
Pump Curve with Bowl Efficiency…



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What factors can affect pump output of flow and pressure?

- Changes in TDH, PWL changes, irrigation system changes
- Worn pump or irrigation system poorly maintained
  - Sand or silt can wear impellers
  - Bearings wear
  - Shaft and tubing not aligned properly
  - Motor has been re-wound multiple times, decreasing motor efficiency
  - Plugged irrigation system emission devices

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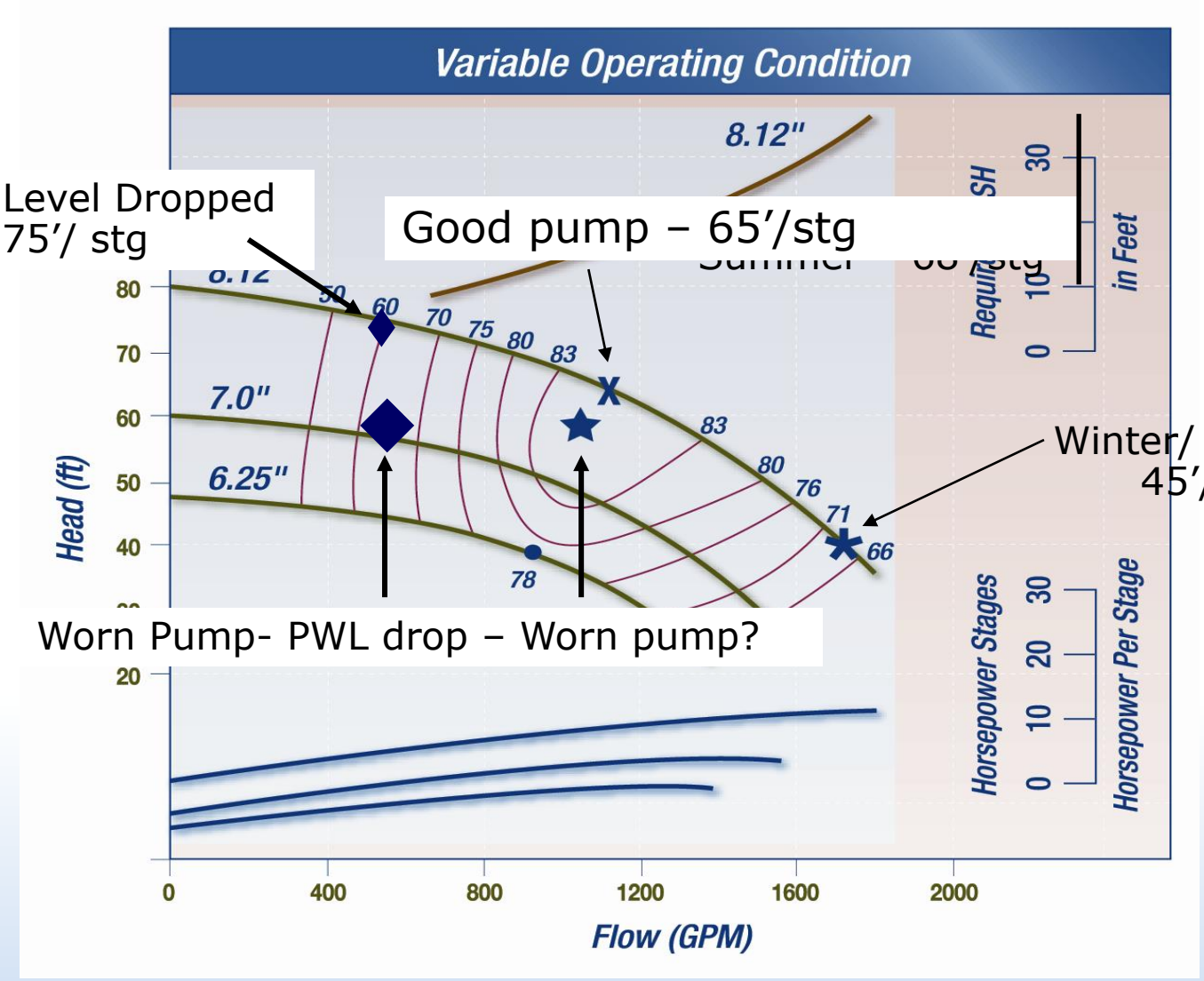

Water Level Dropped – 75'/ stg

Good pump – 65'/stg

Winter/ Spring – 45'/stg

Worn Pump- PWL drop – Worn pump?

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What can be done for lowering PWL?

1. Replace low efficiency old pump with new, high efficient and increased horsepower pump.
2. Oversize the pump HP and install a Variable Frequency Drive (gambling that the PWL will continue to fall)??? A VFD decreases efficiency by 4%, costs a lot to install and maintain.
3. Oversize the I/C driven pump and run a lower RPMs. As water levels lower, increase the speed of the pump.

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Groundwater Pump Efficiency Example…

-Before -	-After-
• Pump Horsepower- 75	• Pump Horsepower- 75
• PWL- 190 ft	• PWL 230 ft
• Discharge Pressure- 40 psi X 2.31 = 92 ft	• Discharge Pressure- 22.5 psi X 2.31 = 52 ft
• TDH = 282 ft	• TDH = 282 ft
• Flow Rate- 650 GPM	• Flow Rate- 510 GPM
• OPE- 62% (Good)	• OPE- 48% (Poor)

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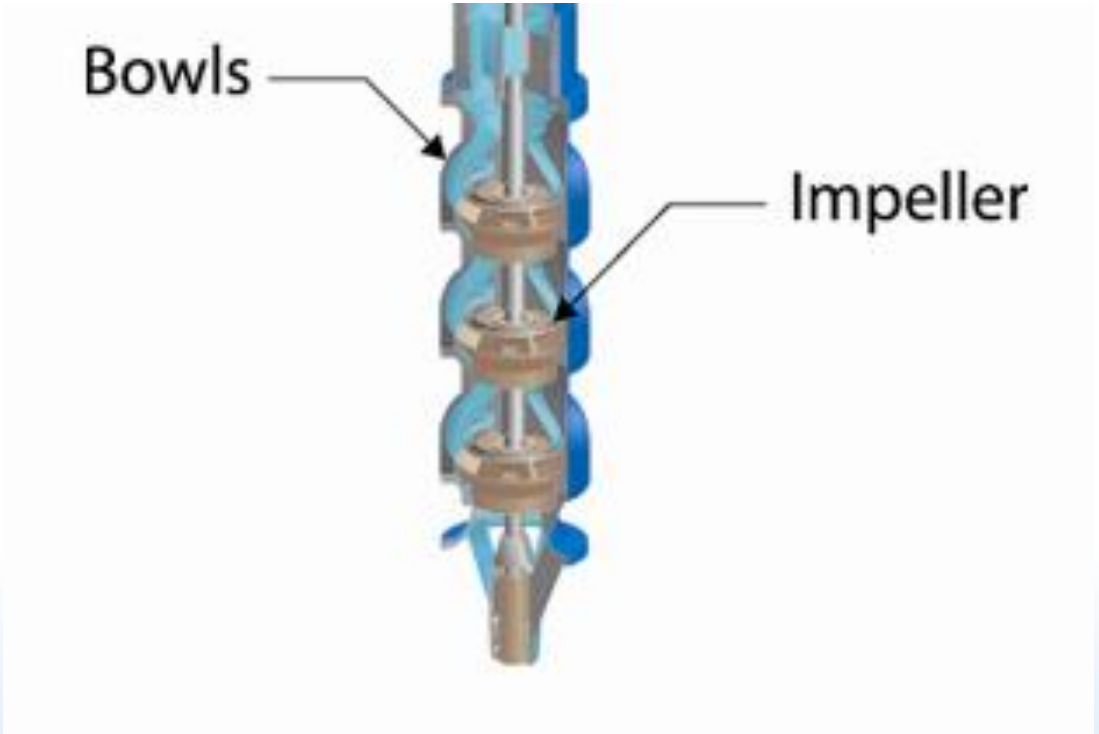
Bowl Efficiency

(Impeller Efficiency)

- The pump itself- After repairs poor pumps average 25-35% increased



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Affect of increased TDH on pumping costs and efficiency

Electric pumping cost example:

kWh/ acre foot = 1.0241 X TDH/ OPE

kWh/ acre foot- kilowatt hours per acre foot (energy per acre foot)

1.0241- Constant

TDH- Total Dynamic Head (lift in feet)

OPE- Overall Pump Efficiency

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Example

kWh/ acre foot = 1.0241 X TDH/ OPE

TDH- 400 feet

OPE- 0.60 or 60%

1.0241 X 400/ 0.60 = 682.73 or 683 kWh/ acre foot

kWh cost $0.21

683 X $0.21 = $143.43 per to pump one acre foot

Notice there is no flow rate, a 50 HP pump take twice the time as a 100 HP pump to pump an acre foot if the TDH and OPE are the same

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How do we size a pump?

HPin = Flow X TDH/ 3960 X OPE

HPin- Horsepower In

TDH- Total Dynamic Head (Lift in feet)

3960- Constant

OPE- Overall Pump Efficiency

Ex: Flow = 700 GPM

TDH= 400 feet

OPE = 0.25 or 25%

700 X 400/ 3960 X 0.60

280,000/ 2,376 = 117.8 or 118 HP pump (install 125 HP perhaps)

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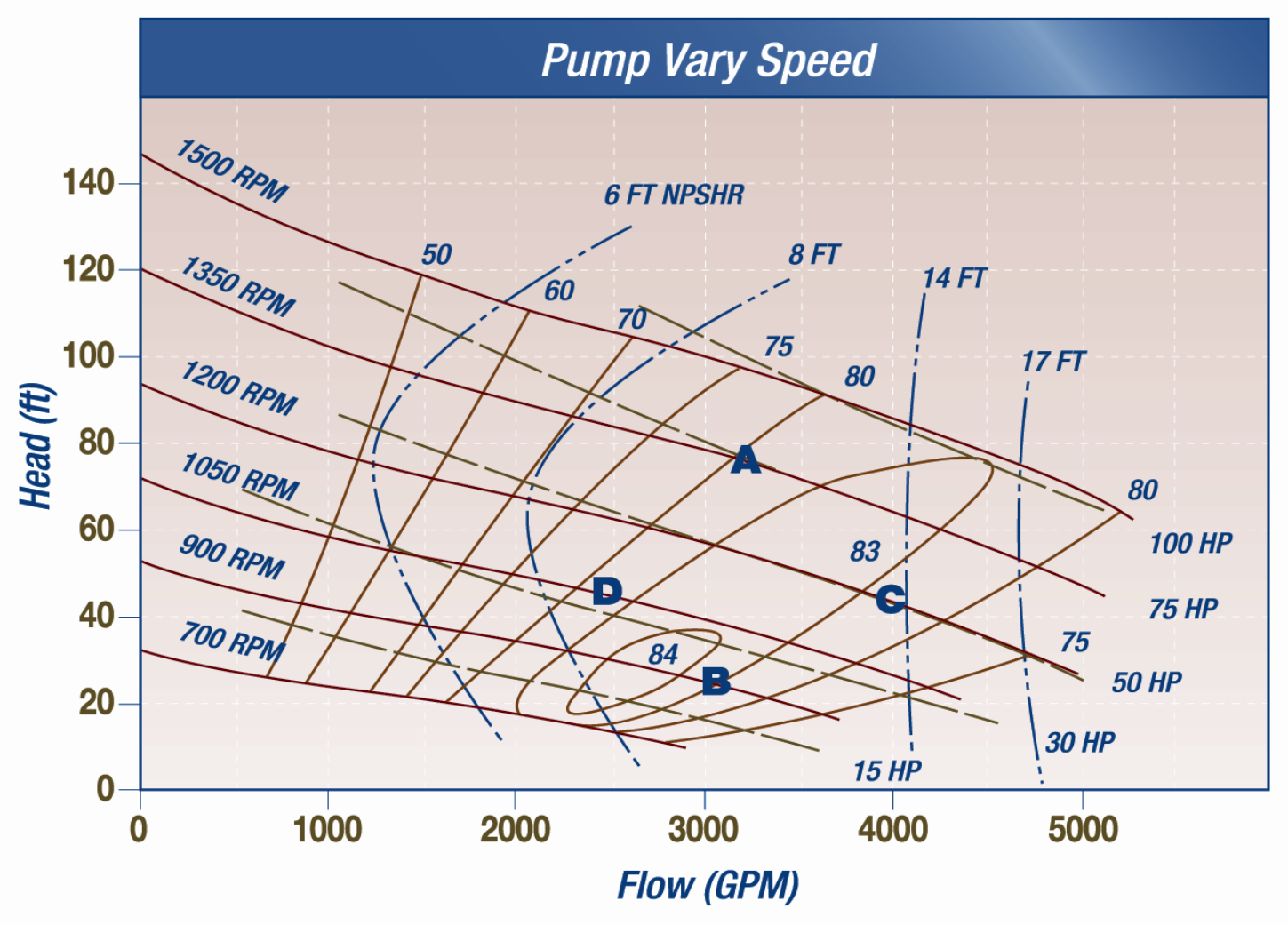
Pump Curves at different speeds- VFDs



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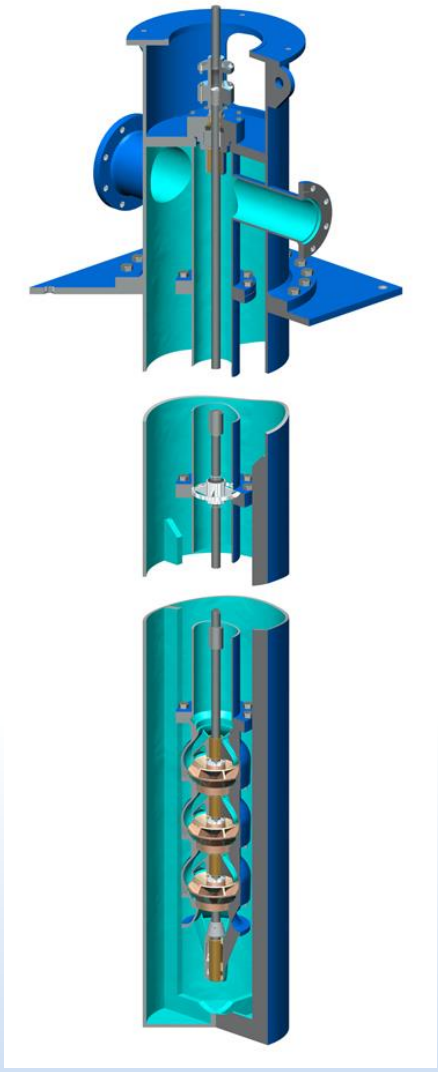
Brake Horsepower, not including power source



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Continuous pump efficiency testing

What is needed to get continuous pump efficiency?

1. Flow rate from an accurate flow meter
2. Total Dynamic Head in feet or Total Pump lift including:
    a. Feet of lift from the Pumping Water Level (as the pump is running (well water level sensor)
    b. Pressure X 2.31 = feet of head at the discharge
3. Energy in
    a. Horsepower in

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OPE equation- just switch the HPin equation

If:

HPin = Flow X TDH/ 3960 X OPE

Then:

OPE = Flow X TDH/ 3960 X HPin

Ex.

Flow- 400 GPM

TDH- 450 feet

Hpin- 181.81 (from earlier HPin equation)

400 X 450/ 3960 X 181.81 = 180,000/ 719,968 = 0.25 or 25% OPE

If we are monitoring flow, TDH including Pumping Water Level and discharge pressure, and HPin from the pump, we can get continuous OPE

Get your pumps tested, subsidized pump efficiency tests- 40+ HP every 23 months

Eligible pumps

- Agricultural pumps
- Municipal pumps
- Large turf, golf courses, parks, recreational
- Tertiary treated wastewater

Ineligible pumps

- Primary and secondary treated wastewater
- Differences between PG&E and SCE?
- Industrial - differences between SCE and PG&E?
- Change in operating condition (i.e. flood to drip)

Contact us

PG&E Advanced Pumping Efficiency Program (APEP)

- (800) 845-6038 - APEP main office
- Bill Green - wgreen@csufresno.edu
- Kayla Perez- kaylaperez@mail.fresnostate.edu
- Crystal & Adriana – apep.student@gmail.com
- APEP web site- pumpefficiency.org
- PumpingEfficiency@pge.com

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Thank you!

Questions?