Smarter Irrigation for Profit

NCEA
National Centre for Engineering in Agriculture

UNIVERSITY OF SOUTHERN QUEENSLAND

Centre Pivot Irrigation Performance & Energy Use Implications

SA Dairy Mt Gambier
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Dr Joseph FOLEY BEng(Agric), MEng(Mech), PhD MIEAust
Agricultural Engineer - Water Engineering and Irrigation
em: foley@usq.edu.au

Dairy Australia

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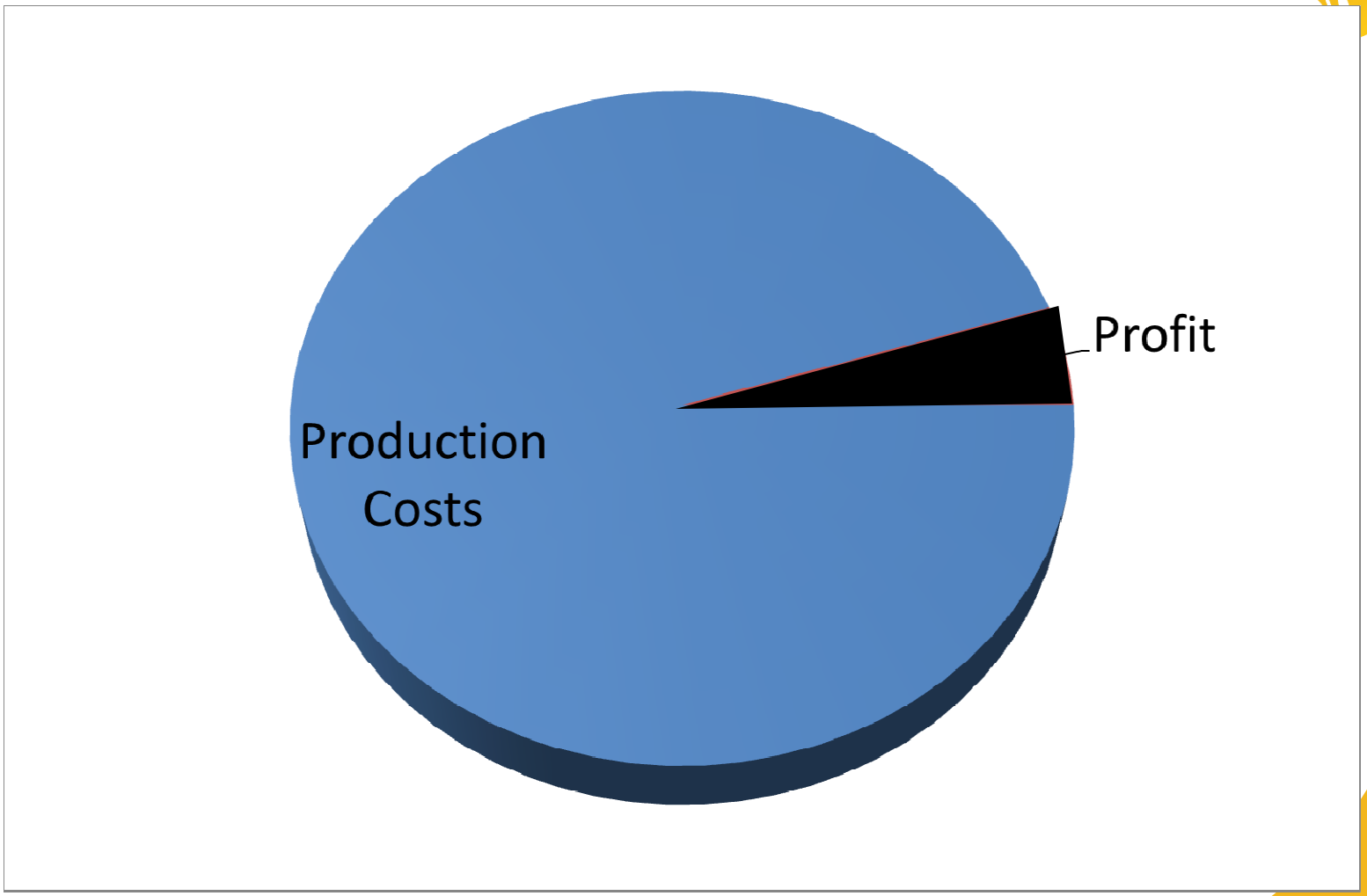
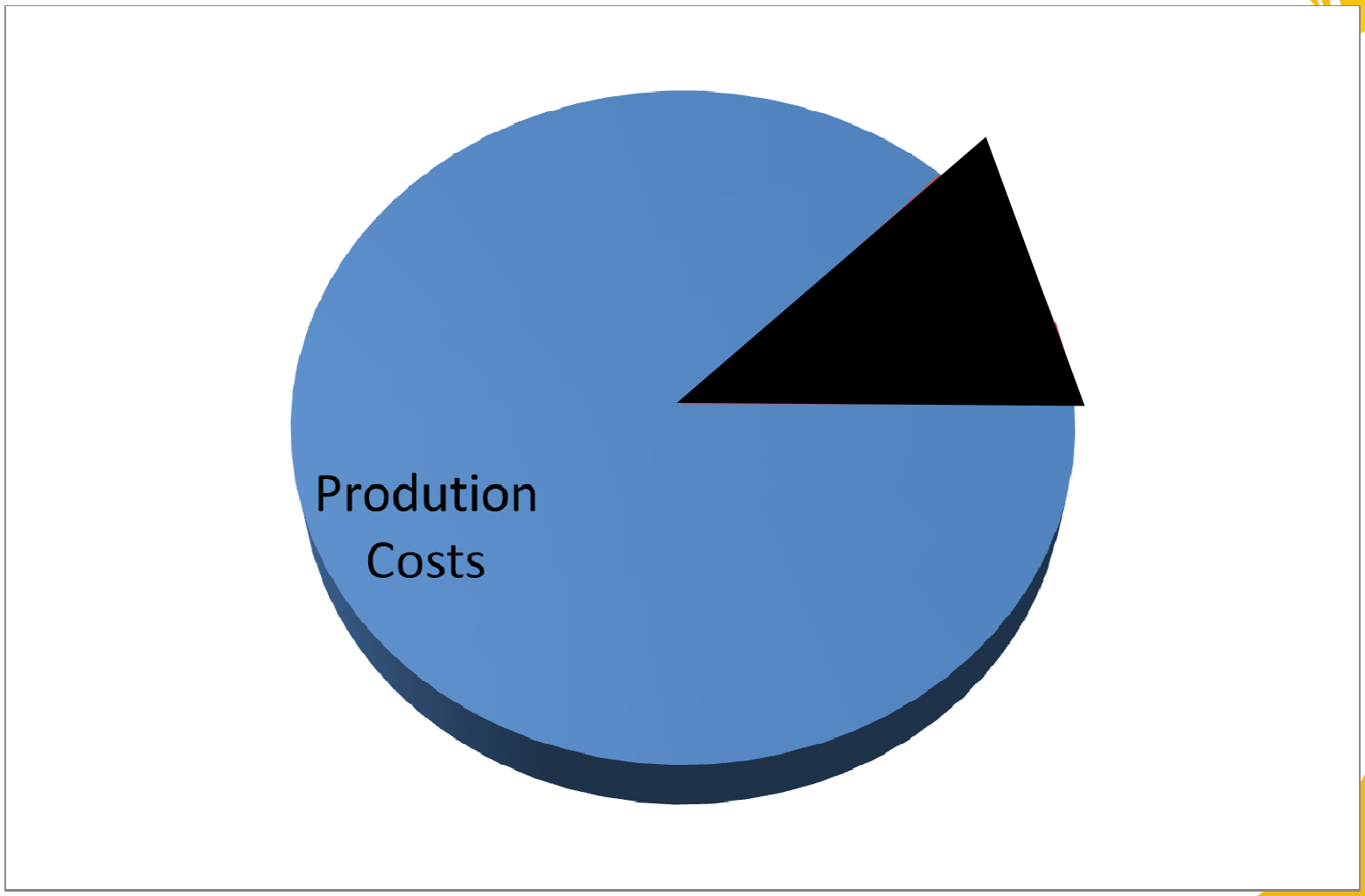
Why are we here? Production Costs vs Profit



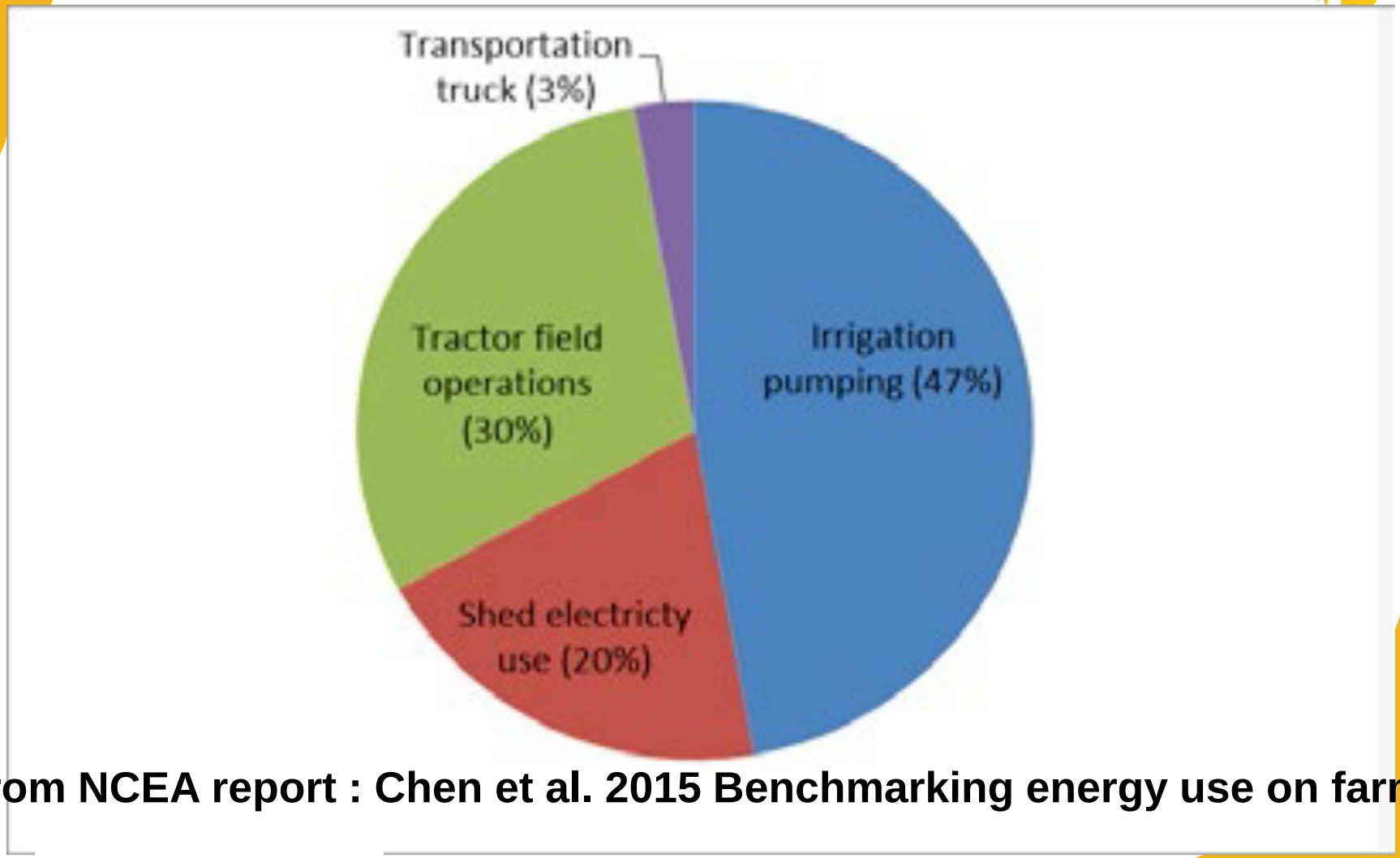
Reducing your Costs a little means increasing Profit a lot



Why focus on Energy?

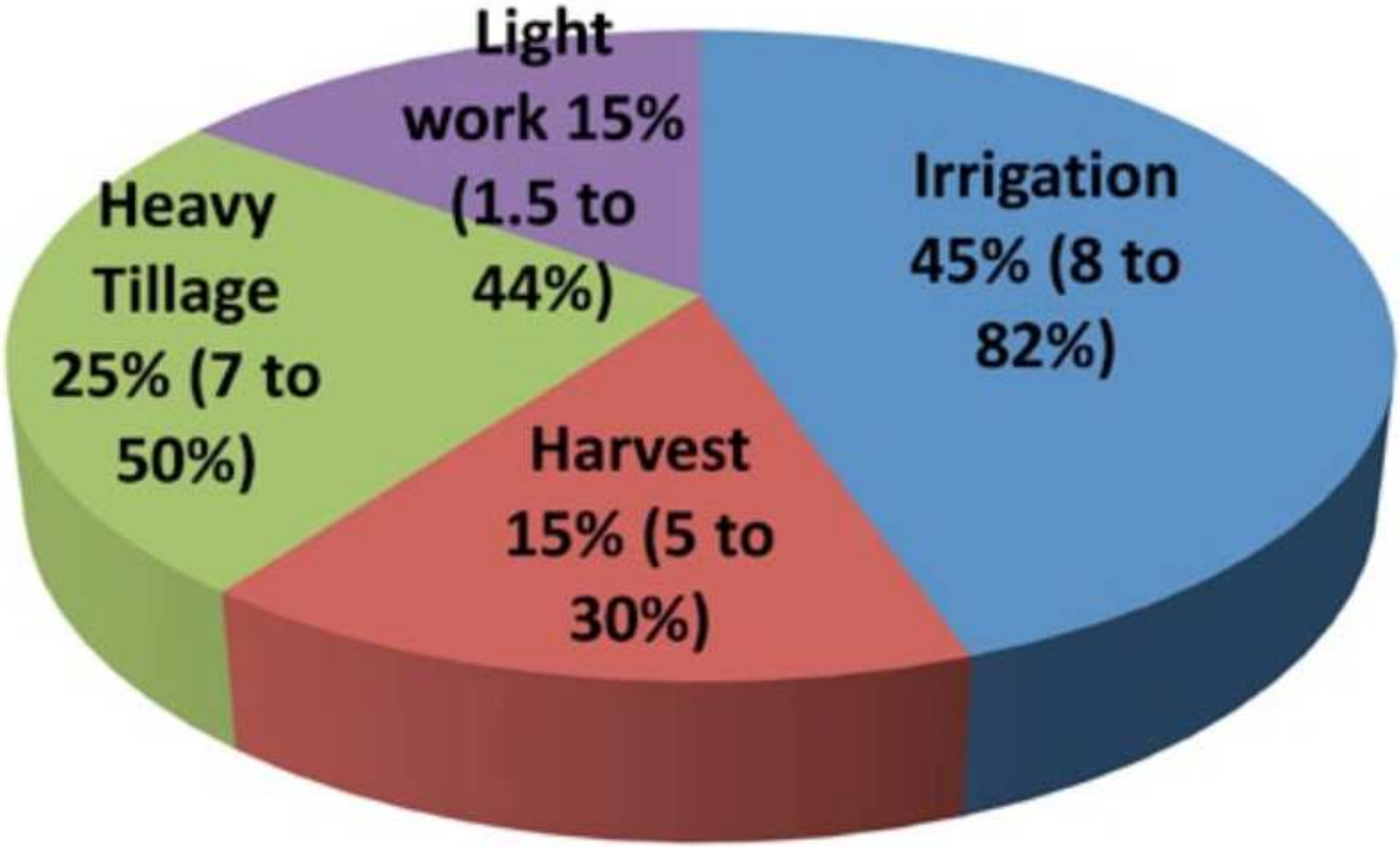
- Agricultural production is energy intensive
  - it is based on machinery, fertilizer & pesticide inputs
- Fastest growing input cost to irrigated agricultural production is Energy costs
- Energy Efficiency is all about how well machinery converts Energy into useful work

Distribution of on-farm energy uses for a hypothetical farm



From NCEA report : Chen et al. 2015 Benchmarking energy use on farm

Energy use split on irrigated grain & cotton farms



From : Foley et al. 2015, Improving Energy Efficiency – Farm Level Benchmarking Report in Cotton, CRDC

Energy use in pumping

Pivot Site	Flow m3/hr	Pump Size	Motor size (kW)	kWh/ML	$/kWhr	$/ML
Rocky Cape	232	150x125-315	30	113	0.23	$26.08
Montana	225	150x125-315	37	157	0.23	$36.16
Cressy	316	150x125-250	75	220	0.23	$50.65
Riana	163		45	304	0.23	$70.00
Sisters Creek	92	100x65-315	75	787	0.23	$181.05

- **Benchmarks**
  - 4 to 8 kWh/ML/m head
  - 150 to 300 kW.h/ML
  - $30 to 70/ML Daley and Callow 2014

Fact Sheet: Energy in pumping

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fact sheet May 2015

Fundamentals of energy use in water pumping

Lifting and moving water around farms with pumping systems for irrigation consumes plenty of energy as water is a heavy liquid. Every litre of water has a mass of one kilogram. A cubic metre of water has a mass of 1000 kg, or a tonne, and a volume of 1000 litres. A Megalitre (ML) has a mass of one million kilograms or one thousand tonnes.

First facts first:

Fact 1. Earth's gravity, g = 9.81 metres per second per second (m/s2)
Fact 2. 1 Litre (L) of water = 1 kilogram (kg)
Fact 3. 1 MegaLitre of water (ML) = 1 million kilograms or 1 thousand tonnes

When we lift water we use energy to work against

Pump located at St George grower Ian Brimblecombe's property. Photo courtesy: Seedbed Media.

Fact 7. 1 kiloWatt-hour (kWh) of electricity contains 3.6 MegaJoules (MJ) of energy

Search engine : "fundamentals of energy use water pumping Joseph Foley"

What is Power? – what is Energy?

- **Energy** is the “stuff you buy” that allows machinery to do work - measured in MegaJoules
- You buy “Litres of Diesel” or “kiloWatt.hours of electricity”
- 1 Litre Diesel holds 38.4 MegaJoules (MJ)
- 1 kiloWatt.hour Electricity holds 3.6 MegaJoules
- **Power** rating is all about how fast you can burn “the stuff you buy”
- A motor with a big power rating in kiloWatts will burn “the stuff you buy” more quickly

Need irrigation but water is heavy. Needs lots of energy to shift it

- Water is very **HEAVY** material!!
- 1 Litre is a kilogram. 1000 litres is a tonne.
- 1 MegaLitre(ML) is 1000 tonnes= 20 B-double truck
- Need **Lots** of Energy to lift & move water
- 1 ML in this room (15m × 30m) is 2.22 m deep
- 1 ML on 1 ha is same as 100 mm water depth
- Every ML per ha is 1000 tonnes per hectare

Lots of Energy needed to lift water

- So, 1 ML per ha is 20 B-double trucks per ha!!
- In an ideal world, each MegaLitre (ML) lifted up one metre of height uses 9.81 MegaJoules (MJ) or 2.725 kiloWatt.hours (kW.h) of Energy
- In the real world, to lift 1 ML up 1 metre, with pump efficiency of 80% and electric motor efficiency of 90% you need 3.785 kiloWatt.hours(kW.h) of Energy
- Best possible case is 3.3 kW.h per ML per metre lift
- Worst likely case is 5.8 kW.h per ML per metre lift

Pump Curve

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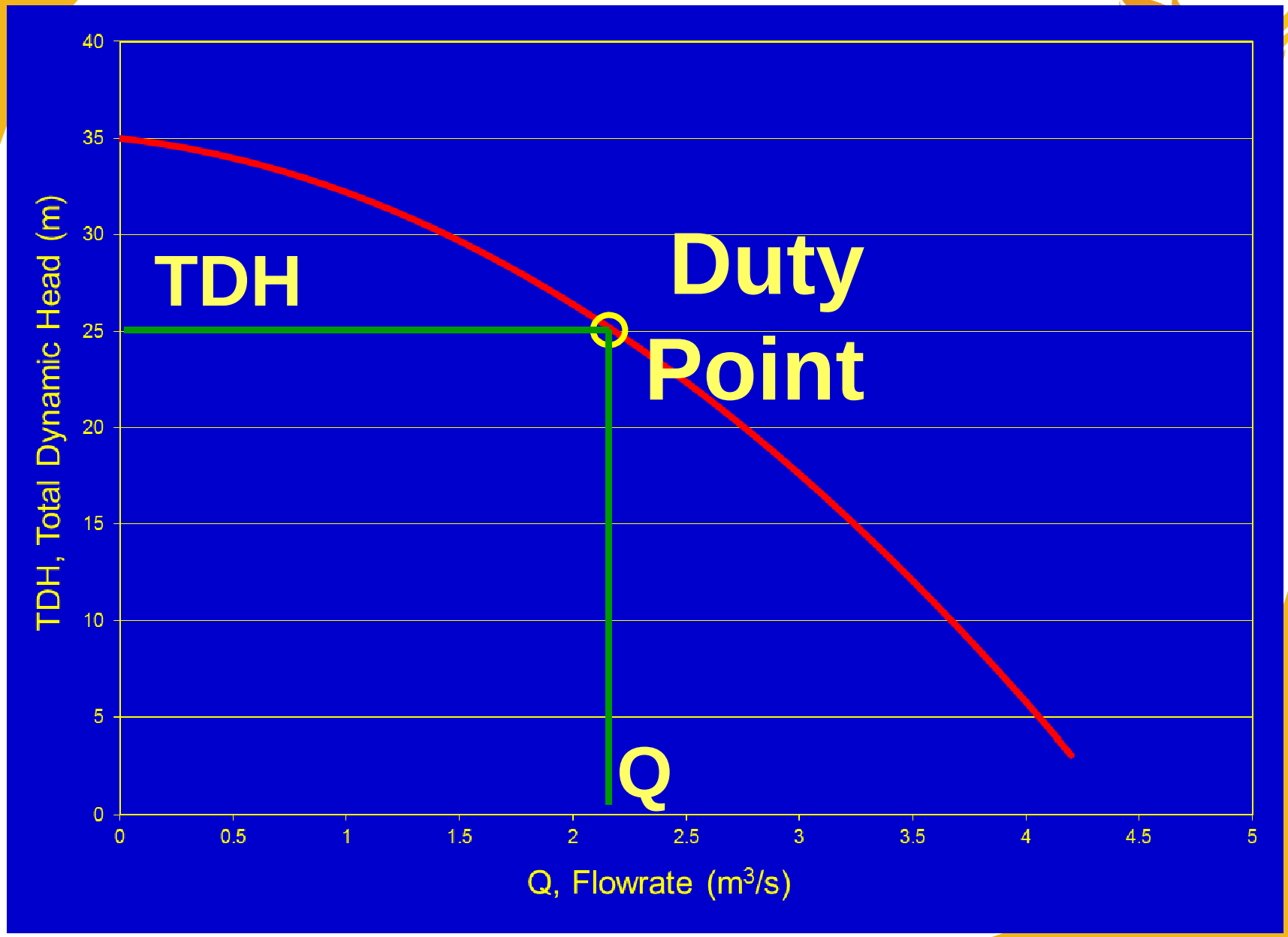


1770 RPM ENCLOSED TYPE IMPELLER 10BKM

NUMBER OF STAGES	EFFICIENCY CHANGE (NO. OF POINTS)
1	- 3
2	- 1
3	- 0

HORSEPOWER WILL BE AFFECTED BY CHANGE IN EFFICIENCY

PUMP DATA

Shaft Dia.(IN)	1 1/2
Maximum Sphere (IN)	1
Maximum Head (FT)*	950
Min. Submergence (IN)**	20
Impeller Weight (LBS)	9.75
Thrust Constant (K)	10
Thrust Bal Const. (K)	N/A
Bowl O.D.(IN.)	9 5/8
Bowl Height (IN.)	8 1/2
Bell DIA. (T) (IN.)	11 1/4
Strainer height (IN.)	4 7/8
Impeller C-line(X)(IN.)	10 3/4
Eye Area (IN^ 2)	20.9

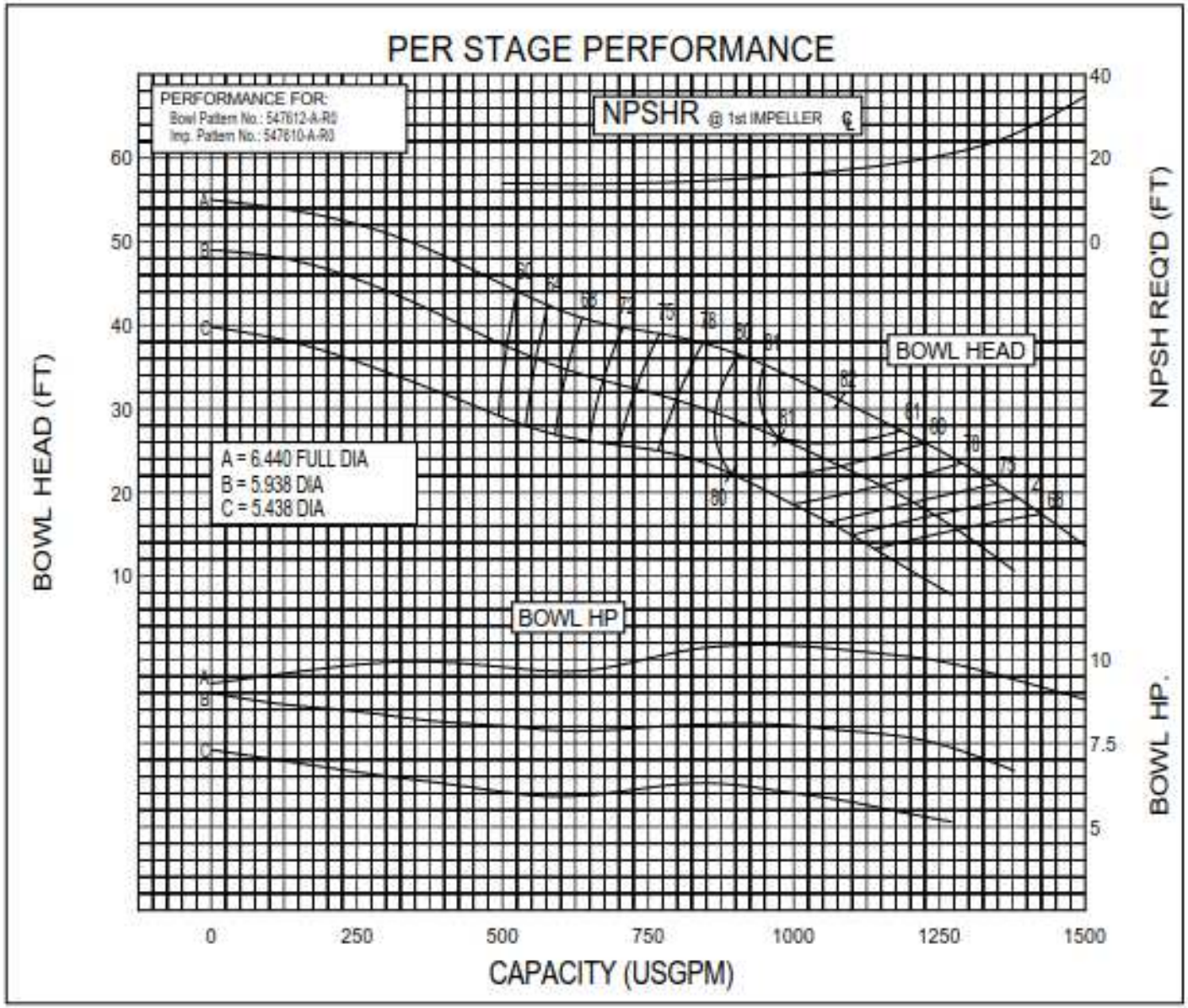
NOTES

Performance indicated based on cold water with specific gravity of 1.0.

* Standard Construction.

** Minimum submergence over lip of bell to prevent vortexing.

Efficiency improvements are available in certain instances. Please contact the factory.



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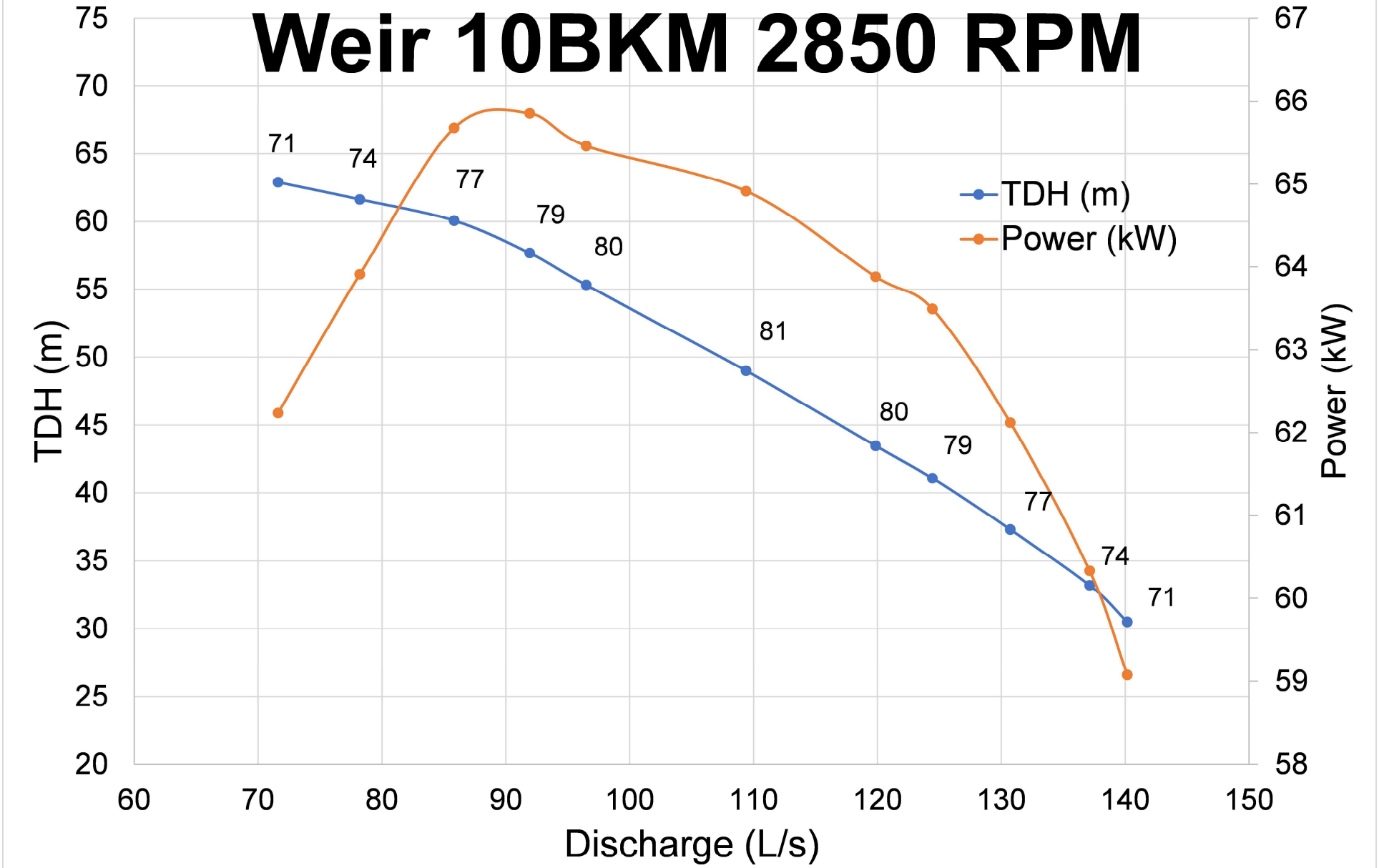

Five key parts involved in pump Total Dynamic Head

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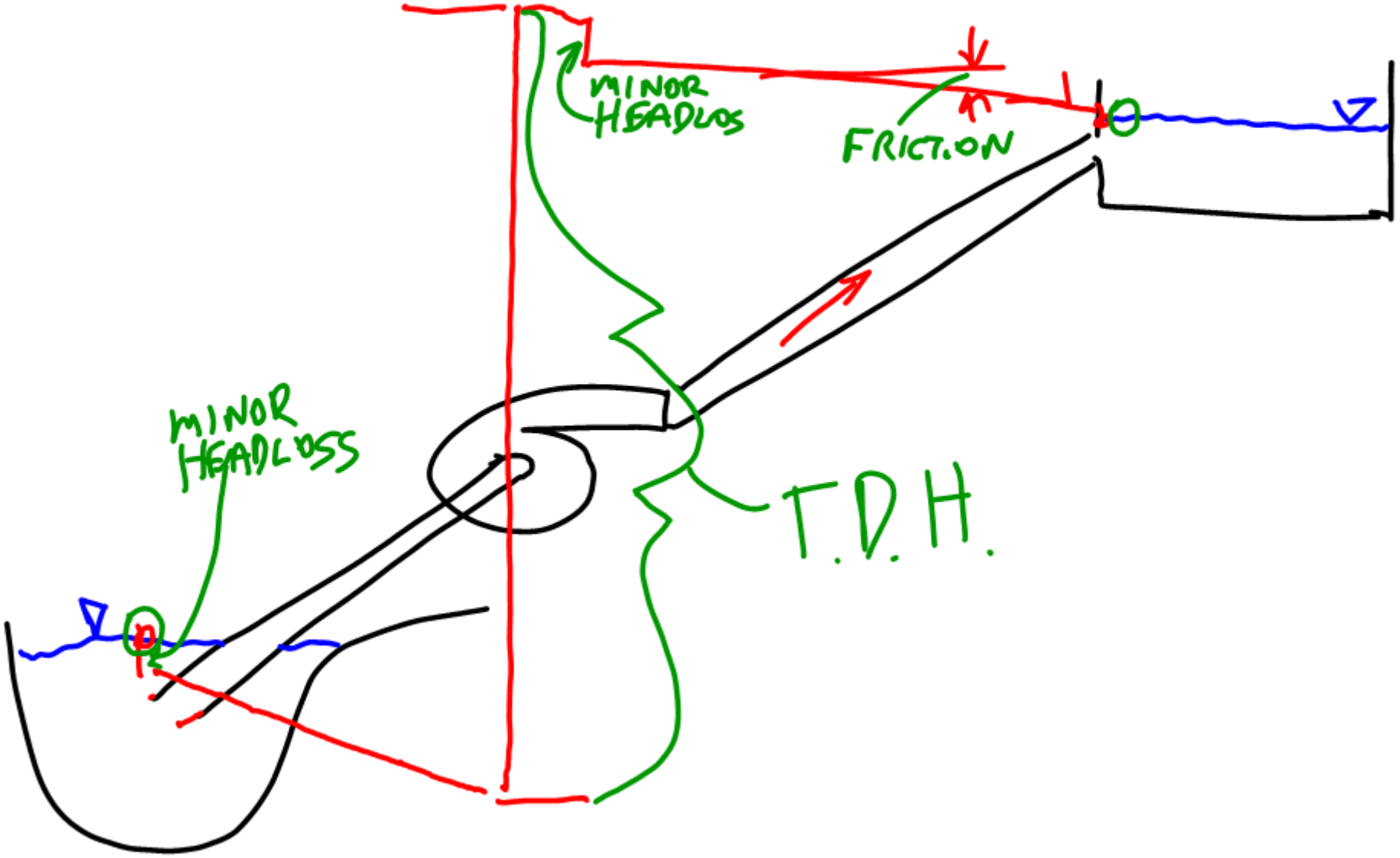
- Elevation Head
- Pressure Head
- Velocity Head
- Friction Headloss
- Minor Headloss

Pump Total Dynamic Head & Energy Line



System Resistance & Pump Curve

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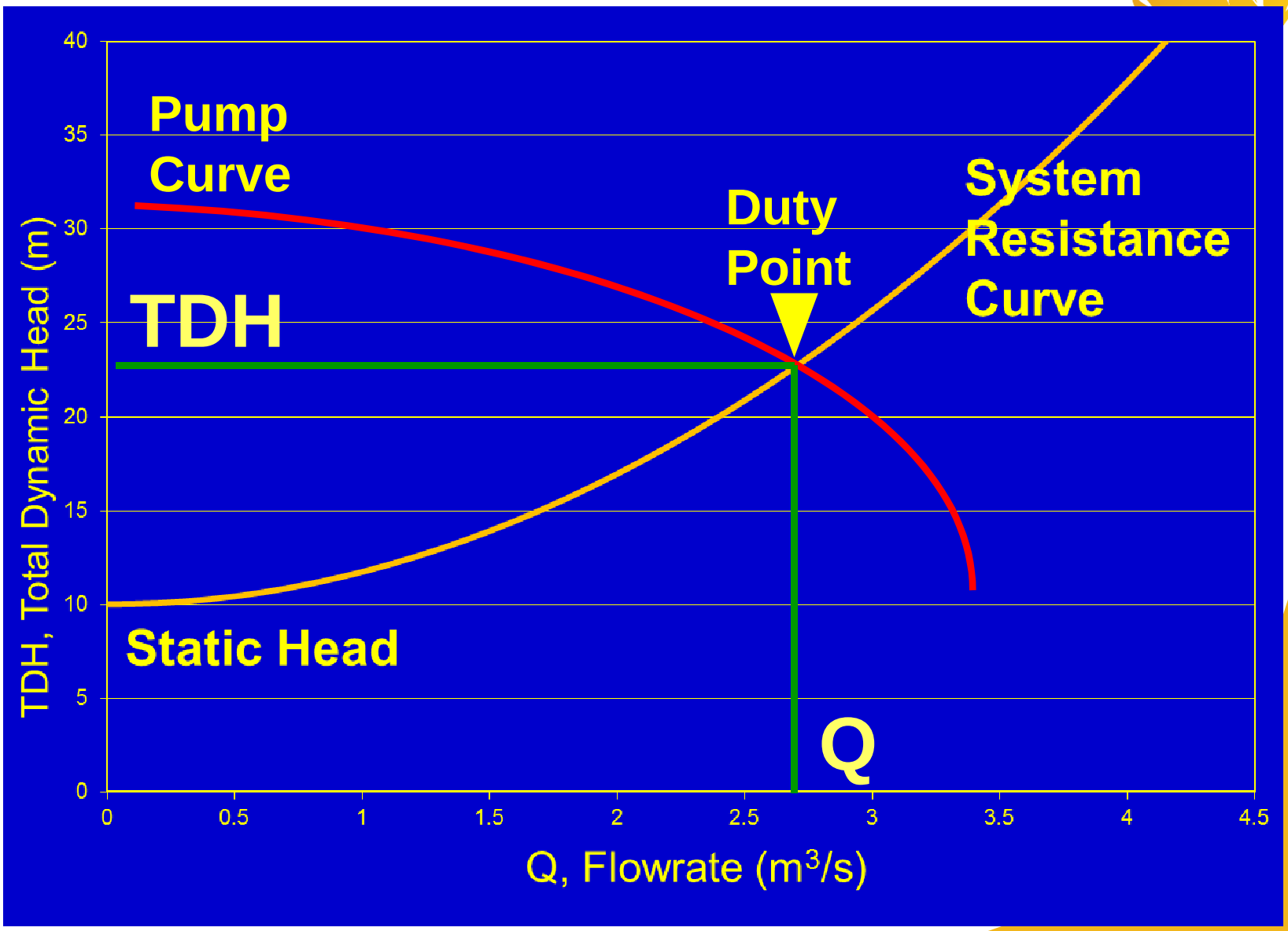

Altering Duty Point

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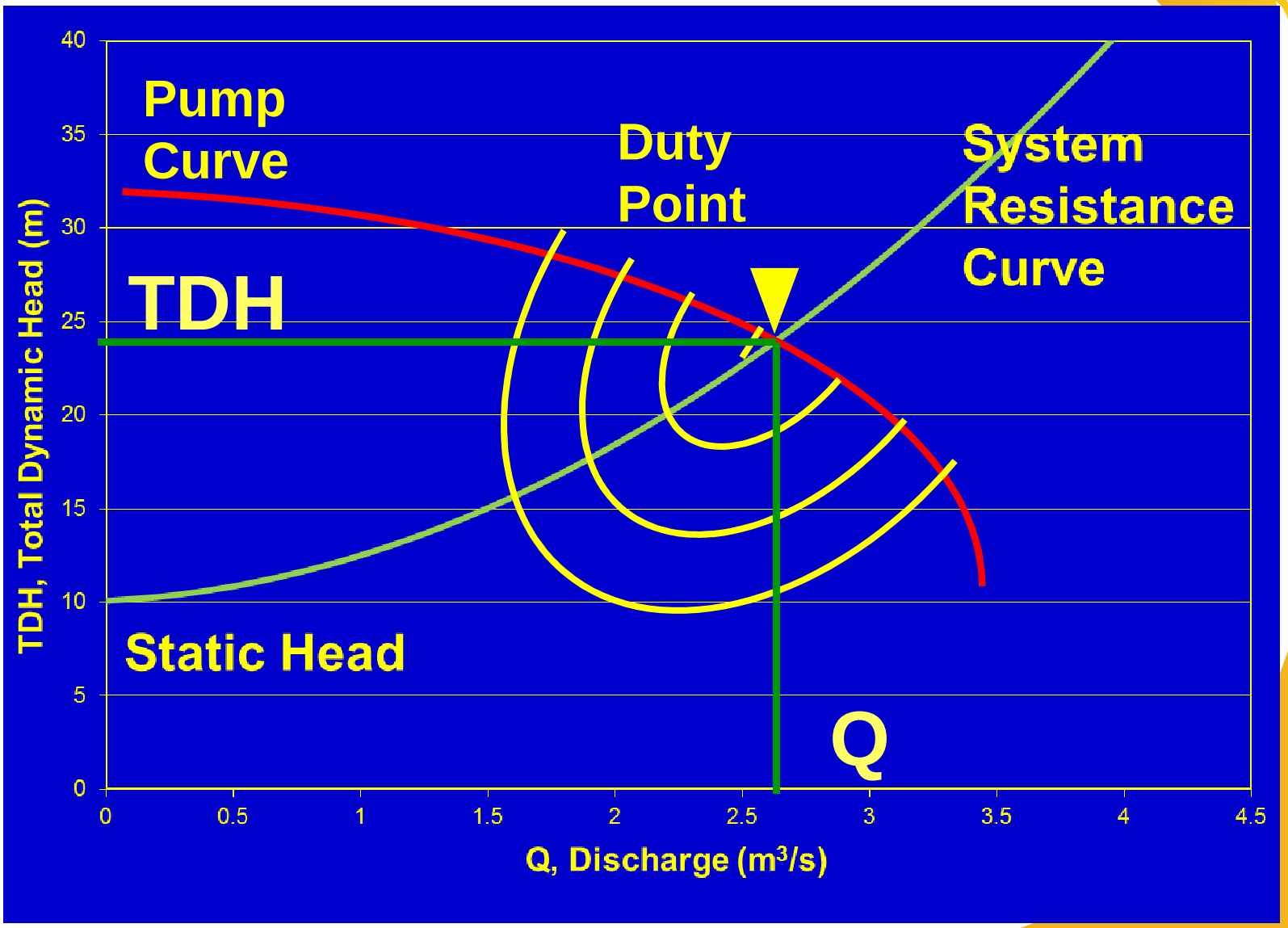

Energy use of Centre Pivot

- Example : CP of 508 metres length with 450 metre deep GW bore and Weir 10BKM 2 stage pump with measured 111 L/s flowrate and measured power draw of 84 kW :
- Two different tariff structures paid across the farm
- Large Business (greater than 160,000 kW.h per year, Agreed demand of 121 kVAr): Peak rate = 23c/kW.h, Off-Peak rate = 14.6c/kW.h, daily charge of $49/day
- Small Business (less than 160,000 kW.h per year): Peak rate = 35.8c/kW.h, Off-Peak rate = 19.5c/kW.h, daily charge of $6/day

Energy use of Centre Pivot

- Same Example – REDUCE system capacity
- A 11.84 mm per day sprinkler package will have a flow of 111 L/s and a pump TDH = 48.5 m with machine power draw of 84 kW.
- A 7.4 mm per day sprinkler package will have a flow of 69.4 L/s and a friction headloss 39% of original saving 6.5 m head, so TDH = 42 m head, need different pump, but gives 39.2 kW power draw
- Comparison with 51.8 mm applied for the week, which is 42 ML pumped for the week.

Energy use of Centre Pivot

- Same Pivot – REDUCE system capacity, change pump
- For 11.84 mm per day sprinkler package, pumping 15 hrs/day, 7 days per week, Cost is $1810/wk
- For 7.4 mm per day sprinkler package, pumping all week , cost is $1900/wk
- Saving of $90 per week in peak summer months from pumping costs by using high system capacity
- About a 1.3% increase in actual energy consumed (8820 kW.h vs 8702 kW.h)
- Compared 51.8 mm applied for the week, which is 42 ML pumped for the week for both.

Energy use of Centre Pivot

- Same Pivot – CHANGE tariff to Small Business
- For 11.84 mm per day sprinkler package, pumping 15 hrs/day, 7 days per week, Cost is $1810/wk
- For small business tariffs 35.8c & 19.5 c/kW.h & $6/d :
- Cost is $2105/week pumping 15hrs /day
- $295 /week saving using Large Business Agreed Demand

Energy use of Centre Pivot

- Same Pivot – CHANGE kVAr rating
- For 11.84 mm per day sprinkler package, pump power draw of 84 kW for pumping & movement, plus 2.2 kW from stock & domestic pump
- Assuming $\cos\phi = 0.9$, current kVAr is 120.955 kVA
- kVA rating is charged $0.274/kVAr/day
- For existing 86.6 kW power draw, then $86.6 \div 0.9$ giving kVAr of 96.2 kVA
- Reducing kVA demand to 80%, saving $2400/yr

Irrigation Energy Costs

- Moving water is all about using energy (kW.h)
- Every ML of water per ha is a 1000 tonne/ha
- Increasing energy costs, forces improved conversion of the energy you buy (kW.h)
- Electricity(kWh) to pump 1 ML $= (2.725 \times TDH) \div (Eff._{Pump} \times Eff._{Drive} \times Eff._{Motor})$
- Moving toward lower pump TDH

  = lower energy costs
- Don't burn your profit to irrigate better

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