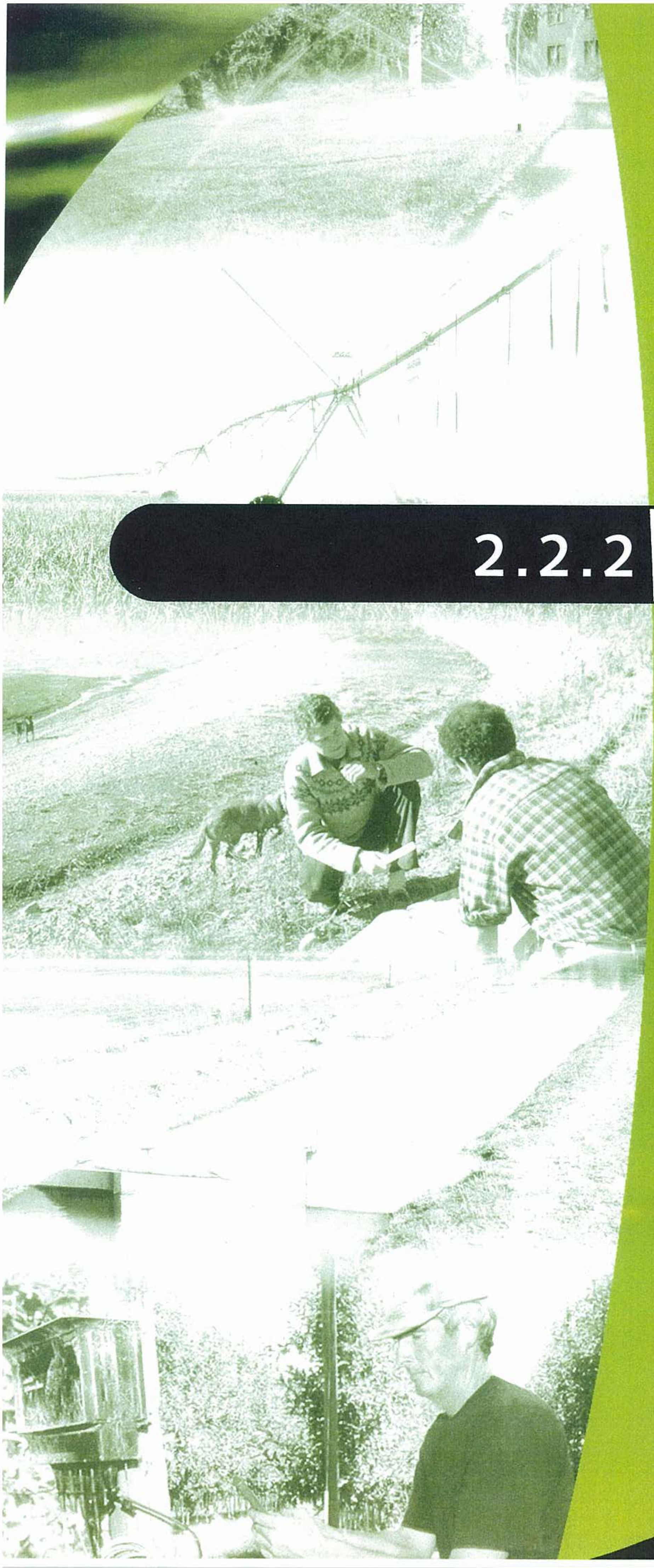


2.2.2 PUMPS AND WELLS

How to operate your pump to minimise energy use

Most sprinkler irrigation systems use either positive displacement, surface centrifugal or multistage submersible pumps to provide the pressure to operate the system. Factors such as irrigation system configuration, changing groundwater levels and water quality can affect how much energy, whether it be electricity or diesel, is used.

Power rating

The aim is usually to pump as much water as possible with as little energy as possible. A simple measure to use for comparative purposes is power rating, which is:

$$\text{Power rating (kWh/m}^3\text{)} = \frac{\text{seasonal energy used for irrigation (kWh)}}{\text{seasonal water use (m}^3\text{)}}$$

Electricity use can be obtained from your electricity accounts. 1 kWh = 1 unit of electricity. If using diesel, energy use is approximately 3.2 kWh per litre of diesel used.

Power ratings should be calculated at the end of each season and if they are increasing, the reason for the increase should be determined.

What affects energy use

Over a season, total energy use is affected by:

- number of hours system is used
- time of day system is used (where night-rate electricity or TOU metering is available)
- condition of pumps
- condition of motors
- flow rate relative to most efficient operating point
- degree of flow restrictions or throttling in the system
- groundwater levels.

Power ratings are affected by all of the above except the number of hours the system is used.

What can you do about it?

Number of operating hours

This depends on the climatic conditions occurring each season (which you can do little about), and how efficiently the irrigation has been carried out. Poorly designed and maintained systems will need to operate for more hours than well-designed and maintained systems to achieve the same result.

If you think there might be problems with the design, get an independent irrigation system audit carried out. Make sure the irrigation system is properly maintained so that breakdowns and unwanted stoppages are minimised. Use irrigation scheduling or soil moisture measurement to improve operation.

Time of day

It is usually uneconomic to design an irrigation system to operate only on night-rate electricity because of the extra investment in capital required to produce the higher capacity (2-3 times the capacity of systems designed for 23-24 hours per day operation).

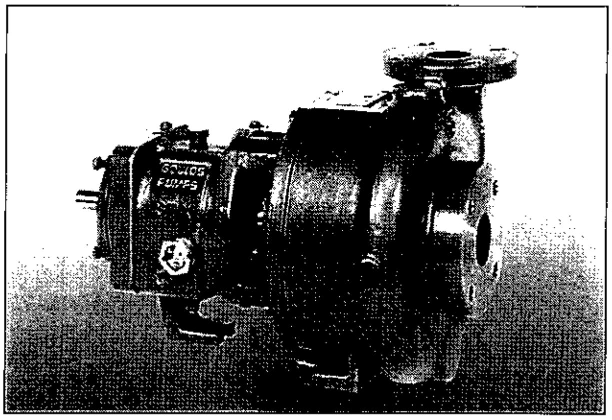
Where a system is designed for night-rate only, then clearly that is when it should be operated.

Where a system is designed for 23-24 hour operation, the key is to operate only at night when irrigation demand is low. Rather than operating for 24 hours once every three days for example, operate every day for 8 hours. This is usually possible in the spring and autumn. As the demand increases, increase the hours per day, but fully utilise the night-rate electricity. Savings in seasonal electricity costs can be as much as 35%.

If electricity is charged at a constant rate regardless of the time of use, it is still generally better to irrigate at night because of cooler conditions and less wind, resulting in higher efficiency.

Condition of pumps

Worn pumps increase energy use and the power rating in two ways. The first is because the pump is operating at a lower efficiency. The second is because the irrigation system has to be operated for longer hours to provide the same level of performance.



Sometimes, worn pumps use slightly less energy, but that is because they are pumping less water at lower pressure. Other times, they can use more energy, particularly when worn bearings or shafts are present.

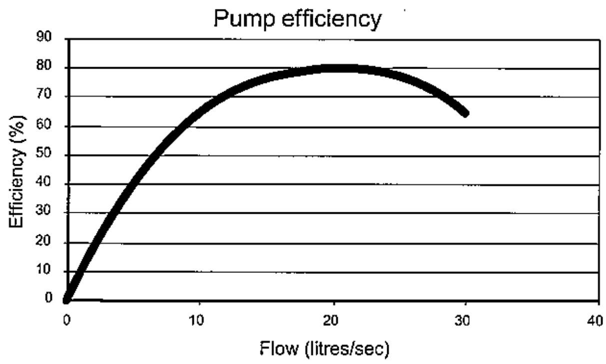
The main requirement is to monitor pump performance. Calculate power ratings for your pump and if they have increased, identify the cause. Have the pump checked and if necessary, repaired.

Condition of motors

Electric motor performance does not normally change significantly over the life of the motor.

Diesel motors however, do wear slowly, losing efficiency and increasing fuel usage. As the power required by a pump is determined by the design of the pump and its speed, maintaining a constant speed and pump output with a worn diesel motor will result in additional fuel use.

Flow rate relative to most efficient operating point



The efficiency of a pump is defined as:

$$\text{Power efficiency (\%)} = \frac{100 \times \text{pump hydraulic power (kW)}}{\text{pump input power (kW)}}$$

Centrifugal pumps generally reach maximum efficiency at flows between 60 and 75% of maximum pump flow. In the example above, a maximum efficiency of 80% is obtained at a flow of 20 litres/sec.

To minimise energy use, the pump should be operated at flows at or above the flow at maximum efficiency. Operating the pump at flows below this point will almost always result in a higher power rating. To check the pump operating point, measure the flow being pumped and determine the efficiency from the technical data supplied with the pump.

Degree of flow restrictions or throttling in the system

Any unnecessary restrictions in the irrigation system will result in wasted energy. Examples are throttling of gate valves at pump headworks, pressure regulating valves not operating fully open under normal operating conditions and small pipes causing high velocities. A whistling or screaming noise is a strong indication of restrictions in the system.

Where possible, increase the flow from the system by using larger nozzles or emitters so that gate valves and pressure regulating valves are operated fully open. Replace restrictive pipe sections with larger pipes.

If it is not possible to increase pump flow (perhaps the water supply cannot operate at higher flows), trim the pump impellers or reduce pump speed to decrease output. For electrical motors, a variable speed drive is a very efficient way of reducing pump speed.

Groundwater levels

Falling groundwater levels can cause an increase in power ratings because it takes more power to pump from a greater depth. Very little can be done to prevent falling groundwater levels. Although many irrigation systems are not sensitive to falling levels (see Section 2.2.2), eventually performance will drop when levels fall far enough.

If a noticable increase in power rating is observed or it is necessary to throttle the pump, then it is probably advisable to make adjustments in the system to improve overall efficiency. If the falling water levels are temporary, it may be necessary to nozzle back irrigators or operate blocks at lower pressure. If the falling water levels are more permanent, it may be better to trim the pump impellers or reduce pump speed to decrease output.

June 2001

How groundwater level fluctuations affect pumping

Seasonal and long-term groundwater level fluctuations occur in most wells in New Zealand. The changes are due to natural balances of recharge and discharge, the effects of neighbours' pumping, and cumulative pumping effects.

When water levels rise or fall, pumping rates are affected. Low water levels often become evident during starting of pumps, as low levels cause pump cutout. As levels become lower, throttling of the system may be necessary to prevent stoppage. The extent to which irrigation systems are affected depends on the following factors.

Design water level

When an irrigation system is designed and pumps selected, the designer bases the calculations on a fixed water level. This is typically either the water level at the time of drilling the well or the lowest known water level for the groundwater in the area. Irrigation systems designed at above average water levels will under-perform for the majority of the time. That is why irrigation systems should be designed on the basis of lower than average water levels.

Depth to water

Whenever water levels rise above the design water level, the irrigation system will operate at flows higher than it was designed to. When water levels fall, the irrigation system will operate at flows lower than it was designed to. The exception to this is on systems that have pressure-regulated sprinklers and have sufficient pump capacity to operate at full pressure. In general, water level changes in wells with deep water levels affect pumping flow rates less than do water level changes in shallow wells.

Specific capacity

The specific capacity of a well is a measure of how much the water level in the well draws down when it is pumped. It is calculated by dividing the pumping rate (usually measured in litres/second) by the drawdown (usually measured in metres). Low producing wells have low specific capacity, and high producing wells have high specific capacity. Contrary to what most people think, low specific capacity wells are less affected by changing water levels than are high specific capacity wells.

Pumping flow rate

Irrigation systems that operate at low flows are more affected by water level changes than those operating at high flows. There is little difference between low and high pumping flow systems if the well is high specific capacity; the effect increases as specific capacity decreases.

Irrigation system operating pressure

Irrigation systems that operate at high pressures are less affected by water level changes than low pressure systems, regardless of the specific capacity of the well.

Pressure regulation

Irrigation systems that are pressure regulated are not affected by changing water levels, provided that the system has the capacity to maintain the regulated pressure. If, however, the system does not maintain the regulated pressure, it can be significantly affected, as pressure regulated systems do not have the benefit of hydraulic balancing that occurs in unregulated systems.

Pump type

Surface centrifugal pumps cannot operate efficiently at suction lifts exceeding 6-8 metres (exact limit depends on pump model). If water level changes cause the pumping level to fall below these limits, a significant reduction in pumping performance occurs. At extreme levels, cavitation can occur, which can severely damage the pump.

Submersible pumps are less affected, provided the pumping level does not fall below the top of the pump. Typically, water levels would have to fall between 12 and 27 metres for a flow reduction of 10% to occur.

Running out of water

When water levels fall to the point of causing cavitation in surface pumps or pump cut-out in submersible pumps, the following options are available:

- Throttle the system at the main valve or elsewhere in the system. This usually results in low irrigation operating pressures and does not allow hydraulic compensation to take place in the system. It is only recommended as a short-term solution. Significant throttling can damage the pump.
- Nozzle back the irrigation system so that it can run at normal pressure. This allows the irrigation system to run at the correct pressure and hydraulic balancing to occur within the system.
- If neighbouring pumping is causing well interference, try to come to some arrangement with neighbours so that you can pump when neighbours turn off.
- Lower the pump. Surface pumps can be lowered into a sump to reduce the suction lift. Submersible pumps can sometimes be lowered to gain extra water.
- At the end of the season, have the well tested to find out if well performance can be improved. If it can, have the well re-developed.
- Deepen the well. There is a risk, however, of not finding a better supply at greater depths.
- Drill another well. Taking half the flow from each well could reduce drawdown by up to 75%.

Flow versus drawdown

The graph below illustrates a drawdown response to a range of pumping flows from a well. All wells have a unique relationship, but the trend shown below is typical, in that drawdown increases more rapidly at higher flows. For example, pumping this well at 20 l/s results in a drawdown of 3.3 metres, while doubling the flow to 40 l/s more than triples the drawdown to 10.6 metres.

If the available drawdown at the time the irrigation system was designed was 20 metres, and groundwater levels fell by 5 metres so that only 15 metres was available, the amount of water that could be pumped, assuming throttling was necessary, would fall from 58 l/s to 49 l/s.

If another identical well was drilled and half the flow (29 l/s) was taken from each well, drawdown would be reduced to 6.1 metres.

Typical flow drawdown graph