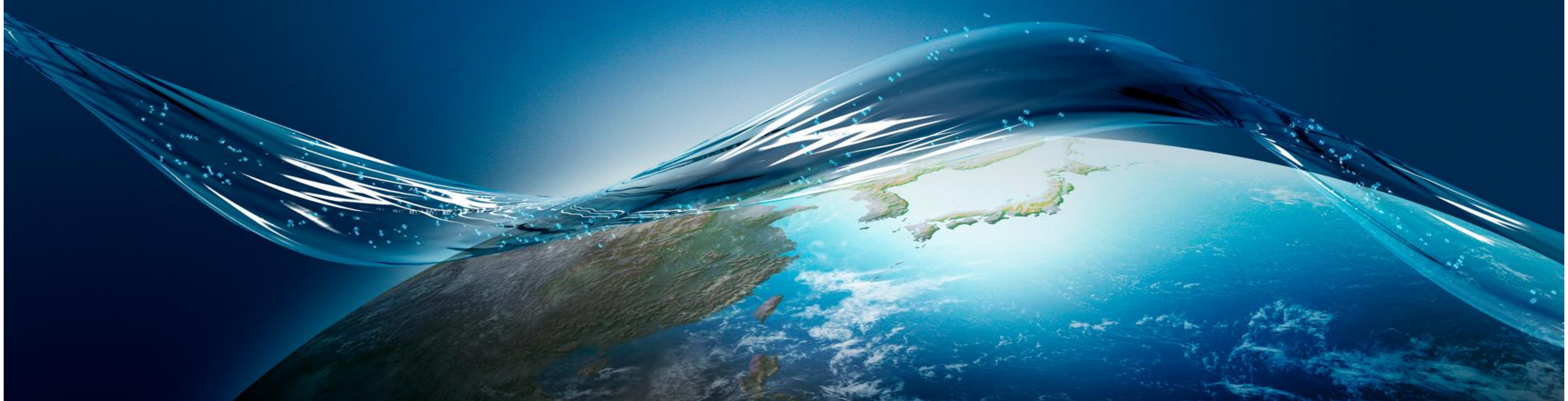
Borehole Pump Design, Selection and Control

Mark Webb

Area Sales Manager

Grundfos Pump Ltd



What I am going to Cover

Who are Grundfos

Borehole Pump Design

Borehole Pump Installations

What is a Set Point and how to Size a Borehole Pump

NPSH – Net Positive Suction Head

Borehole Pump Control

Pump Failure

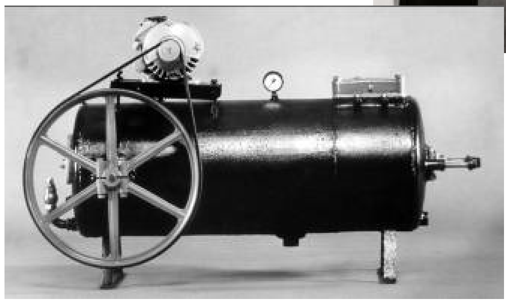
Grundfos in brief

Founded in 1945 by Poul Due Jensen

Annual production of more than 16 million pump units

Turnover of DKK 23 billion in 2014

More than 19,000 employees worldwide



Grundfos in brief

Grundfos primarily manufactures:

Circulator pumps

Water booster pumps/systems

Submersible pumps

Industrial pumps

Dosing pumps

The world's largest manufacturer of pumps and pump systems

Production and sale of electronic motors

Development, production and sale of electronics for the control of pumps and pump systems

Grundfos Pumps UK Ltd

Sales £127 Million (GB only) 2015

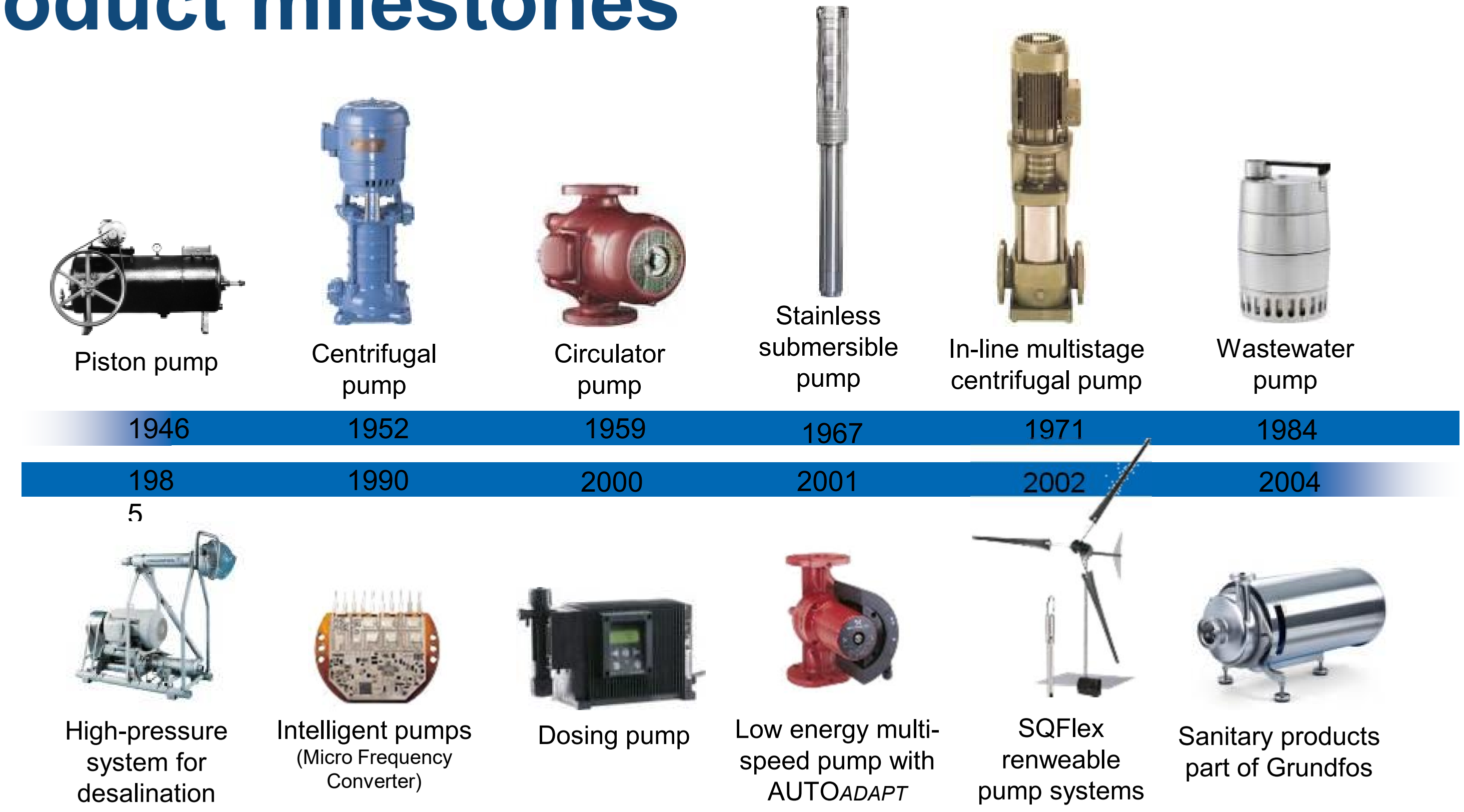
160 Employees in sales

220 Employees in Manufacturing (Sunderland)

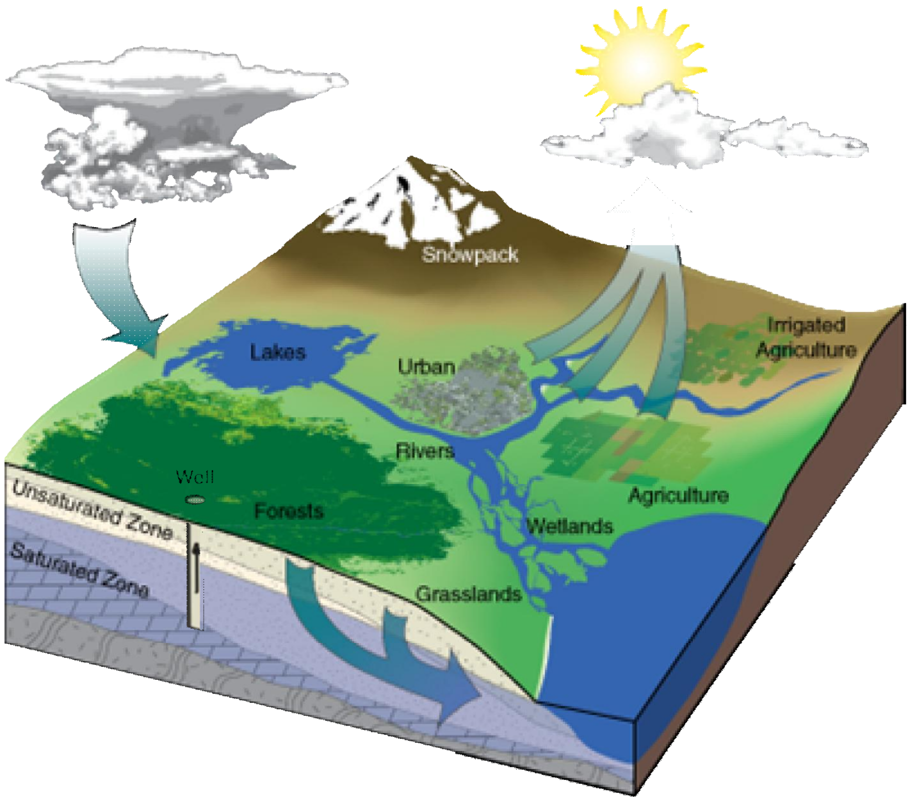
Sales offices, Leighton Buzzard, Manchester, Livingston, Birmingham

Service and Manufacturing Centre at Sunderland

Product milestones



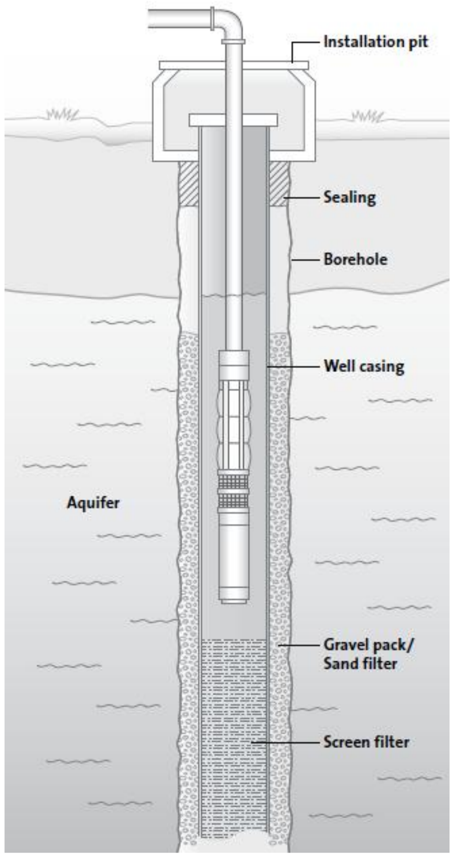
Groundwater



Groundwater wells

The individual wells are to be extended into older groundwater at pollution-free depths when extracting for drinking water. Irrigation wells can easily use water from the upper aquifer, the secondary aquifer, with slightly polluted water quality.

The groundwater level will vary over the seasons, but is to be respected on the yearly basis, as the maximum removable quantity is similar to what is created every year.



Borehole Pump Design

Borehole Pump Design - Principle

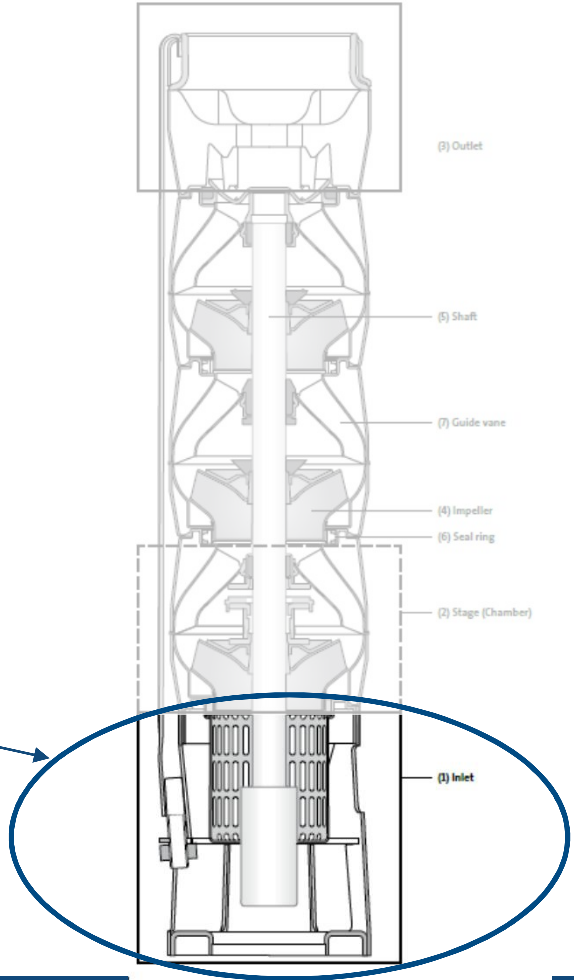
Most borehole pumps are centrifugal pumps where the principle is to transform mechanical energy from the motor to velocity energy in the pumped medium, and thereby creating a pressure difference in the media between the pump inlet and outlet.

The Pump Consists of :

1 – an Inlet

2 – a number of Stages

3 – an Outlet



Inlet / Suction Interconnector

In addition to the guiding the water into the first impeller, the pump inlet is also the interconnector for the motor.

Borehole Pump Design - Principle

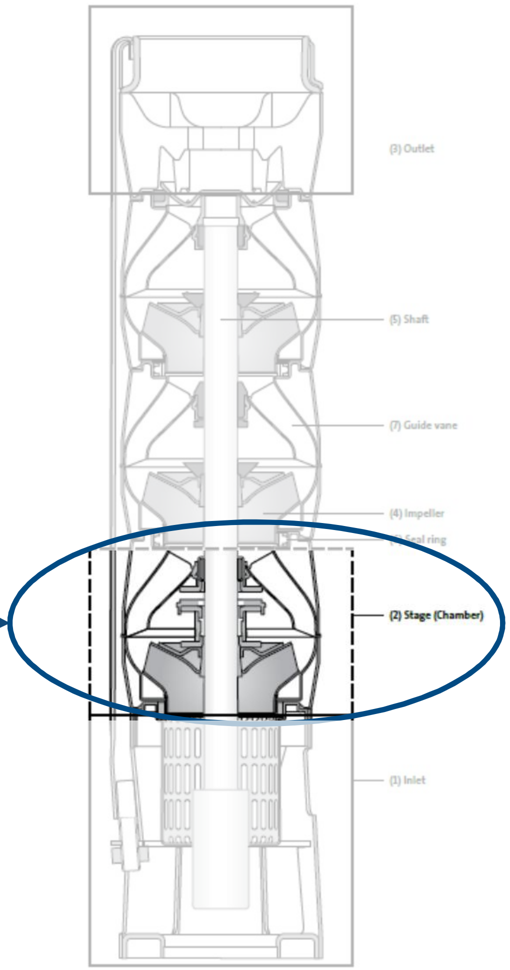
Most borehole pumps are centrifugal pumps where the principle is to transform mechanical energy from the motor to velocity energy in the pumped medium, and thereby creating a pressure difference in the media between the pump inlet and outlet.

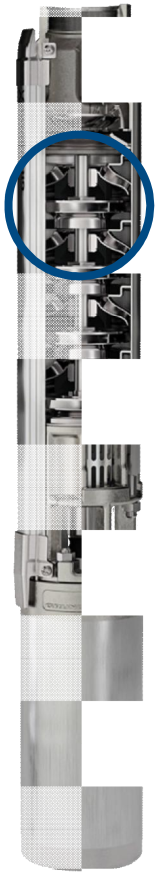
The Pump Consists of :

1 – an Inlet

2 – a number of Stages

3 – an Outlet





Chamber/Impeller

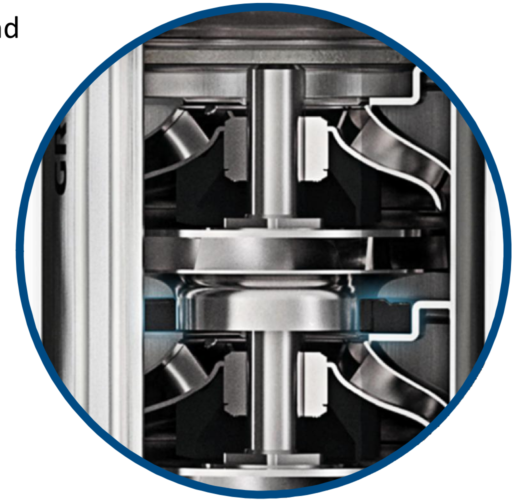
A stage includes:

i. Impeller – where the impeller blades transfer energy to the water in terms of velocity and pressure increase.

ii. Pump Shaft – each impeller is connected to the pump shaft.

iii. Seal Ring – this is between the impeller inlet and the chamber, this ensures any backflow is limited

i. Guide Vane, this leads the water to the next stage.



Stop Ring for Upthrust

Built-in stop ring:

- Prevents upthrust damage
- Protects during the critical start-up
- Ensures longer pump life and low maintenance costs
- Prevents pump damages during transport

Borehole Pump Design - Principle

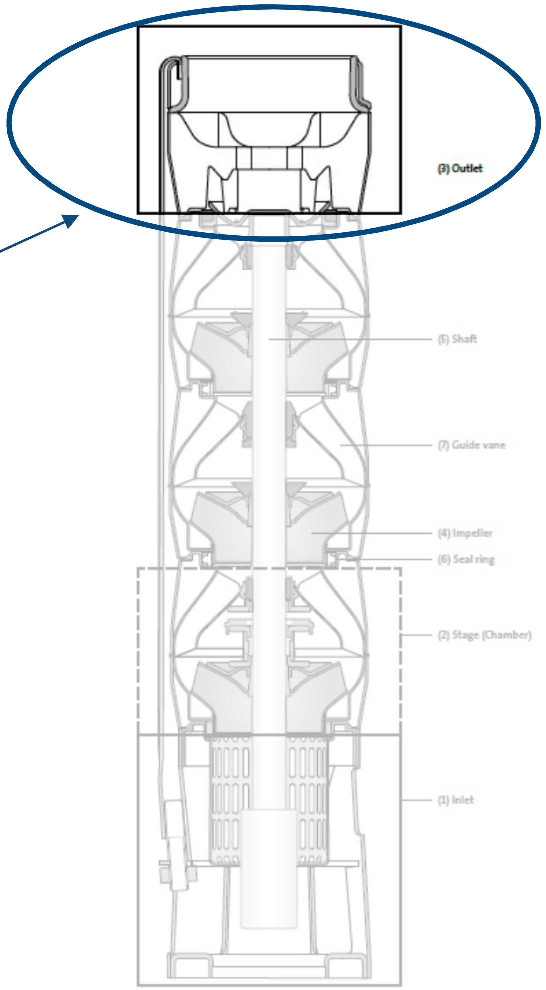
Most borehole pumps are centrifugal pumps where the principle is to transform mechanical energy from the motor to velocity energy in the pumped medium, and thereby creating a pressure difference in the media between the pump inlet and outlet.

The Pump Consists of :

1 – an Inlet

2 – a number of Stages

3 – an Outlet



Pump Outlet

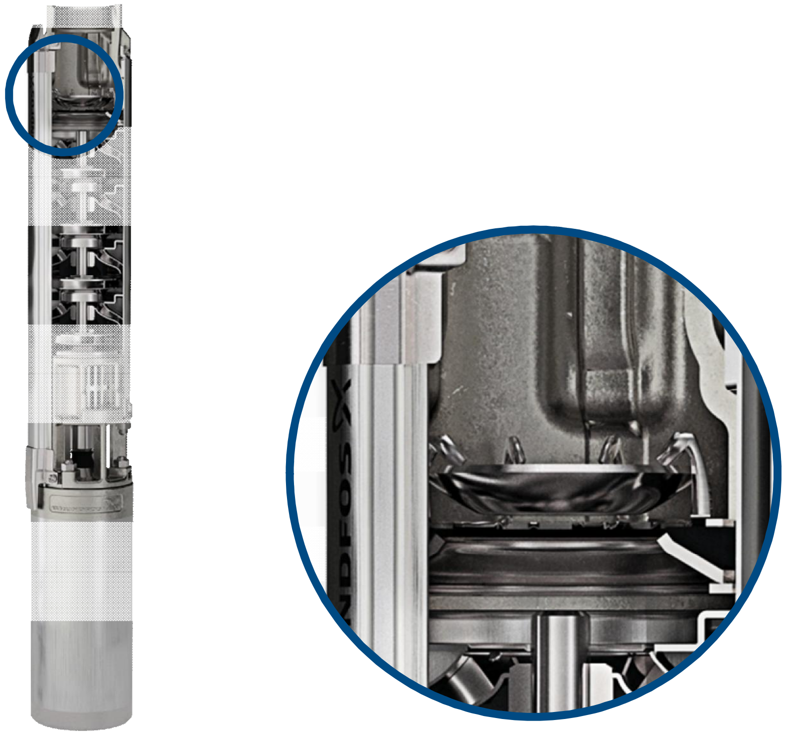
FUNCTIONS:

- Connection port for rise pipe
- Valve casing
- Standard thread Rp or NPT
- Large surfaces for wrench key

Additional Features you may see:

Cable Guard

Non Return Valve



Pump Motor

Borehole motors are specially designed to run underwater, but otherwise their operating principle is the same as all other asynchronous electric motors

A motor consists of a motor body and a motor cable, there are 3 types of borehole motor:

Canned – the windings are enamel wire and hermetically sealed from the surroundings and filled with embedding material in order to withhold the windings and at the same time transfer heat.

Wetwound (rewindable) – these have special water resistant wire and a watertight joint between the windings and the motor cable.

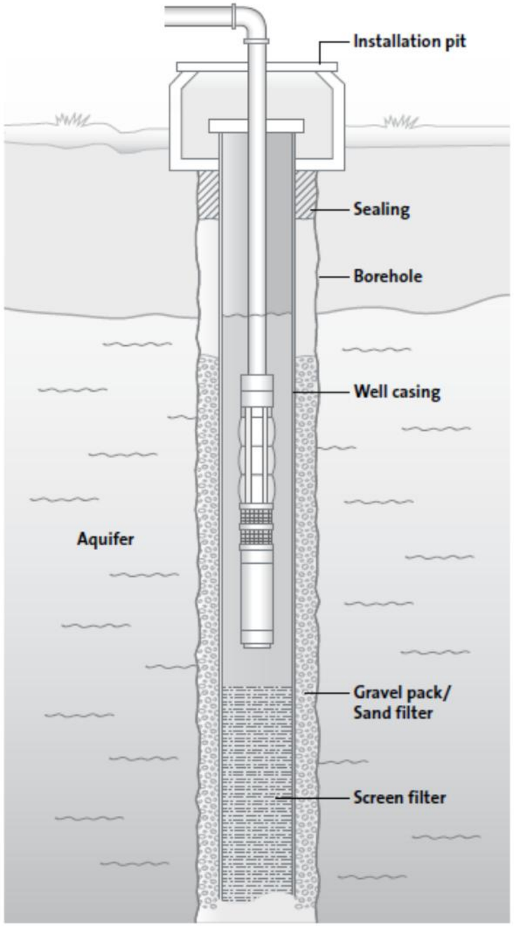
Oil-filled – these are equipped with a impregnated standard surface motor winding. Transformer oil is filled into the motor and used as lubricant and cooling.

Borehole Pump Installation

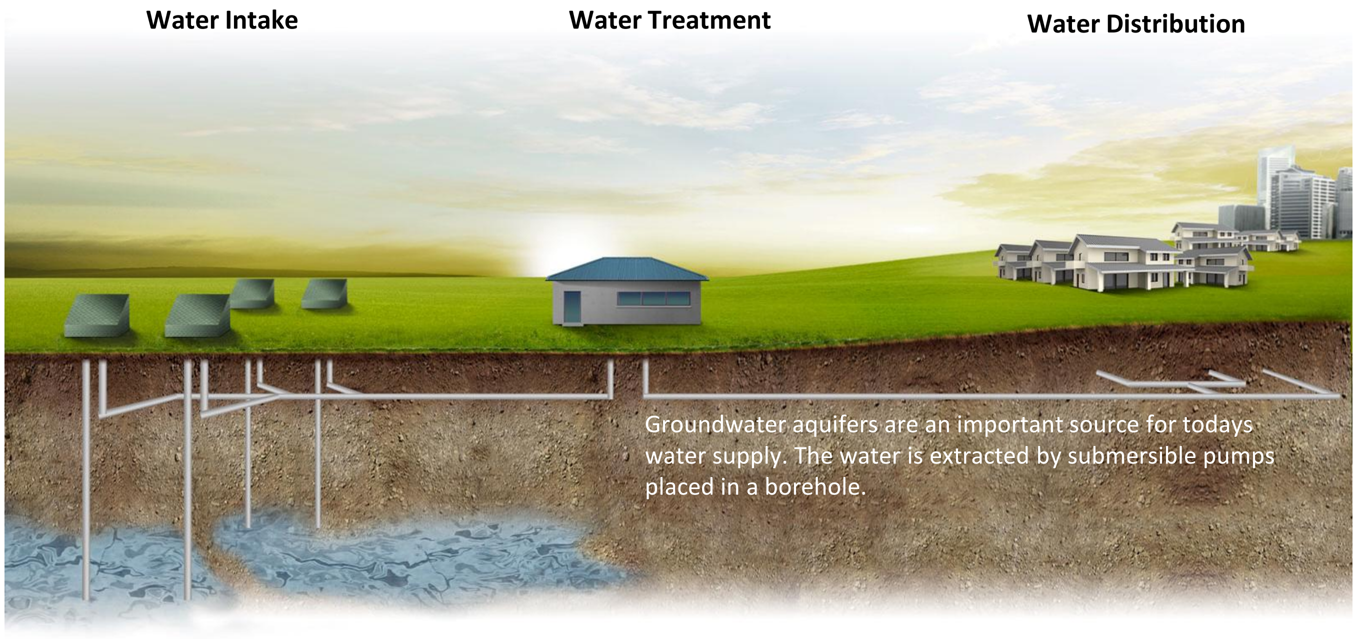
The pump must always be installed above the screen area of the casing. This way you ensure the water is forced past the motor, providing adequate motor cooling. If the pump can not be installed above the screen filter, a cooling sleeve is always recommended to create the necessary flow along the motor for proper cooling.

When selecting a borehole pump, the pump must be able to lift the water from the aquifer to the surface and deliver a certain minimum pressure.

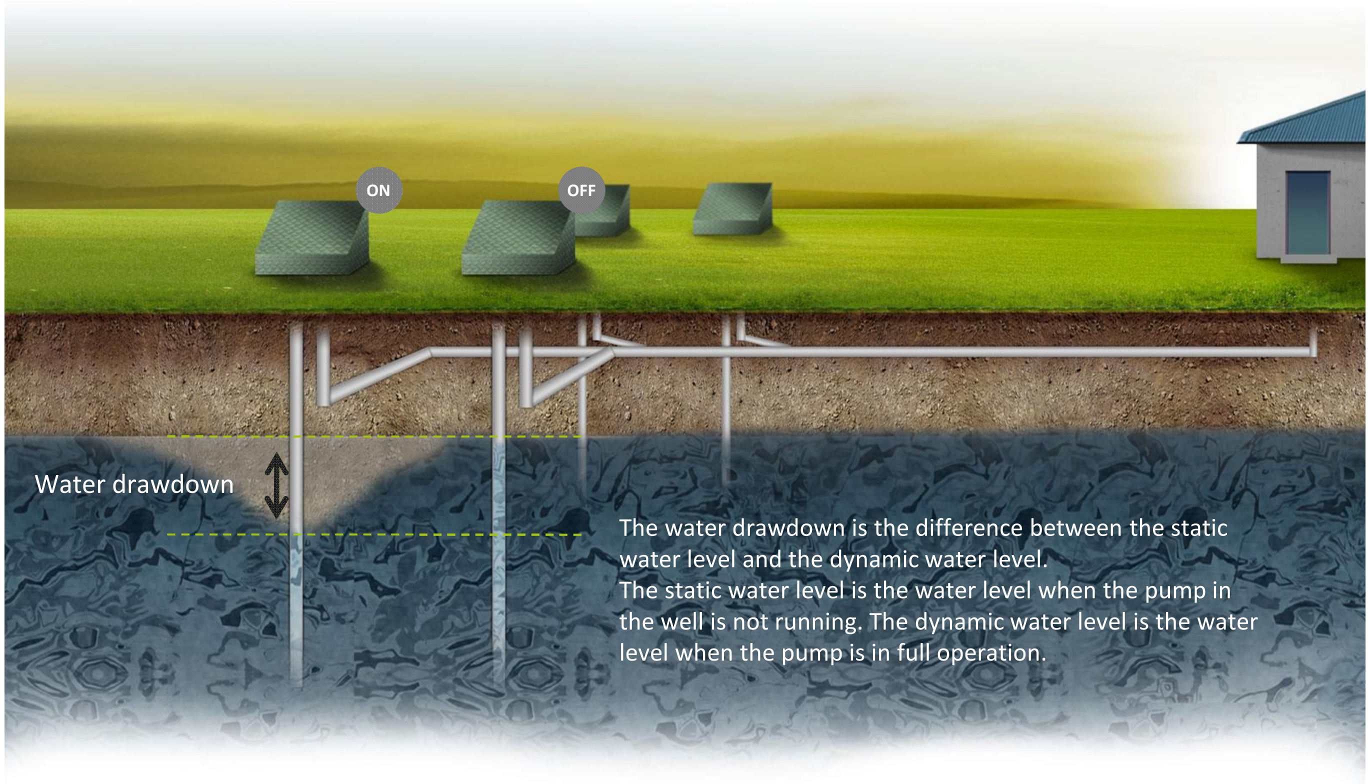
During operation, the water must never fall below the inlet of the pump.



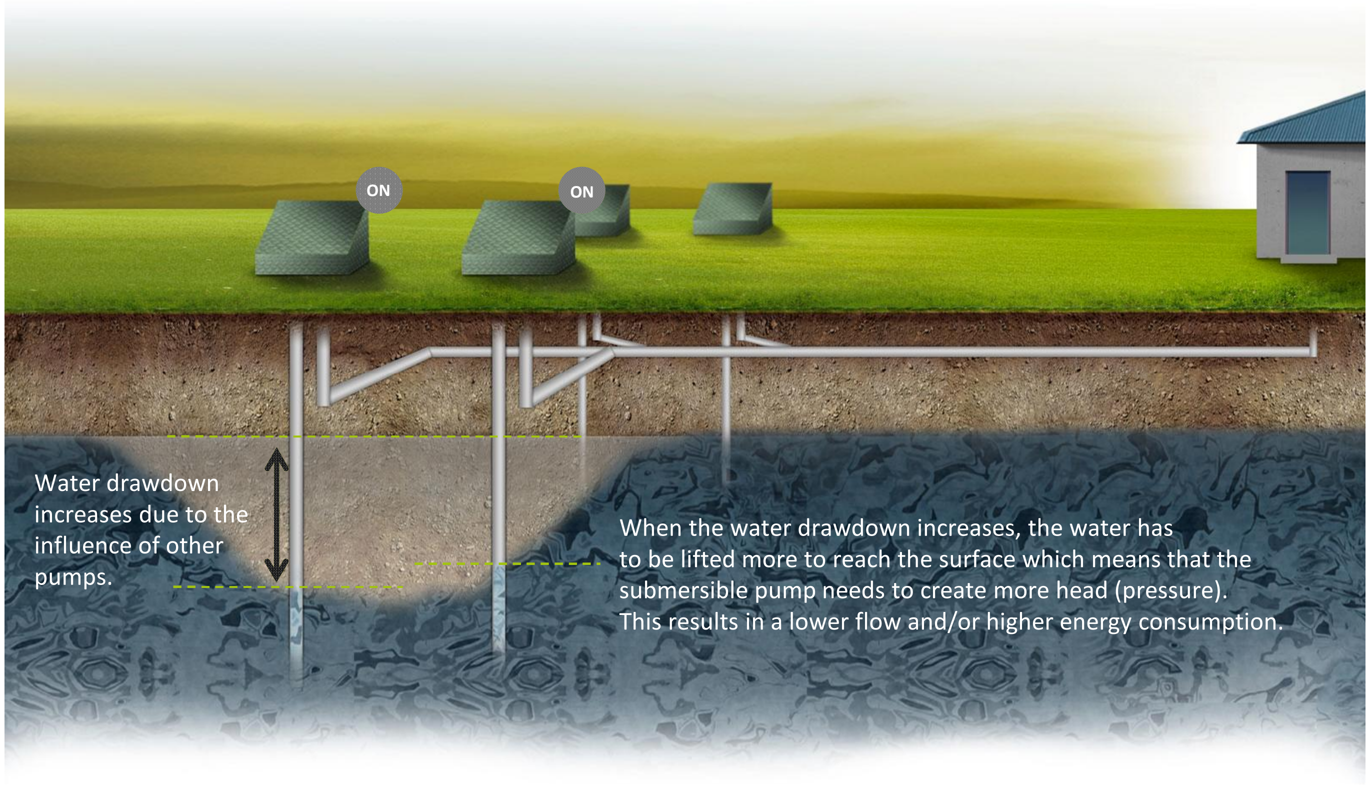
Well fields


Water Intake
Water Treatment
Water Distribution
Groundwater aquifers are an important source for todays water supply. The water is extracted by submersible pumps placed in a borehole.

Well fields


ON
OFF
Water drawdown
The water drawdown is the difference between the static water level and the dynamic water level.
The static water level is the water level when the pump in the well is not running. The dynamic water level is the water level when the pump is in full operation.

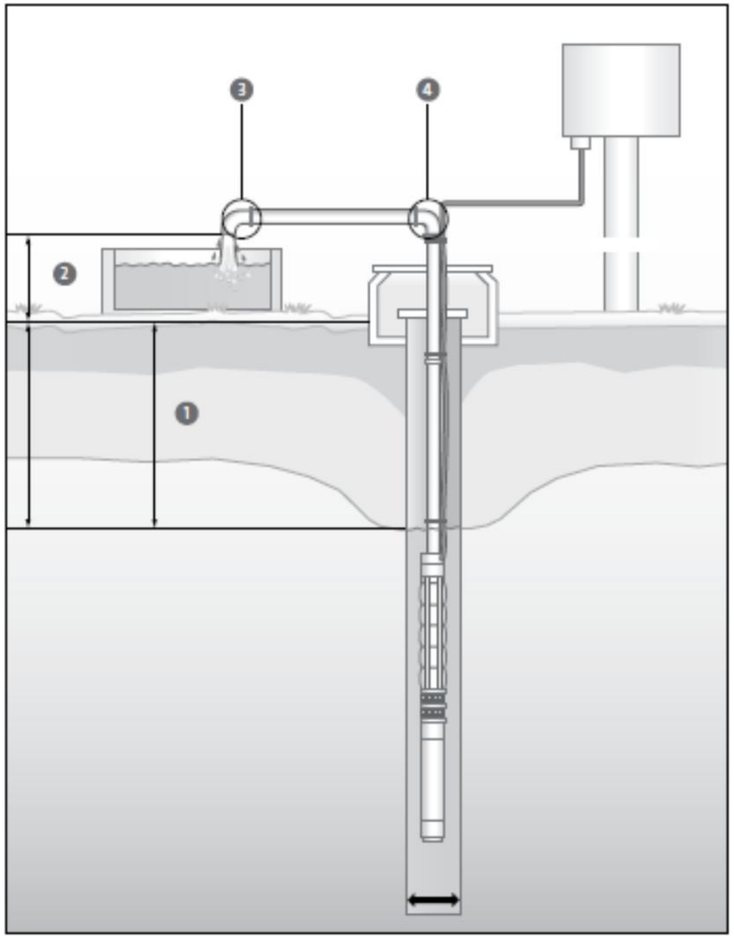
Well fields


ON
ON
Water drawdown increases due to the influence of other pumps.
When the water drawdown increases, the water has to be lifted more to reach the surface which means that the submersible pump needs to create more head (pressure). This results in a lower flow and/or higher energy consumption.

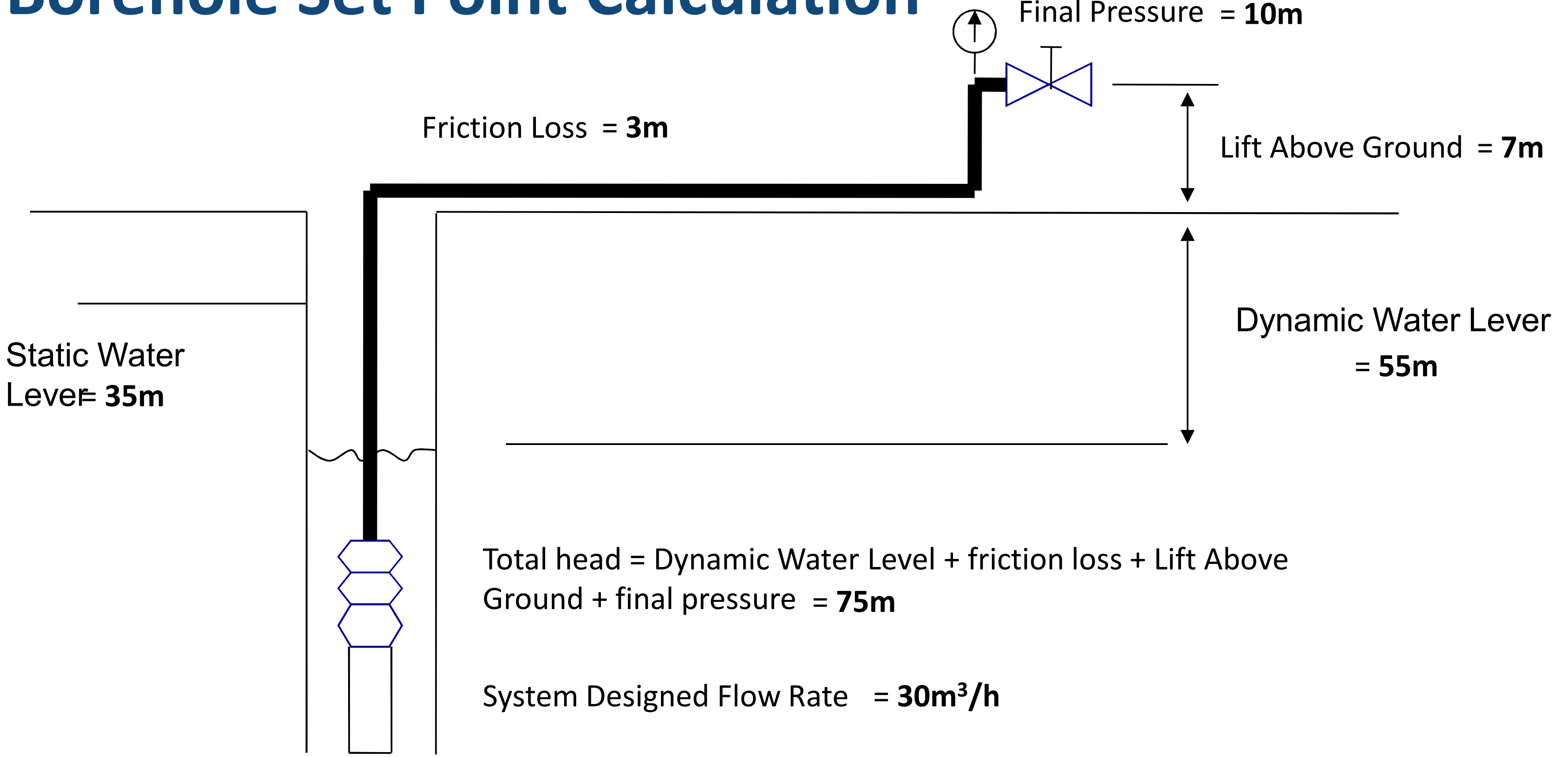
Borehole Pump Selection and Set Point

Selection of a pump starts with understanding the flow required and the head. The total head is the sum of the following:

1: Dynamic Water Table
2: Lift above ground level
3: Discharge Pressure Required
4: Friction losses from Pipes, Valves and Bends.



Borehole Set Point Calculation



Total head = Dynamic Water Level + friction loss + Lift Above Ground + final pressure = **75m**

System Designed Flow Rate = **30m³/h**

Calculated Set Point = 30m3/h at 75m head

Pump Selection

Head in Metres

Pump Curve

Pump End Only - Efficiency

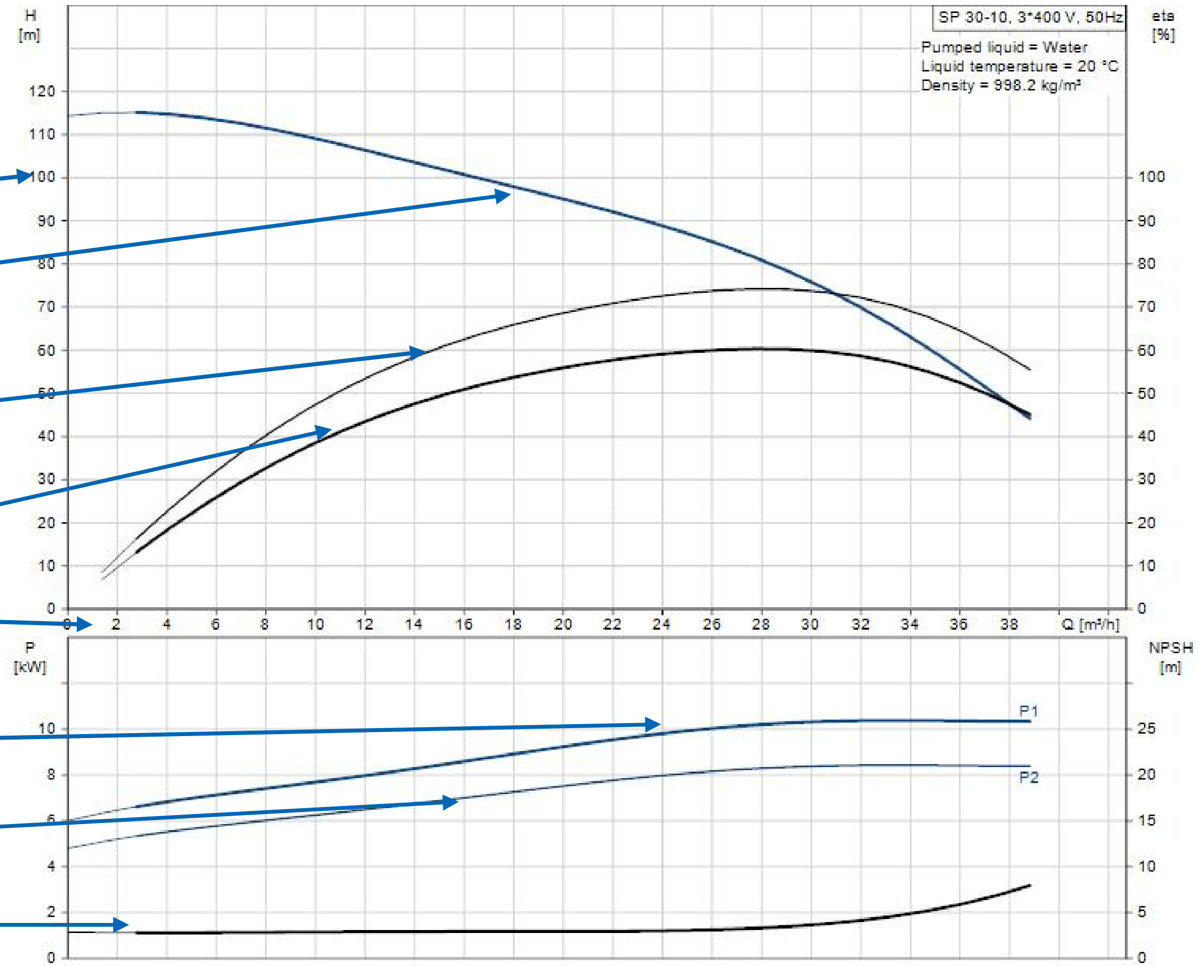
Pump and Motor - Efficiency

Flow in m^3/h

Motor Power in kW

Shaft Power in kW

NPSH Curve in M

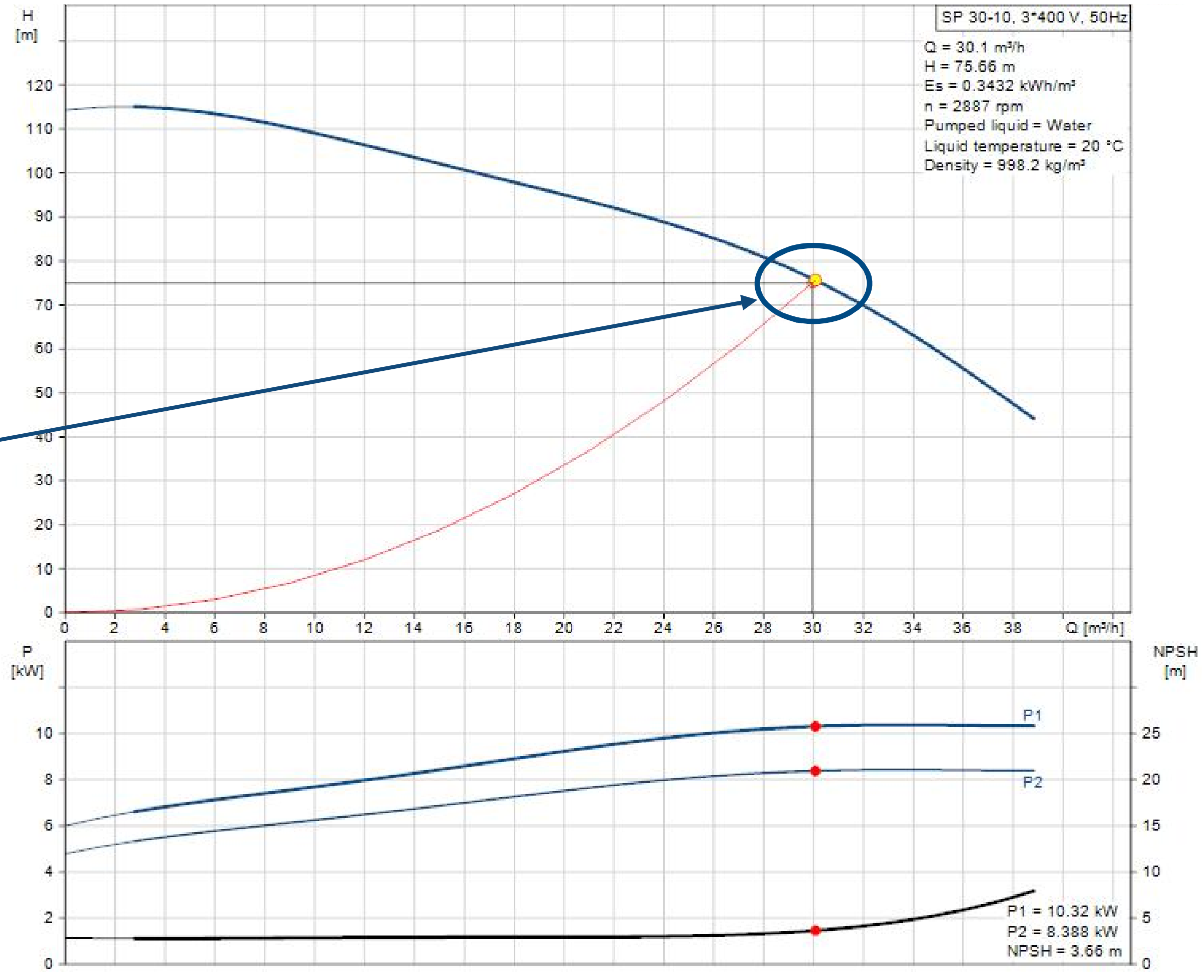


be think innovate

GRUNDFOS

Pump Selection

Set Point
30m^3/h at 75m head



Pump Selection

Static Water Level
And Dynamic Water Level

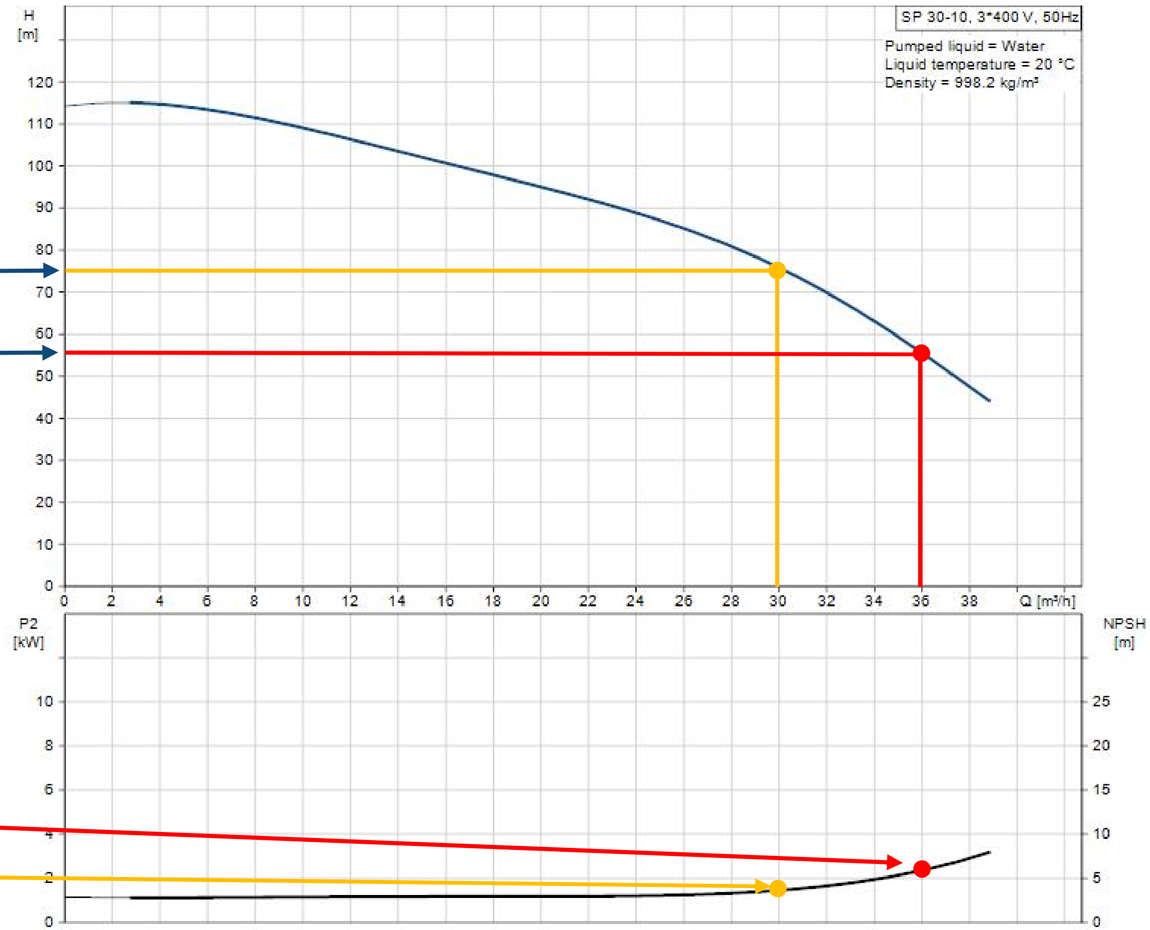
Operational Set Point

Start-up Set Point

NPSH – Net Positive Suction Head

5.92m

3.65m



NPSH – Net Positive Suction Head

The NPSH value stands for "Net Positive Suction Head" and is a measure for required inlet pressure or minimum water level above pump inlet.

In general, the NPSH value will increase for bigger flows and if the required inlet pressure is not met, it will result in evaporation of the and a risk of cavitation damage in the pump.

Cavitation does not normally take place in submersible pumps, if however, the following two factors at the same time, cavitational damage on both pump and motor may arise at low installation depths:

1. Invasive air bubbles
2. Reduction of counter pressure caused for instance by pipe fraction, severe corrosion of riser main and extremely high consumption.

To Calculate the required installation depth to prevent cavitation, the following formula is applied:

$$\mathbf{H = H_b - NPSH - H_{loss} - H_V - H_s}$$

H = installation depth

H_b = Barometric pressure

NPSH = Net Positive Suction Head

H_{loss} = pressure loss in suction pipe

H_v = vapour pressure

H_s = safety factor

When the formula gives a positive H value the standard indication of a minimum installation depth is valid.

NPSH – worked example

An SP30 at a flow of 30m³/h

H_b	10.0m
NPSH from data sheet	3.65m
H_{loss}	0.0m
H_v at 32°C	0.5m
H_s	1.0m
H= 10 – 3.65 – 0 – 0.5 – 1.0 =	4.85m

As H is positive, this means that the pump will be able to create a vacuum of 0.48 bar without being damaged. That means no special precautions have to be taken.

In case of corrosion of the rising main resulting in a 20mm hole, there will be no counter pressure and the pump flow will increase to more than 38.5m³/h

H_b is unchanged	10.0m
NPSH will increase to	8.0m
H_{loss}	0.0m
H_v will increase due to recirculation in well	4.6m
H_s is unchanged	1.0m
H = 10 – 8.0 – 0 – 4.6 – 1 =	-3.6m

This value of H means that the pump inlet must be at least 3.6m below the dynamic water level, otherwise the pump will cavitate.

Damage caused by Cavitation

Normal Impeller

Damaged Impeller

Causes of Borehole Pump Failure

Cavitation / Corrosion

Sediment / Mineral build-up

Motor Failure

i. Dry Run
ii. Phase out / Imbalance
iii. Over/Under Voltage
iv. Lightening Strike
v. Discharge Restriction
vi. Too Many Start / Stops per hour

Borehole Pump Controls – Pressure Switch

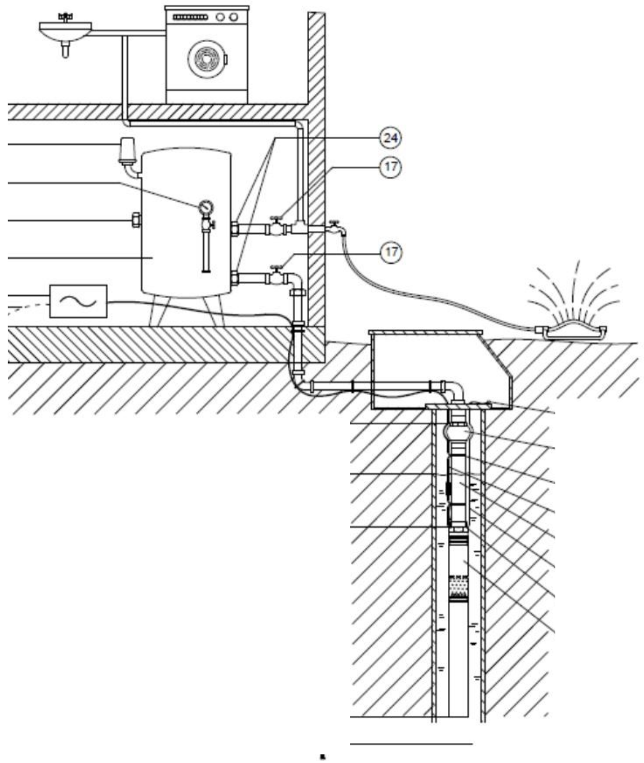
Required Equipment:

Pump

Control Box

Pressure Vessel

Pressure Switch



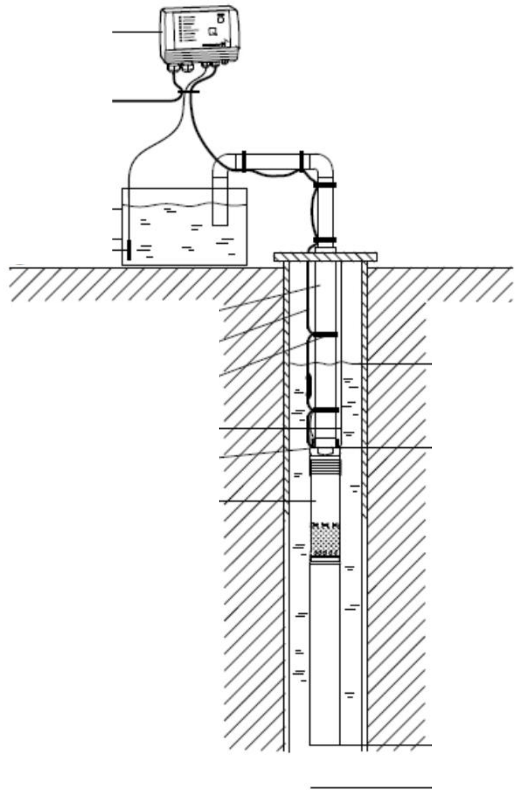
Borehole Pump Controls – Level Switch

Required Equipment:

Pump

Control Box

Float Switch



Borehole Pump Controls – Variable Speed

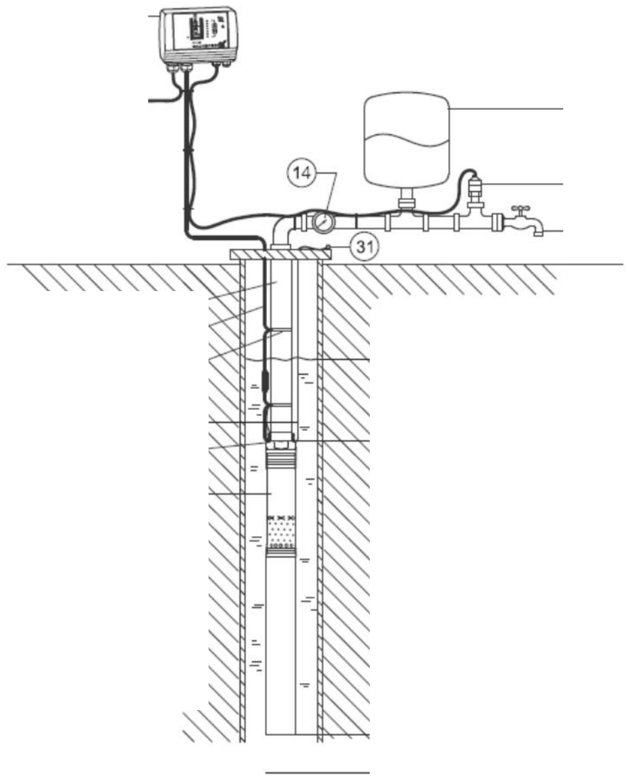
Required Equipment:

Pump

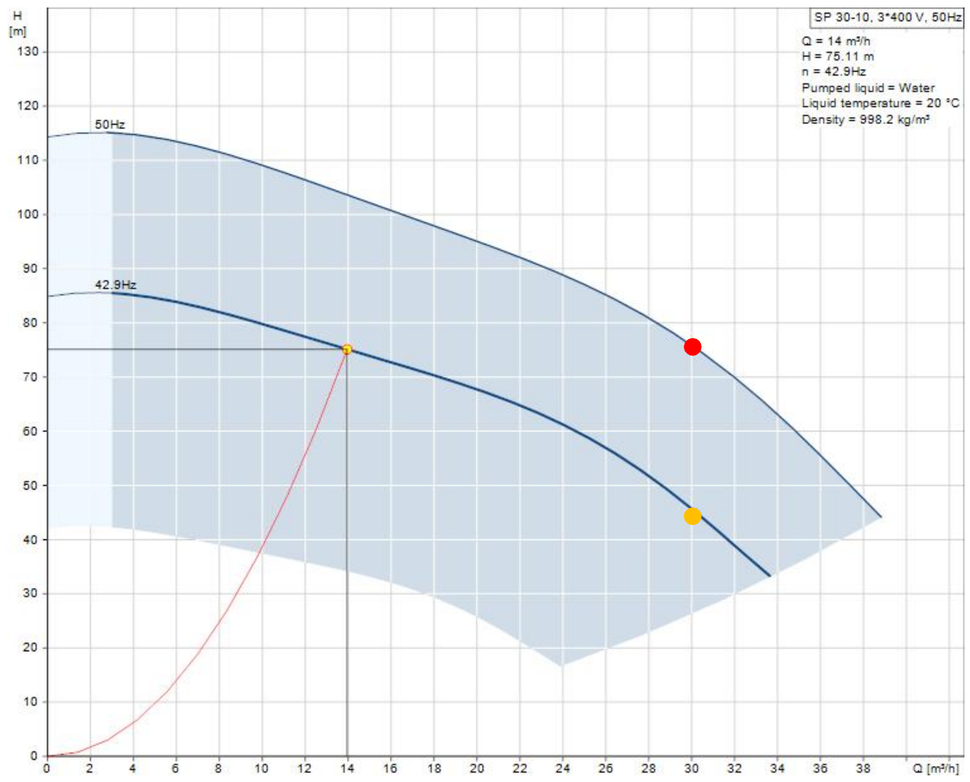
Variable Speed Drive

Sensor

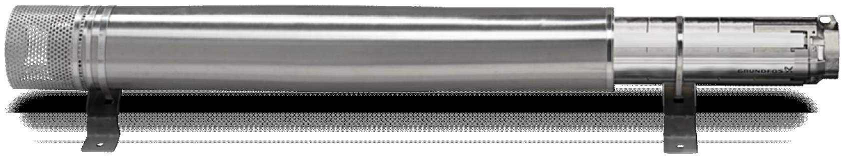
Pressure Vessel depending on application



Borehole Pump Controls – Variable Speed

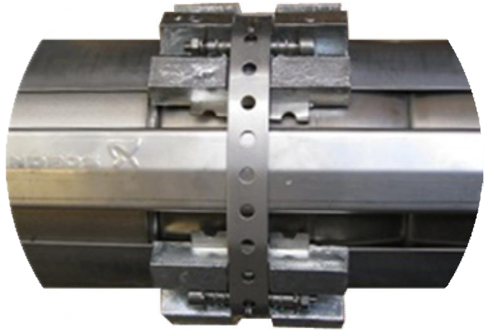


Accessories



Flow Sleeve

Connecting pieces



Galvanic protection

Motor protection

Cable

Drop cable and kits

SP 30-10

Cable dimensions at 3 x 400 V, 50 Hz, DOL

Voltage drop: 3 %

Motor	kW	I_n [A]	Cos φ 100 %	Dimensions [mm^2]															
				1.5	2.5	4	6	10	16	25	35	50	70	95	120	150	185	240	300
4"	0.37	1.4	0.64	462	767														
4"	0.55	2.2	0.64	294	488	777													
4"	0.75	2.3	0.72	250	416	662	987												
4"	1.1	3.4	0.72	169	281	448	668												
4"	1.5	4.2	0.75	132	219	348	520	857											
4"	2.2	5.5	0.82	92	153	244	364	602	951										
4"	3	7.85	0.77	69	114	182	271	447	705										
4"	4	9.6	0.8	54	90	143	214	353	557	853									
4"	5.5	13	0.81	39	66	104	156	258	407	624	855								
4"	7.5	18.8	0.78	28	47	75	112	185	291	445	609	841							
6"	4	9.2	0.82	55	91	146	218	359	566	867									
6"	5.5	13.6	0.77	40	66	105	157	258	407	622	850								
6"	7.5	17.6	0.8	29	49	78	117	193	304	465	637	882							
6"	9.2	21.8	0.81	23	39	62	93	154	243	372	510	706	950						
6"	11	24.8	0.83		34	53	80	132	209	320	440	610	823						
6"	13	30	0.81		28	45	68	112	176	270	370	513	690	893					


OPTIMISED
WATER SOLUTIONS
be
think
innovate
GRUNDFOS

Meet the energy challenge now

Owners in the water supply and wastewater industries face a series of challenges:

- Rising energy costs
- Increasing green taxation
- Demand for CO_2 reduction
- Demand for lower operation and maintenance costs

GRUNDFOS SOLUTIONS CAN MAKE AN IMMEDIATE AND SUBSTANTIAL DIFFERENCE IN THE FIGHT TO REDUCE GLOBAL ENERGY CONSUMPTION

10% Pumps account for no less than 10% of the world's entire energy consumption

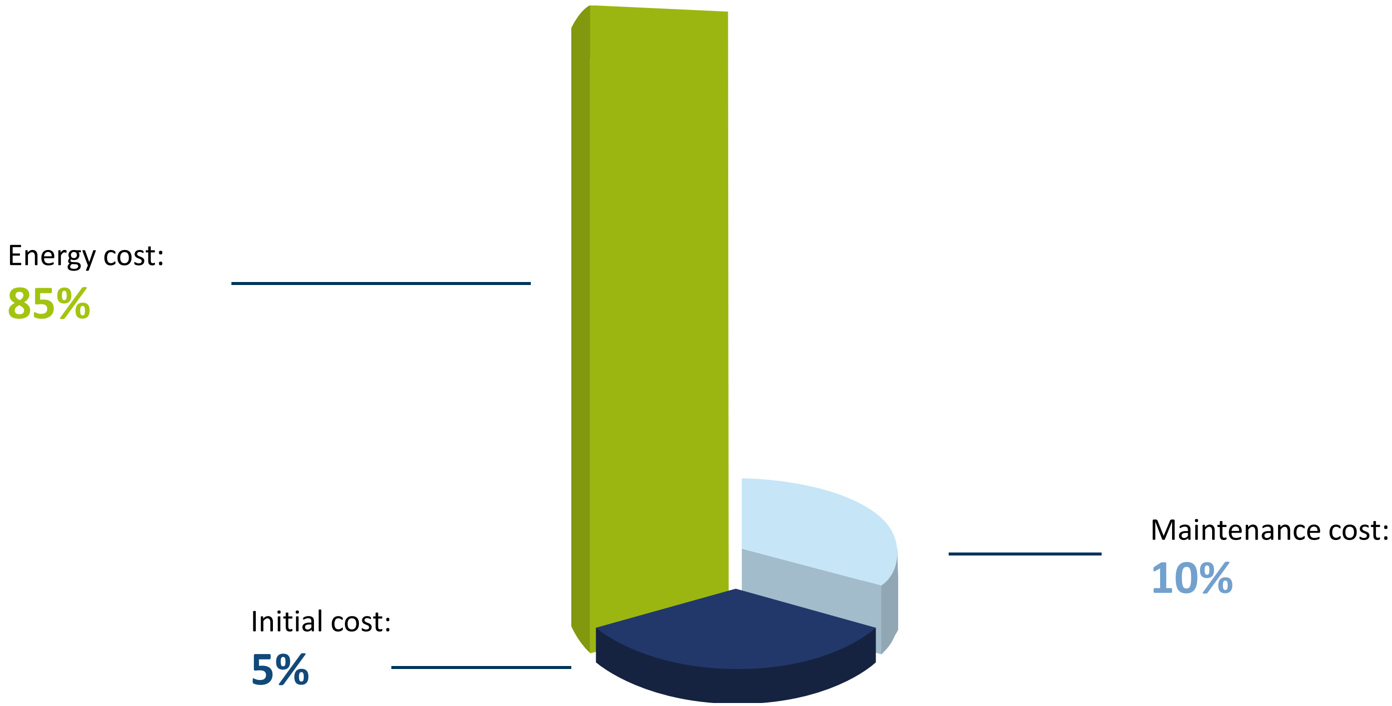
4% If every business switched to high-efficiency pumps this number would be reduced by 4%

Meet the energy challenge NOW

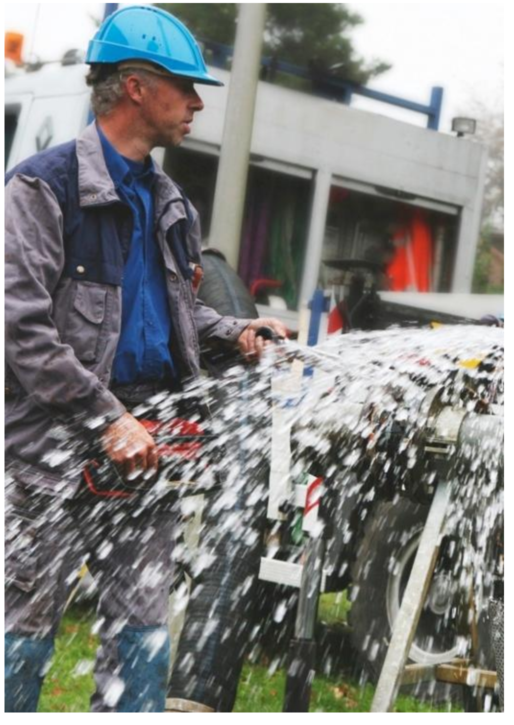
Slide 39

5156651 Fremhæv 10% og 4% med større skrift
Placer evt i to "boxe" i venstre side
Allan Pontoppidan, 13/12/2013

Optimising Life Cycle Costs



Well Field Energy Audit – want to save 30-50%?



Extracting groundwater from well fields represents up to 40-50% of the total energy consumption when supplying groundwater to the public

A WFEA provides an overview of the entire system's energy savings potential

Includes everything from initial pressure loss calculations to final recommendations for improvement (see more details in the next slides).

Recommendations can include replacing old pumps, replacing over-sized pumps and how they are controlled and operated

CASE:

Savings: 55.000 kWh/year = 21 %

- **Loosdrecht – The Netherlands**
- **Extraction: 2,9 mill. m³/yr**
- **Payback: < 5 year**

The challenge

- The Dutch drinking water supplier Vitens committed to an energy saving target and asked Grundfos to improve efficiency at one of its plants
- Grundfos provided a Pump Audit and Well Field Energy Audit

The solution

- Although the plant proved relatively efficient, Grundfos saw its submersible pumps were oversized
- These were replaced with correctly sized SP125 versions that use 21% less energy

Borehole Pump Design, Selection and Control

Any Questions