Solving application problems for Wastewater pumping stations

If any of your objectives are to:-

- Cope with Peak Wet Weather Flows
- Cope with power outages during peak flows
- Lower costs over the life of the pump station installation
- Improve O.H.&S. at pump stations
- Remove confined spaces issues

Then here's why the Gorman-Rupp self priming centrifugal pumps will prove to be your best option in every circumstance.

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Topics:

1. Coping with peak wet weather flows (PWWF)
2. Coping with power outages during peak flows
3. Lowering life cycle costs
4. Improving O.H.&S.

1. Coping with peak wet weather flows

One of the major issues facing designers in times where regulations on sewage spills are becoming more stringent is coping with PWWF. There always seems to be compromises that have to be made. Do you increase the size of your pumps to cope with the higher PWW flows and suffer inefficient operation during normal times or do you put up with falling short in flow during the peak times so that you're operating efficiently during "normal" operating times?

What if there was a way to do both? Let's look at some innovative ways to cover a list of tough scenarios:-

In all these scenarios we will use the following flow criteria:-

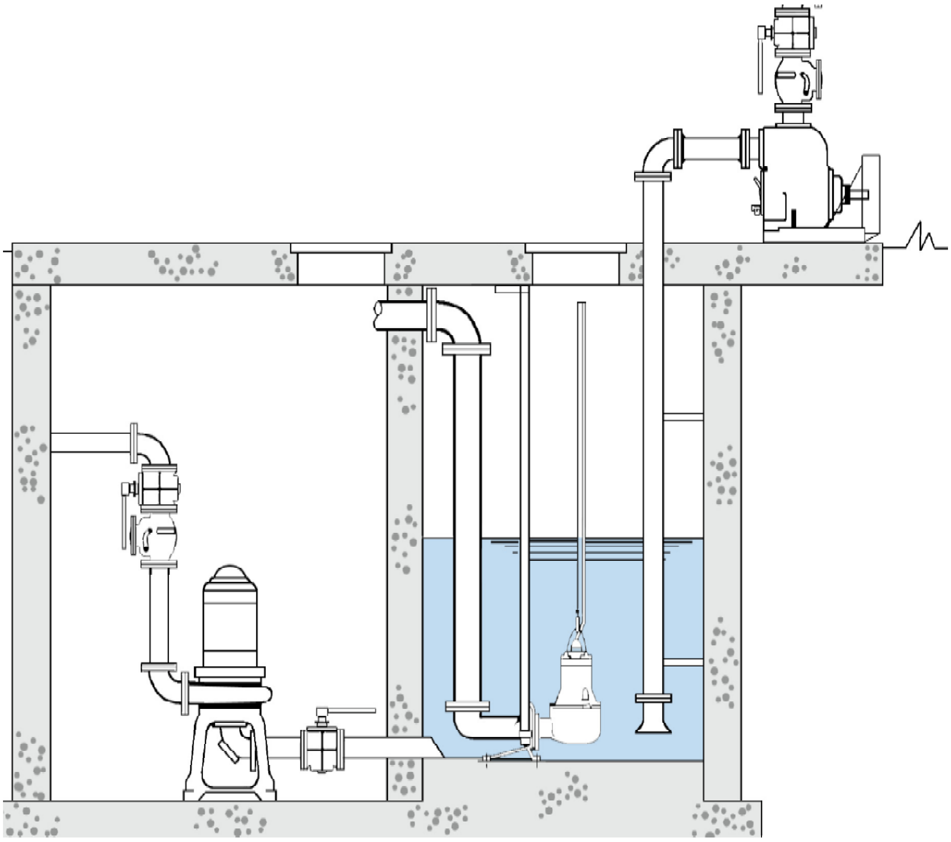
1. Average dry weather flow of 50 l/s
2. Peak dry weather flow of 80 l/s
3. Peak wet weather flow of 150 l/s.

Also, in all scenarios, we will use 1000m as the rising main length. We will also compare the use of submersibles vs Gorman-Rupp self priming centrifugal "high and dry" technology.

Introducing the Gorman-Rupp Self Priming Centrifugal Wastewater Pumps.

Before going any further, we need to give you an understanding of the pumps being proposed as the solution:-

A picture tells a thousand words........



A conventional centrifugal is on the left. A submersible (the industry "standard") is in the middle, and the Gorman-Rupp self primer is on the right, sitting high and dry above the wet well. Some of the main points to consider with the Gorman-Rupp self priming centrifugal pumps:-

- They will prime to 7.6 metres and deliver unattended automatic priming and operation every time.
- They have been the self priming "industry standard" since the introduction of the Classic T Series pump line in 1963. An upgraded version was released in 2000 (Super T Series) and the latest technology

in high performance sewage pumping was released in 2005 with the introduction of the Gorman-Rupp Ultra V Series (higher heads, higher efficiencies, more features)

- Gorman-Rupp's Super T and Ultra V Series pumps have been designed to be the easiest sewage pumps on the market to maintain and service and generally have life cycles well in excess of submersible pumps.
- Blockages can be removed in minutes, not hours
- Clearance adjustments can be done by one person in less than 5 minutes
- A complete overhaul can be accomplished in under an hour.
- Some additional white papers have been written covering some of these points

Now we can get on with having a look at our 6 scenarios, remembering our system (1000m of main) and our flow characteristics (ADWF of 50 l/s, PDWF of 80 l/s and PWWF of 150 l/s):-

1. 9m Static Head, 250mm main, non-critical station
2. 9m Static Head, 250mm main, critical station
3. 9m Static Head, 200mm main, non-critical station
4. 9m Static Head, 200mm main, critical station
5. 35m Static Head, 250mm main, non-critical station
6. 35m Static Head, 250mm main, critical station

Scenario No.1

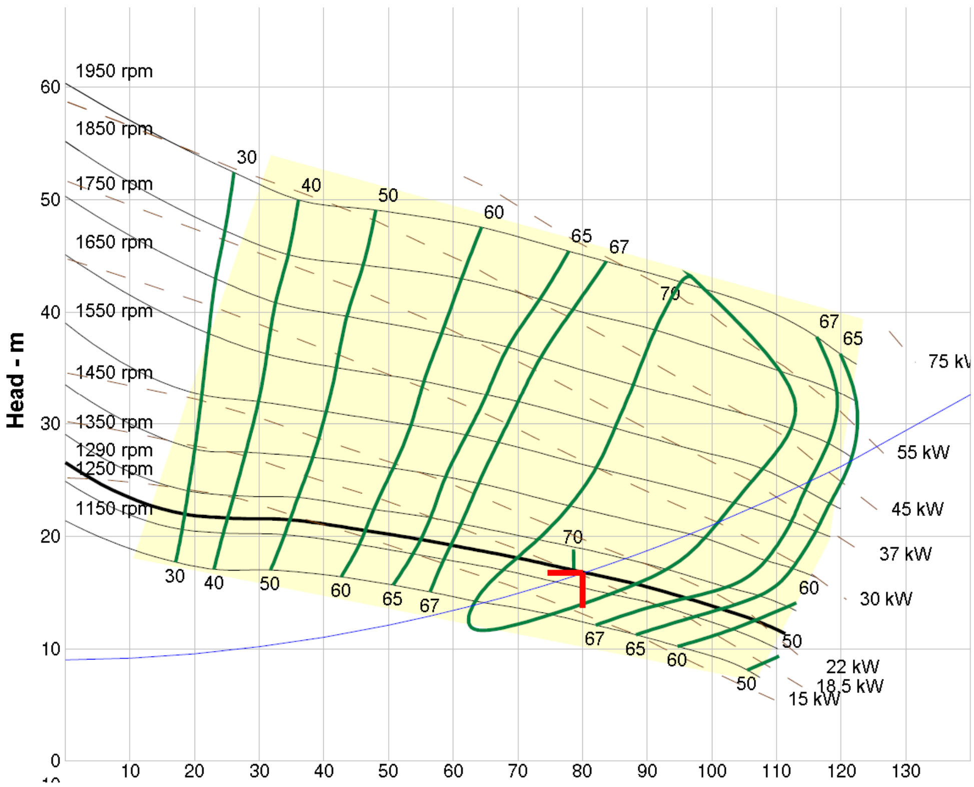
The system head calculations look like this for that station:-

Flow	Static Head	Friction Head	TDH
50 l/s	9m	3.1m	12.1m
80 l/s	9m	7.7m	16.7m
100 l/s	9m	12m	21.0m
150 l/s	9m	26.8m	35.8m

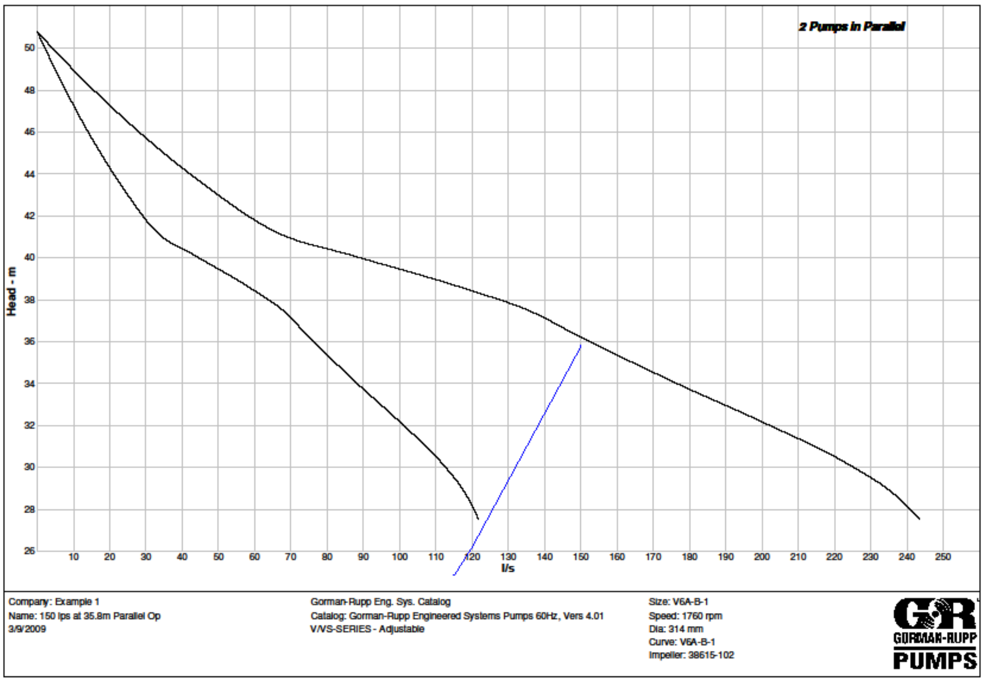
Now let's have a look at a pump selection. The following data is straight from the Gorman-Rupp Application Selection Program (GRASP). This program allows us to put in the system head curve, which shows the selected pump being capable of covering flows up to 80 l/s.

The Gorman-Rupp selection program has selected a V6A60-B. Here is an excerpt from the data sheet:-

---- Data Point ----	
Flow:	80 l/s
Head:	16.8 m
Eff:	70%
Power:	18.7 kW
NPSHr:	3.11 m
---- Design Curve ----	
Shutoff head:	26.6 m
Shutoff dP:	260 kPa
Min flow:	--- l/s
BEP: 70% @ 78.6 l/s	
NOL power: 22.8 kW @ 111 l/s	
-- Max Curve --	
Max power: 66.5 kW @ 122 l/s	



As in-flows into the station start to exceed this and approach peak wet weather flow (PWWF), we can bring in the second pump to operate in parallel with the first pump. As the friction head increases with the increased flow, the "lag" (or second) pump would need to come on at the same speed as the lead pump, but then both pumps ramp up to 1760 rpm. At this speed, 55kW motors need to be selected to meet the maximum flow rates. The performance curve for the pumps in parallel and system head would then look as follows:-



This non-critical application could also be done with submersible pumps (although easy service and maintenance features would be lost). That brings us to :-

Scenario No. 2. (same system as above, but in a critical position)

OK, so what if the above duty was at a “critical” station? By critical, we mean that there might be very little storage in the system, and any pump or motor failure of either pump, would mean that pumping at PWWF was not possible.

This is where the use of Gorman-Rupp self priming pumps can provide the solution where submersible pumps cannot (without going to very large pumps). With the G-R option, you just add another pump to act as the standby pump. Unlike submersibles, only the G-R suction lines need to be in the wet well, so you can have 2, 3 or more suction lines in the wet well. You would need a very big wet well to do the same thing with submersibles.

So with our G-R option, we have 3 pumps operating alternatively during average and peak dry weather flows. If in-flow exceeds discharge flow, one of the other 2 pumps is started. If one of these fails, it is "locked out" and the 3rd one started to run in parallel with the working pump. The station, with one pump down, is still able to cope with PWWF.

A new concept

Before going on to the next scenario, we need to introduce Gorman-Rupp's "Parallel/Series" operating concept. This duplex (2 pumps alternating as duty pumps) system operates like any other pump station when only one of the pumps is required to deliver the day-to-day average flows. However, when flows increase beyond the capability of single pump operation, the system automatically shifts into **series** operation when the second pump cuts-in (instead of operating in parallel).

This system allows us to overcome friction head that would normally render the 2nd pump almost useless. This astounding feature is accomplished with the simple addition of interconnect piping between the discharge of one pump and the suction of a second pump and the addition of a suction check valve to one pump. When the "lag" pump is called into service, the system automatically shifts into series operation due to pressure differentials between the suction and discharge sides of each pump.

This system is only possible using Gorman-Rupp self priming pumps. The system cannot work with submersible pumps because there is no way to configure the piping to deliver the desired result.

Now we're ready for...

Scenario N.3 (9m static with 1000m of 200mm main)

The system head calculations look like this for that station:-

Flow	Static Head	Friction Head	TDH
50 l/s	9m	13.6m	22.6m
80 l/s	9m	23.6m	32.6m
100 l/s	9m	35.0m	44.0m
150 l/s	9m	82.0m	91.0m

Now let's have a look at pump selection:-

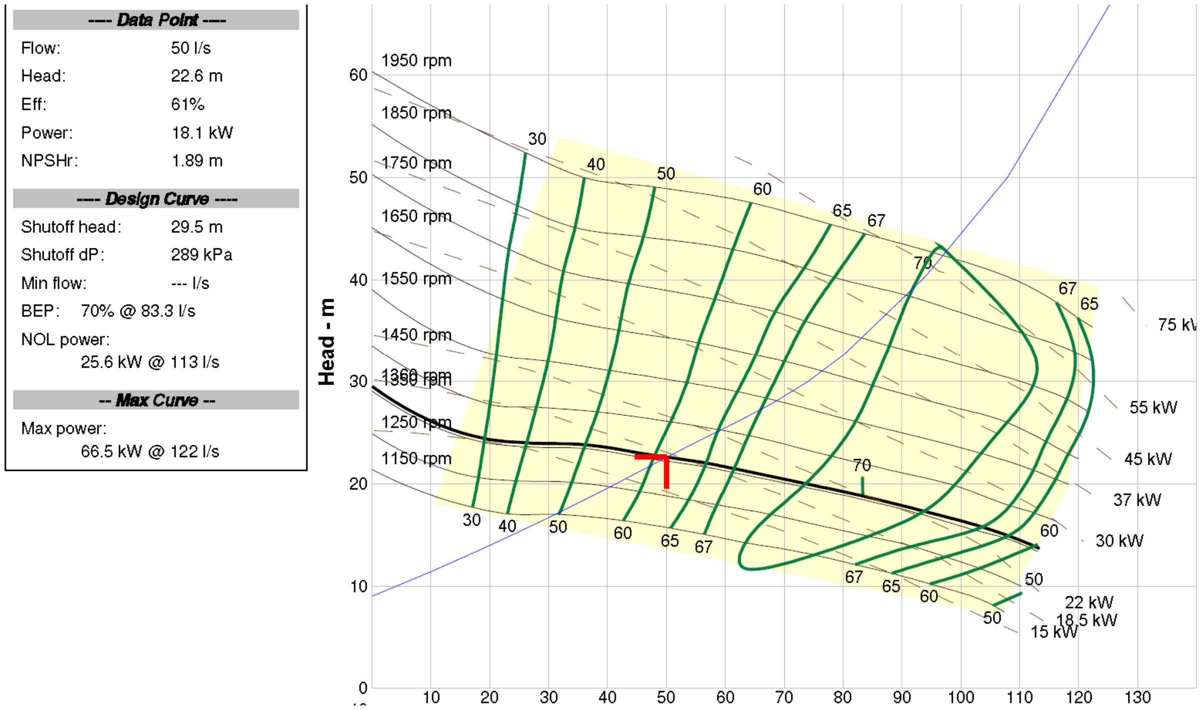
The selection here is two (2) sets of parallel/series connected V6A60S-B pumps. A total of 4 pumps. Pumps 1 & 2 are parallel/series connected, and pumps 3 & 4 are parallel/series connected.

- All pumps are capable of operating on their own
- When Pump 1 operates with pumps 3 or 4, the 2 pumps will operate in parallel.
- When Pump 2 operates with pumps 3 or 4, the 2 pumps will operate in parallel.
- When Pumps 1 & 2 operate or 3 & 4 operate, they will operate in series.
- When all 4 pumps are running, pumps 1&2 will operate in series, pumps 3&4 will operate in series, and both sets will pump in parallel.

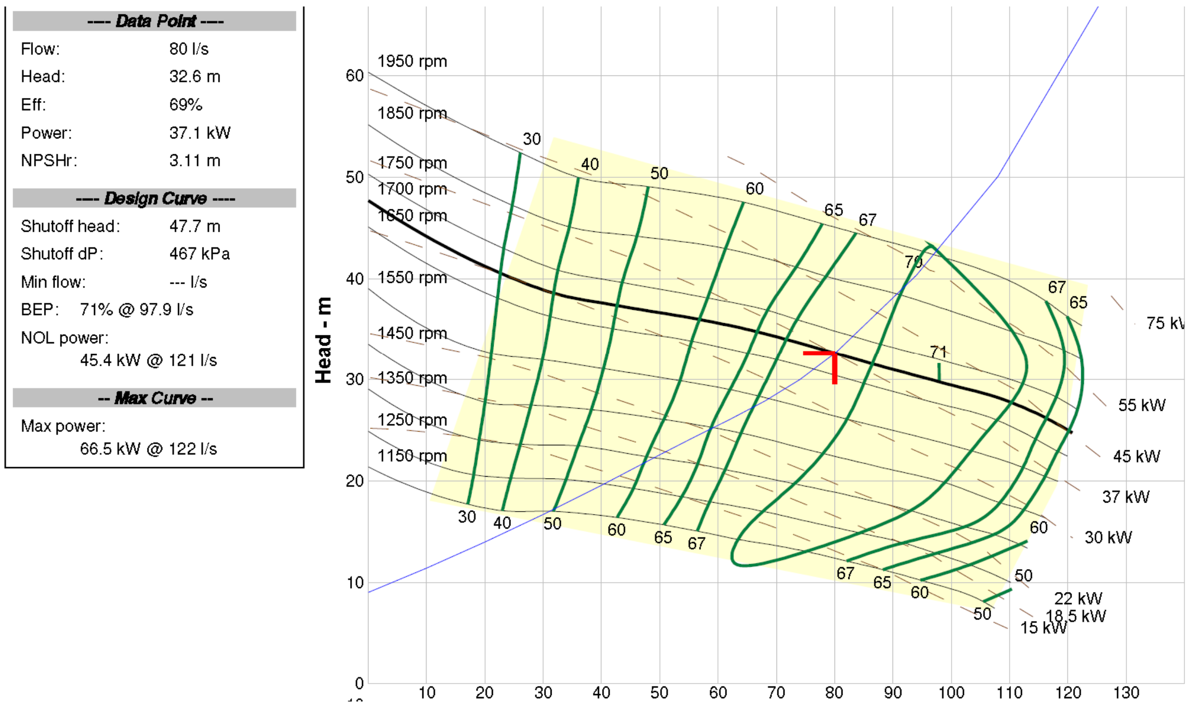
This may seem complicated, but it is only a matter of the controls being designed to select which pumps need to operate based on the level in the wet well.

Let's explain how this will deliver the solution:-

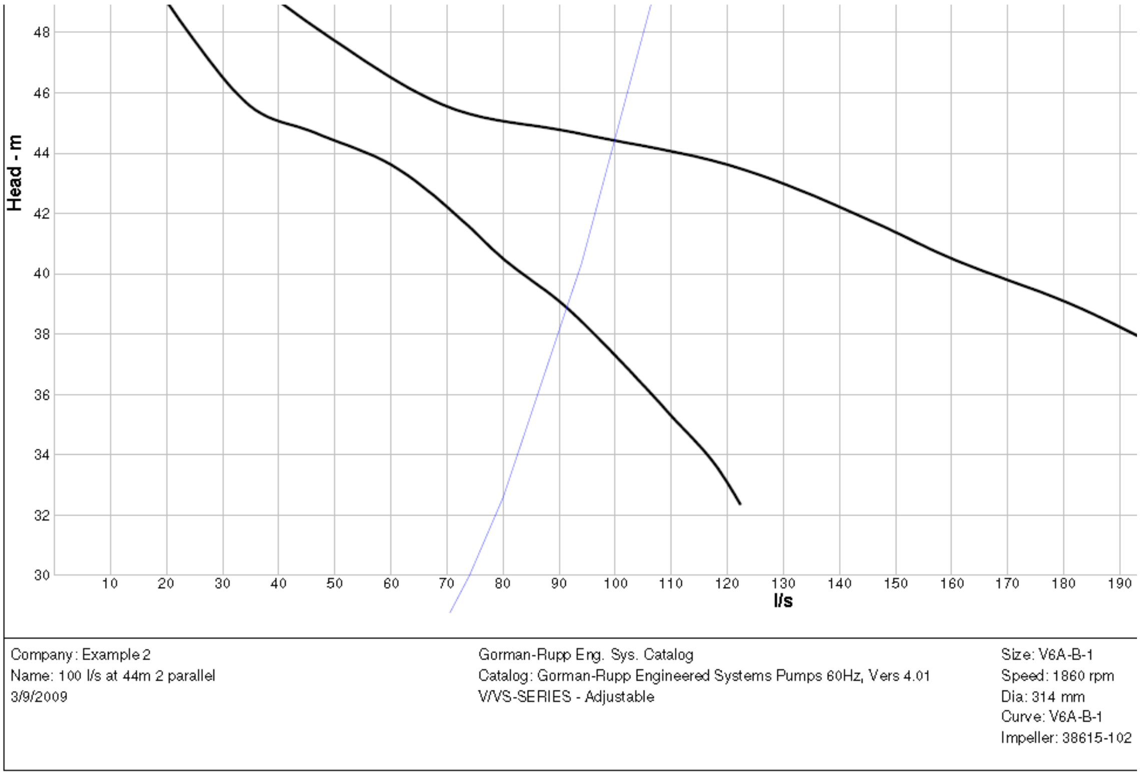
The Gorman-Rupp V6A60-B is a good selection for the ADWF (50 l/s at 22.6m), running at 1360rpm. So let's say Pump No. 1 operates when needed. The curve and system head would look like this...



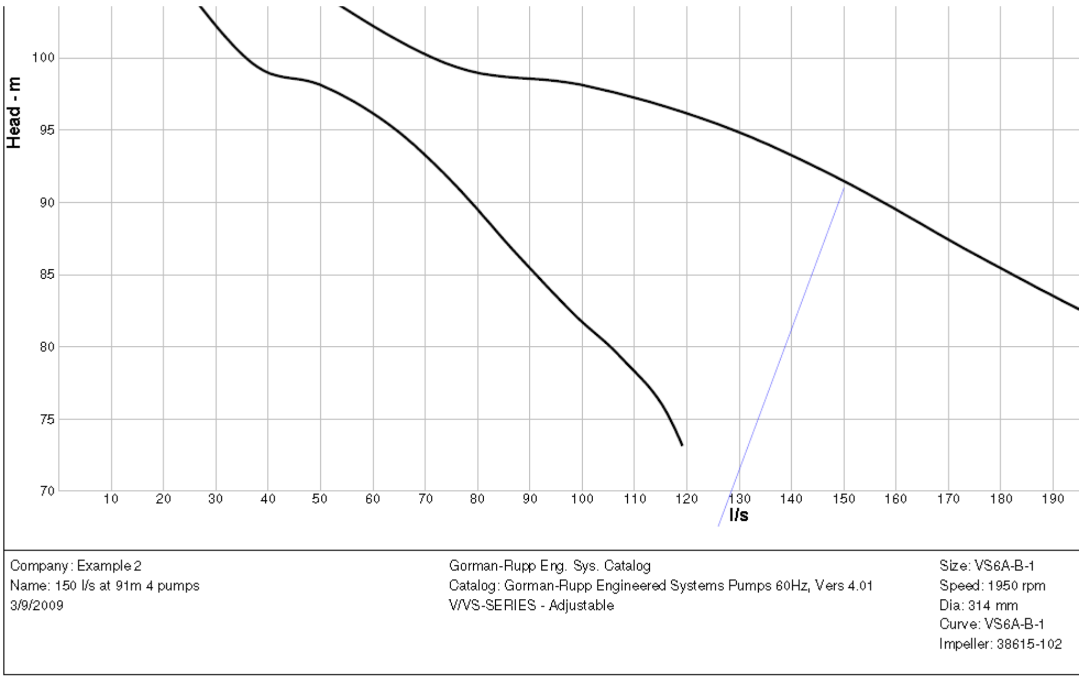
When in-flows reach PDWF (80 l/s at 32.6m), we can ramp the pump up to 1700 rpm to meet this duty...



When in-flows exceed this, either pumps 3 or 4 can be called into service to operate in parallel to produce up to 100 l/s at 44m tdh. It looks like this...



When flows exceed this 100 l/s and approach PWWF, all 4 pumps are called into service. Pumps 1&2 operate in series, as do pumps 3&4. Both sets pump in parallel into the system, which looks like this...



All 4 pumps are operating to produce 150 l/s at 91m TDH.

Now if this was a critical station with very limited storage and we needed to be able to pump at PWWF. This brings us on to..

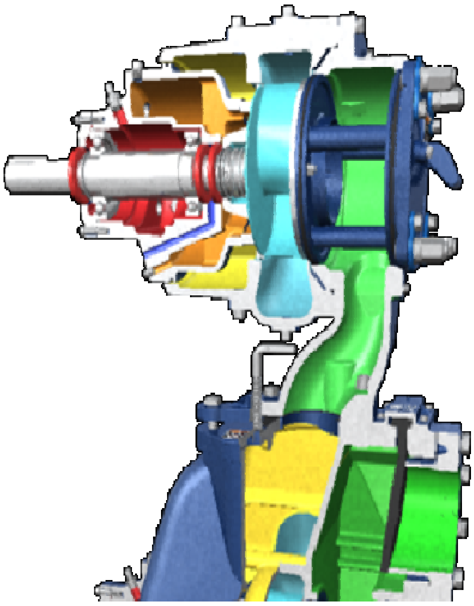
Scenario No. 4 (150 l/s, 9m static, 200mm main, but critical station)

The problem with the above solution in a critical application is that if one of the pumps is out of service for any reason, PWW flows could not be reached. The simple solution is to add another parallel/series connected set of pumps. There is now 6 pumps in the station, but here are the benefits:-

- Wet well size does not need to change, as only the suction lines need to be in the pit.
- Any one of the 6 pumps can deliver the day-to-day average flows, meaning equipment will last a very long time (controls set up to start the pump with the least hours of operation each time)
- If one of the pumps has a failure or choke, the station can still produce Peak Wet Weather Flows.

Before going onto the last 2 scenarios, another pumping solution needs to be introduced - The Gorman-Rupp 2nd stage “Ultra Mate”.

On the bottom is the Ultra V. On top is the Ultra-Mate



A unique transition piece joins the 2 stages, reducing losses associated with staged pumps and reducing the footprint taken up by a high head pumping solution.

The Ultra Mate is a purpose built 2nd stage addition to the Ultra V Series pump, enabling this pump to deliver heads up to 90 metres. This new addition delivers a great deal of versatility. The discharge can be rotated for left, right or vertical discharge, but also delivers the capability of greatly reducing capital costs when VFD's are used. This is because only the 2nd stage needs to be VFD driven, the first stage can utilise a soft starter.

We can now discuss:-

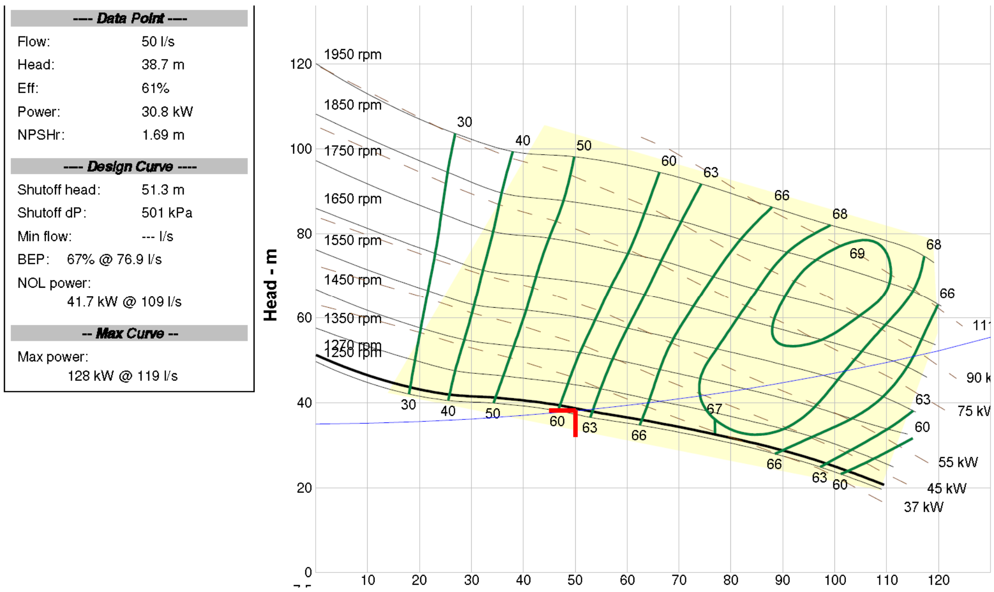
Scenario No. 5 (35m static head, 100m of 200mm main)

The system head calculations look like this for the station:-

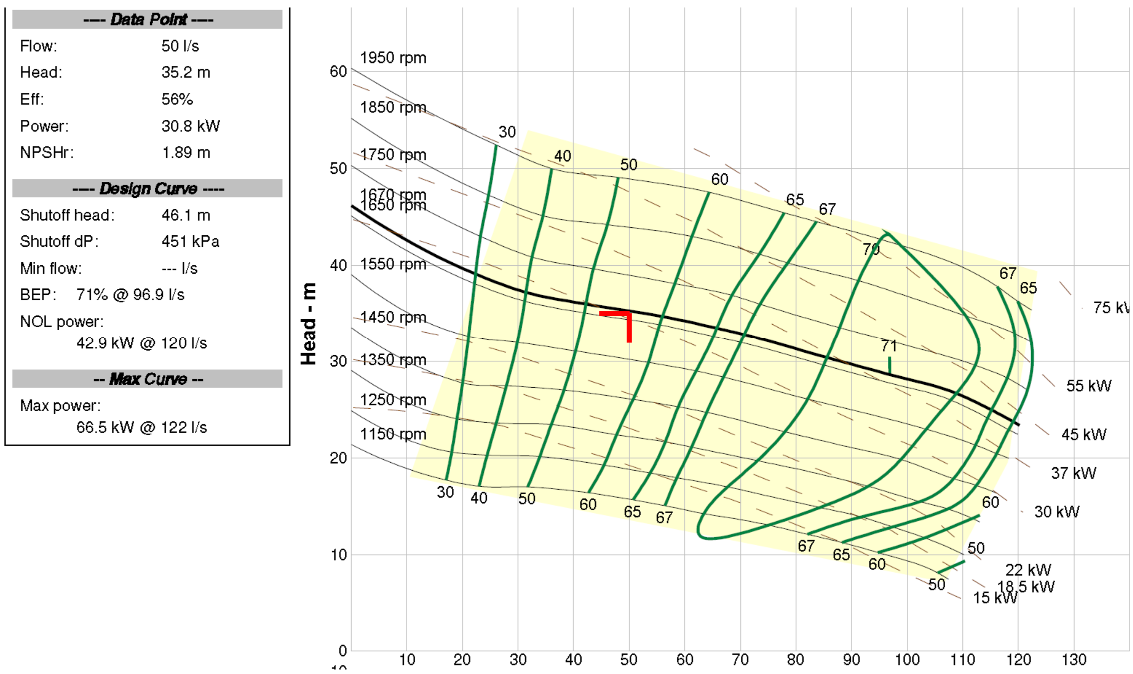
Flow	Static Head	Friction Head	TDH
50 l/s	35.0m	3.1m	38.1m
80 l/s	35.0m	7.7m	42.7m
100 l/s	35.0m	12m	47.0m
150 l/s	35.0m	26.8m	61.8m

The selection here is for a duplex VS6 set with 4 electric motors, with both first stage pumps having soft starters and both 2nd stage pumps having VFD drives.

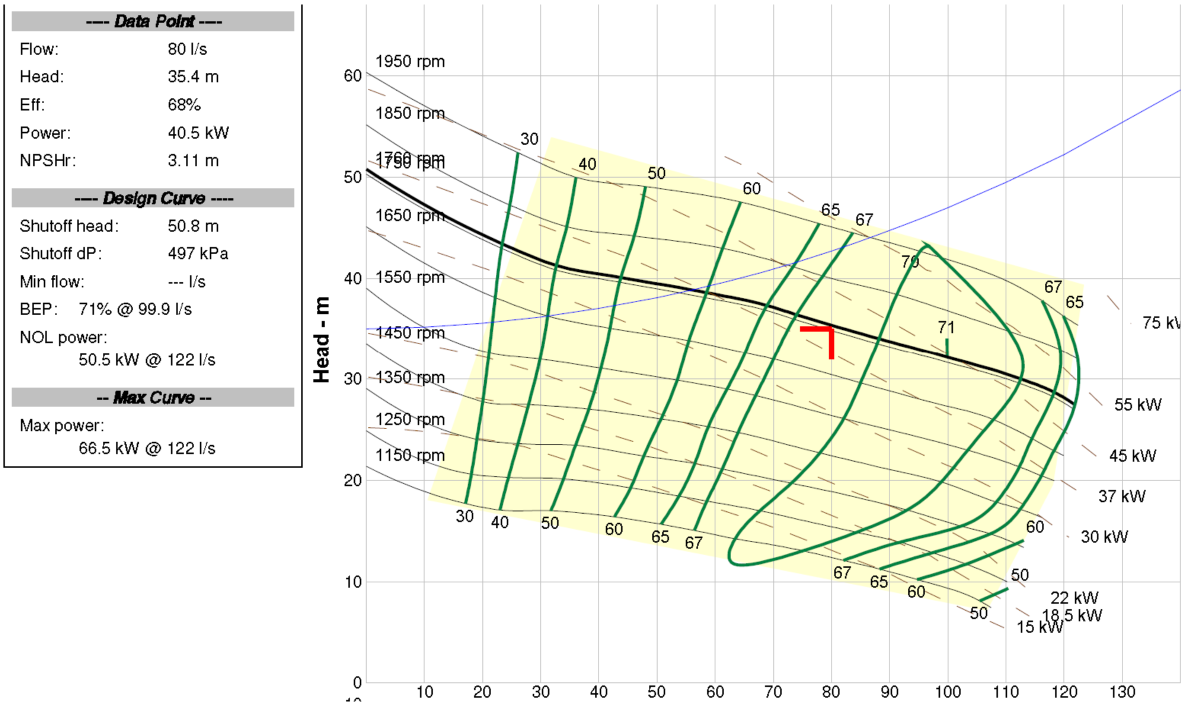
This first curve shows the VS6 (Ultra V with Ultra Mate) delivering the 50 l/s at 38.1m (ADWF), but both stages only running at 1270 rpm



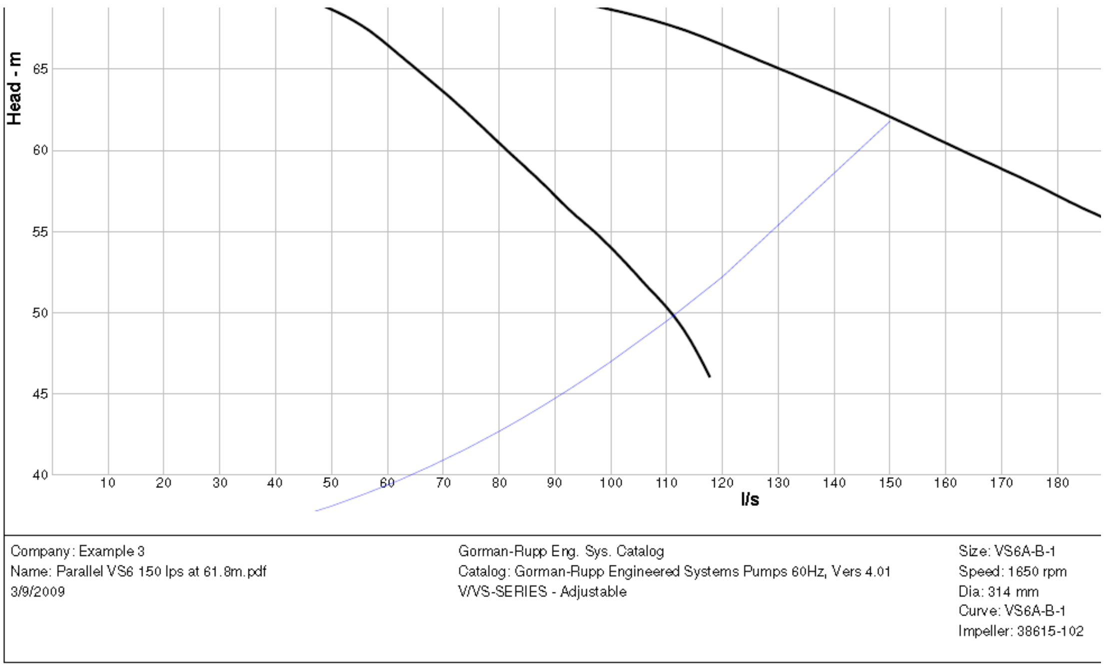
The 2nd curve shows the first stage delivering 50 l/s at 35m at 1670rpm. So we set it up with a soft starter to always run at this speed. We therefore only need to run the 2nd stage at about 100rpm to make up the additional 3.1m (see the head difference each 100rpm represents through the speed range. At the faster speeds each 100rpm represents about 5 metres of head and at the lower speeds, 100 rpm represents about 3.0 - 3.5 metres).



As the in-flow increases and we need to produce 80 l/s. See the following curve and notice the first stage still runs at 1670 rpm fixed speed (red arrow), but see the system head curve (blue) above it. This 7.7 metre difference is taken up by the 2nd stage and requires it to ramp up to 250-300 rpm.



To reach the maximum flow (as in-flows approach PWWF), we must start up the station's lag pump (the 2nd VS6A60-B set), running them in parallel with the first set, then ramp the 2nd stages of each unit up to approximately 750 – 800 rpm (speed determined by the level control system – ramping up if the levels are increasing and slowing if the level is decreasing).



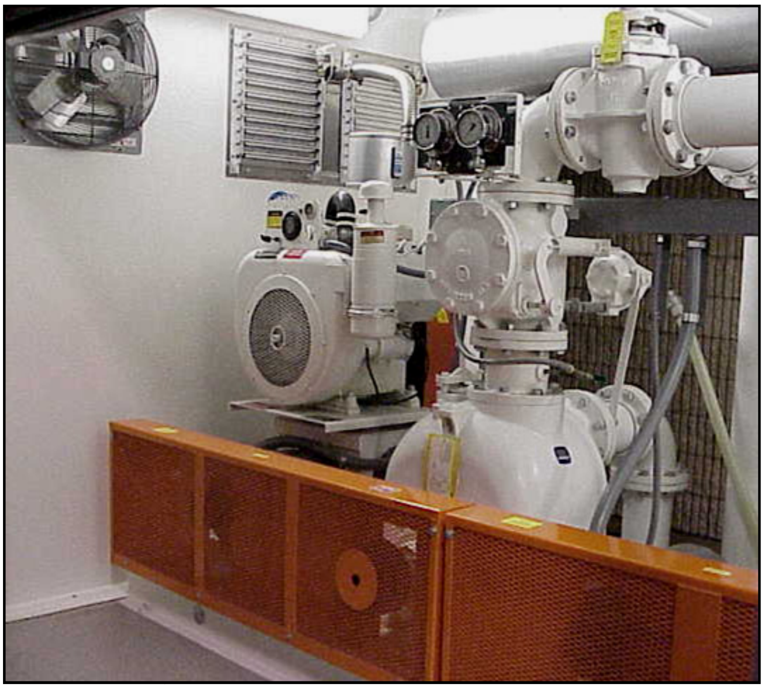
If this were a critical station, we would then move to...

Scenario No. 6

With exactly the same duty as the above, but needing both stages of both pumps to be operating to achieve PWWF, all we do is add another VS6A60-B. We then have 3 suction lines, but because they are self primers, the wet well does not have to change. The system would then be 1 duty and 2 standby for ADWF and PDWF, and switch to 2 duty and 1 standby for PWWF (when 2 sets run in parallel.

2. Coping with power outages during peak flows

Time to introduce another concept here - the Gorman-Rupp “Autostart” pump station.



The *Autostart* is a standard pump station which is fitted with at least one auxiliary engine that will drive a pump in the station under the following conditions:-

- Power outage
- Motor control centre failure
- Electric motor failure

The *Autostart* is a superior option to any other in handling potential overflow situations. The usual considerations are:-

- Additional storage
- Portable generator or pump
- Permanent generator

Additional storage is fine if it has already been built into the system, but it could be quite an expensive option if it is to be newly constructed. Either way, extra storage will only handle additional flows for so long. If the power is down for a lengthy time (eg a sub-station or power lines have been fire damaged), some form of "portable help" will still be required.

Portable generators and pumps are OK, but there is a response time involved. Also, with the portable pump, the right connections need to be available to link into the rising main. With the portable generator, it needs to be sized to suit the power requirements of the station, which also needs to be equipped with manual power transfer switch gear.

Permanent generators do solve the response time issue, but they do have their draw-backs:-

- They need to be sized to suit start current (not run current) of the station. The engine powering the generator with therefore be typically 2 ½ to 3 times bigger than the electric motors of the pumps in the station
- They will run for the full time the power is out. In a residential area, this will mean greater attention on acoustics.

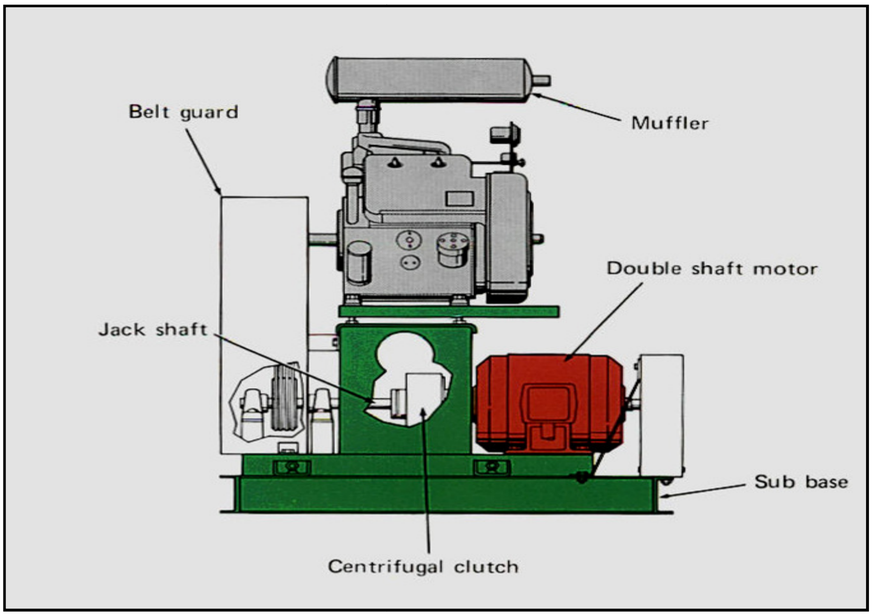
- They will generally need to be backed up by a sometimes expensive service contract.
- They do take up quite a bit of space in the station and may require fuel bunded areas.

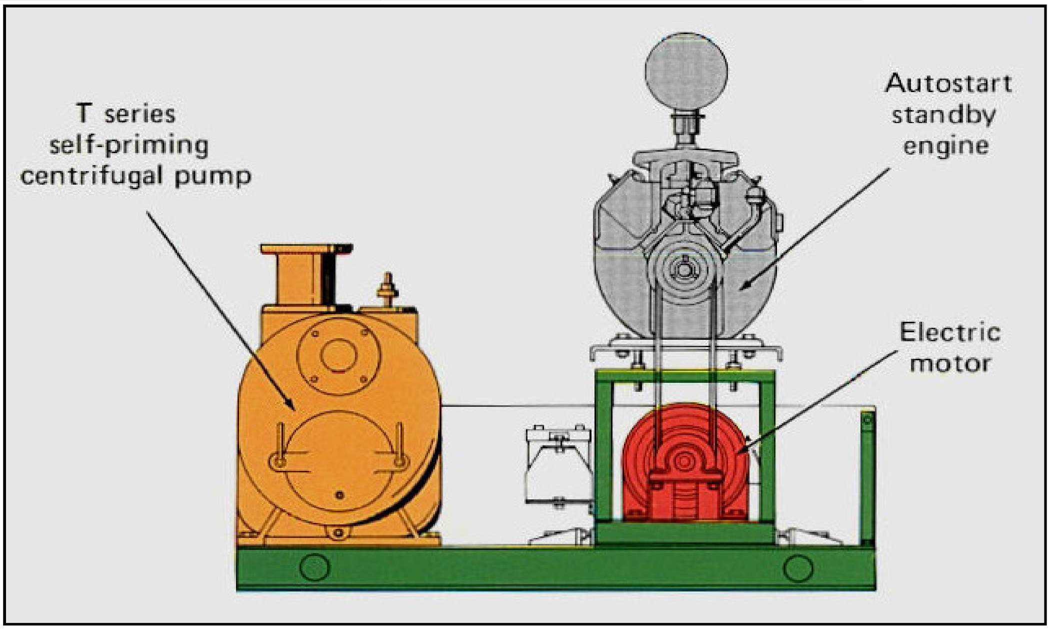
Compare these options to the *Autostart*...

- The *Autostart* is ready to run if the power goes down, or the primary controls fail, or an electric motor fails (generators are only of use if the power fails)
- The *Autostart* only runs while pumping (it starts when the “on level” is reached, and stops when the “off” level is reached).
- The addition of the auxiliary engine does not take up much additional room. This puts it well in front of a permanent generator in the respect of civil costs.
- Also, unlike either generator option, the engine needed to drive the pump only needs to be as big as the electric motors running the pumps during normal operation.
- One more point of difference between the *Autostart* and all other options, is that the *Autostart* is a completely integrated packaged pump system that is built, tested and warranted (for 5 years) by one supplier - pump manufacturer, Gorman-Rupp, with over 75 years of experience and integrity within the pumping field. All the other options require the co-ordination and supply from civil contractors, pump suppliers/manufacturers, generator manufacturers and switchgear suppliers.

How does the *Autostart* work?

The *Autostart* is equipped with an auxiliary engine, connected by V-belts, to a centrifugal clutch which drives one of the pumps in the system.





This "set-up" also gives rise to another excellent feature of the *Autostart.* The pulleys can be sized to run the pumps faster than their usual duty speed. They can therefore pump at increased flow rates during times of power outage, which are normally preceded by storm conditions and the accompanying infiltration demands placed on a station.

The *Autostart* system is equipped with a completely independent DC controller, which after a time delay, locks out the AC control side upon primary AC failure. This controller has its own liquid level sensing device.

During an “outage”, the DC system takes over. It is powered by a 12V battery that is “trickle charged” by the AC power when it is available and an alternator when the engine is running during a pump cycle. So it is always “ready to go”. When the control system “senses” the pump start level, the DC engine control starts the engine, which engages the clutch, which drives one of the pumps in the station. When the control senses “stop”, the engine is shut down.

The state-of-the-art auxiliary engine control protects the system against: high engine temperature; low oil pressure; engine over-speed; and engine over-crank. The system also includes a 24/7 timer that is able to “exercise” the DC system on a weekly basis.
Engines are also available in a variety of fuels, including natural gas, LPG and diesel.
With its moderate cost, the *Autostart* has a combination of advantages that puts it way in front of any other option. Combine this with the advantage of using Gorman-Rupp’s self priming Super T and Ultra V series of sewage pumps, which are easy for operators to access, service and maintain, and you have a system that will deliver years of operator friendly operation with automatic overflow prevention built-in.

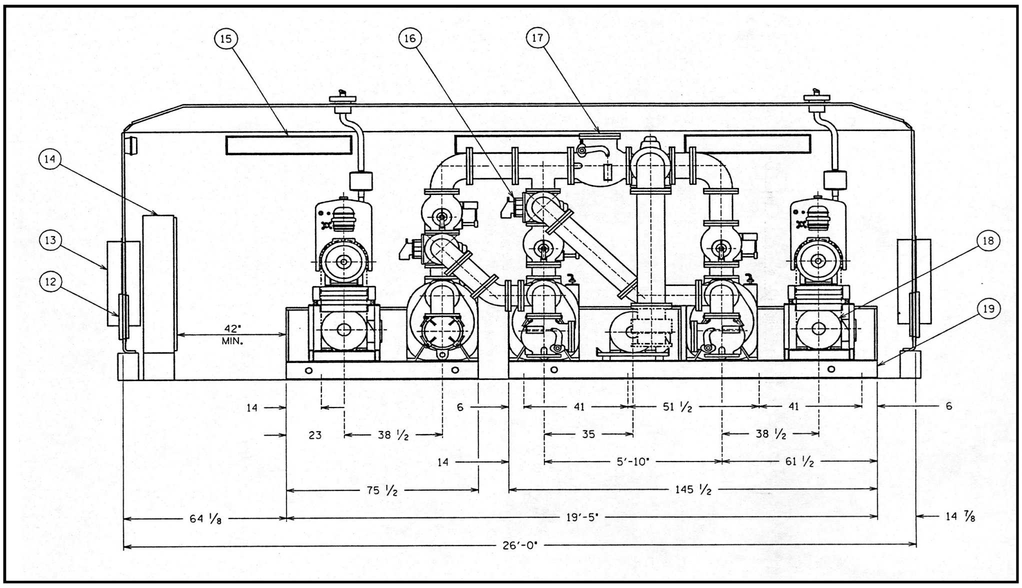
Now let’s integrate our PWWF pumping systems outlined earlier (Scenarios 1 thru 6) and see what is needed to turn these stations into ones that will only keep up to PWWF when the power is on, to stations that will keep up to the PWWF even if the power is out.

1. 9m Static Head, 250mm main, non-critical station. To the original duplex pump station, we add one engine *Autostart* arrangement and the station will handle up to PDWF if the power goes down.
2. 9m Static Head, 250mm main, critical station. To this station (because it is critical), we add 2 engine *Autostart* arrangements. Now the station will handle PWWF even if the power is out.
3. 9m Static Head, 200mm main, non-critical station. To this 4 pump station, we add 2 engine *Autostart* arrangements to be able to drive pumps 1 & 4 to pump in parallel to meet PDWF
4. 9m Static Head, 200mm main, critical station. To this 6 pump station, we add 4 engine Autostart arrangements to be able to drive pumps 1&2 in series and pumps 3&4 in series, with both sets pumping in parallel to meet PWWF.
5. 35m Static Head, 250mm main, non-critical station. Because this option required the use of Gorman-Rupp VS series 2-stage pumping units we need to alter the original design of using only VFD's on the top stage, to using one large common motor to drive both stages, then fit an engine *Autostart* arrangement to the motor of one of the sets to deliver PDWF.
6. 35m Static Head, 250mm main, critical station. As with above, we need to switch to single motors driving both stages of each pump-set. We then add 2 engine *Autostart* arrangements to be able to drive both pump-sets to deliver PDWF.

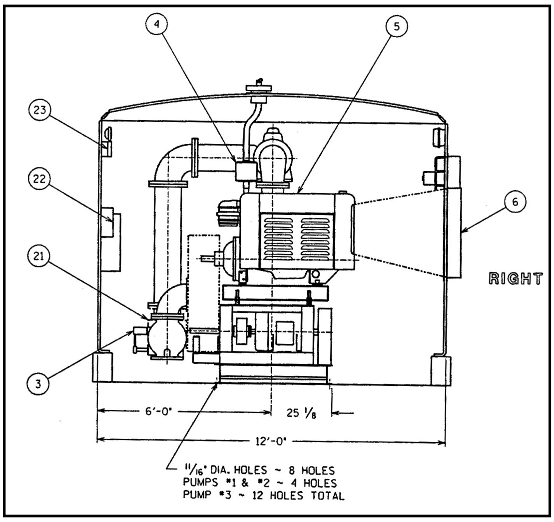
Here is a look at some special application pump stations that Gorman-Rupp has built in the past:-

1. Triplex/Duplex 8"(200mm) Station

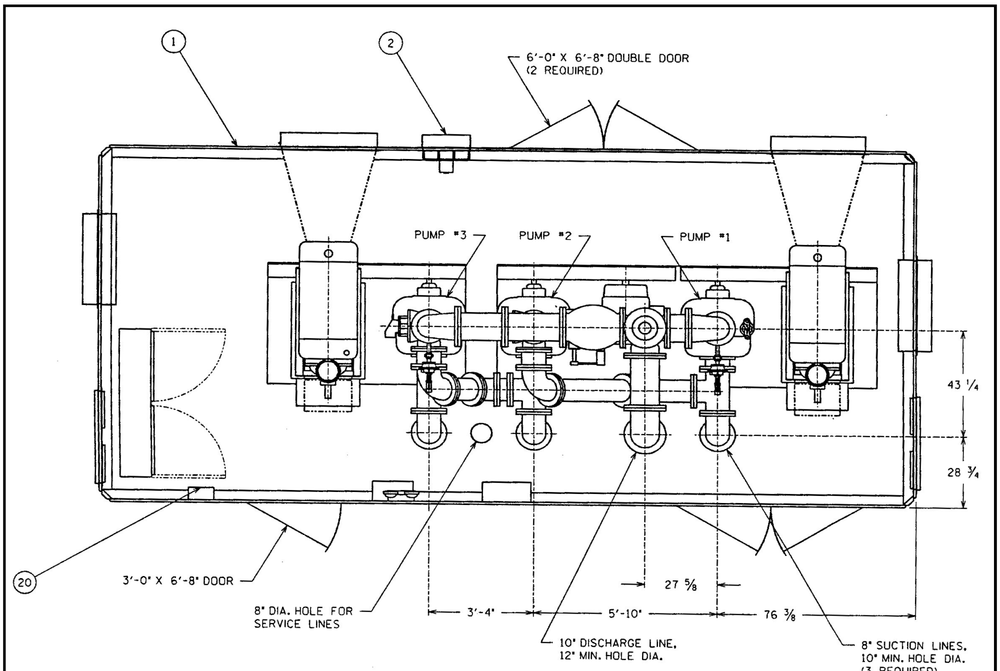
This station has 3 parallel/series connected 8" pumps with *Autostart* arrangements on 2 pumps. Any 2 pumps coming on line will pump in series.



42" MIN.
14
23
38 1/2
6
14
75 1/2
64 1/8
41
51 1/2
41
6
35
38 1/2
5'-10"
61 1/2
145 1/2
19'-5"
14 7/8
26'-0"



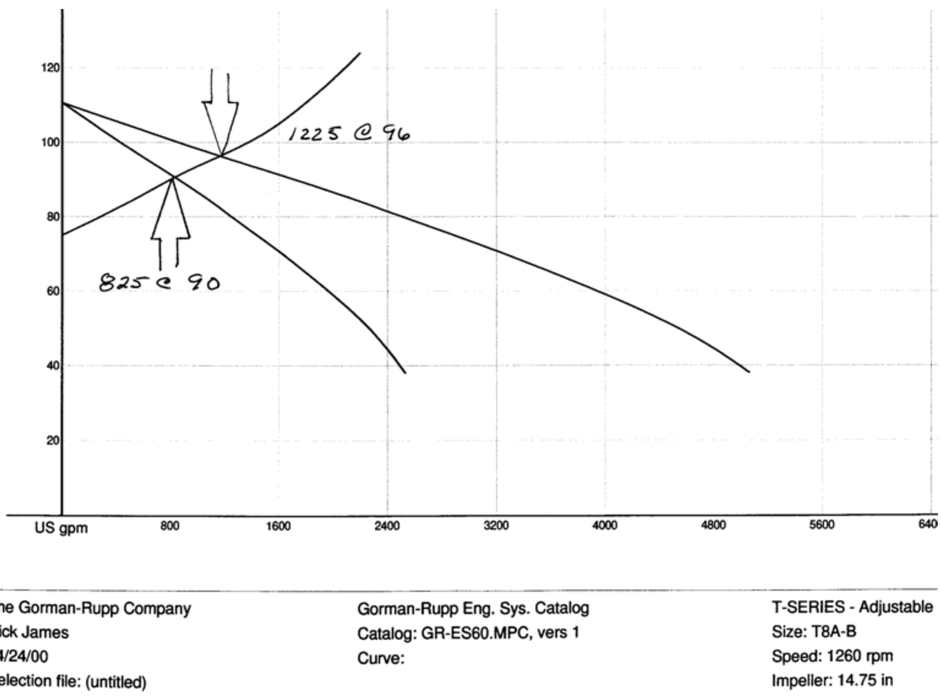
RIGHT
6'-0"
25 1/8
12'-0"
11/16" DIA. HOLES ~ 8 HOLES
PUMPS #1 & #2 ~ 4 HOLES
PUMP #3 ~ 12 HOLES TOTAL



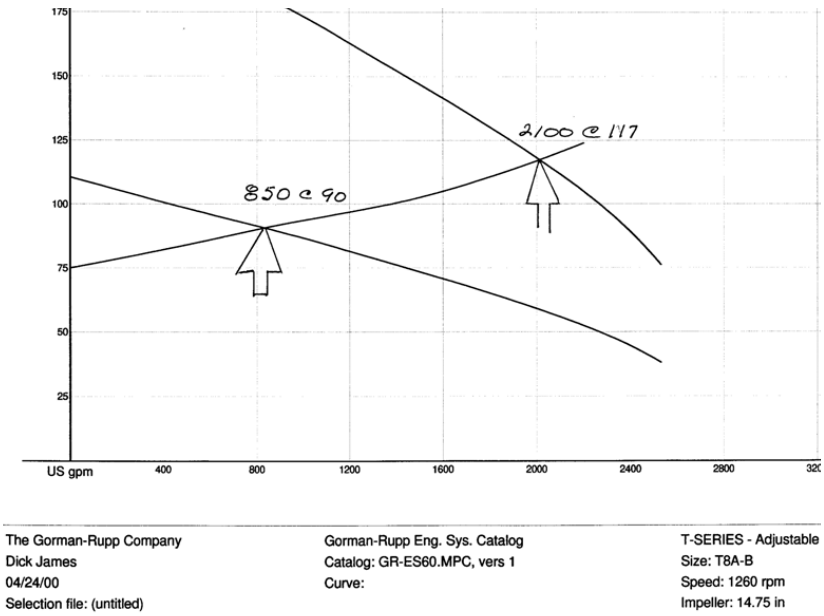
6'-0" X 6'-8" DOUBLE DOOR
(2 REQUIRED)
PUMP #3
PUMP #2
PUMP #1
43 1/4
28 3/4
3'-0" X 6'-8" DOOR
27 5/8
8" DIA. HOLE FOR
SERVICE LINES
3'-4"
5'-10"
76 3/8
10" DISCHARGE LINE,
12" MIN. HOLE DIA.
8" SUCTION LINES,
10" MIN. HOLE DIA.
(3 REQUIRED)

2. Triplex 8" (200mm) Station

Here, the use of "parallel/series" connected pumps was used to deliver flow rates well in excess of that which parallel connected pumps would deliver. See the big variation in the performance curves of, firstly, pumps in parallel...

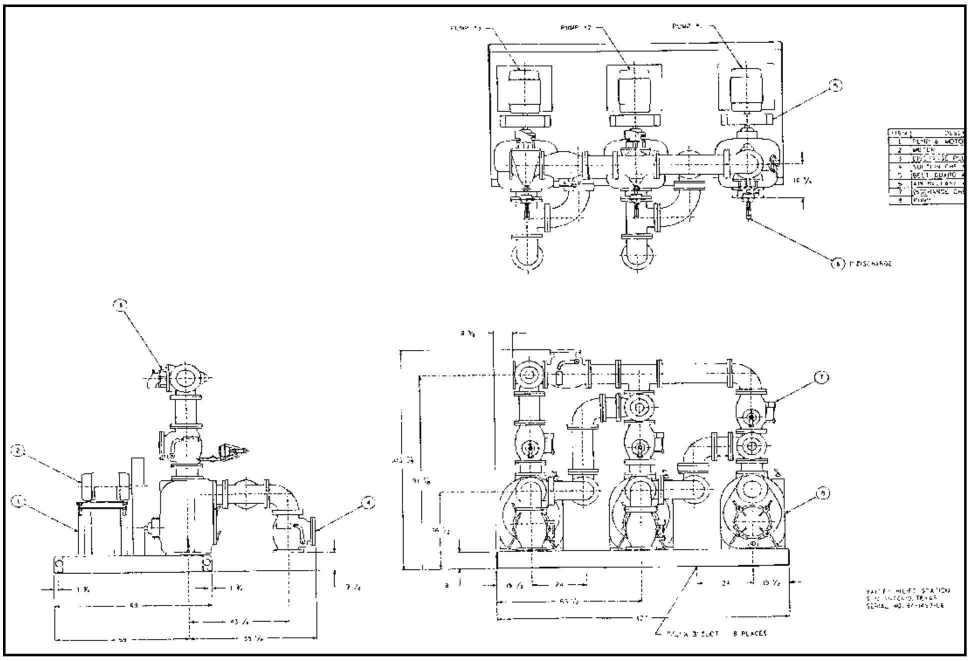


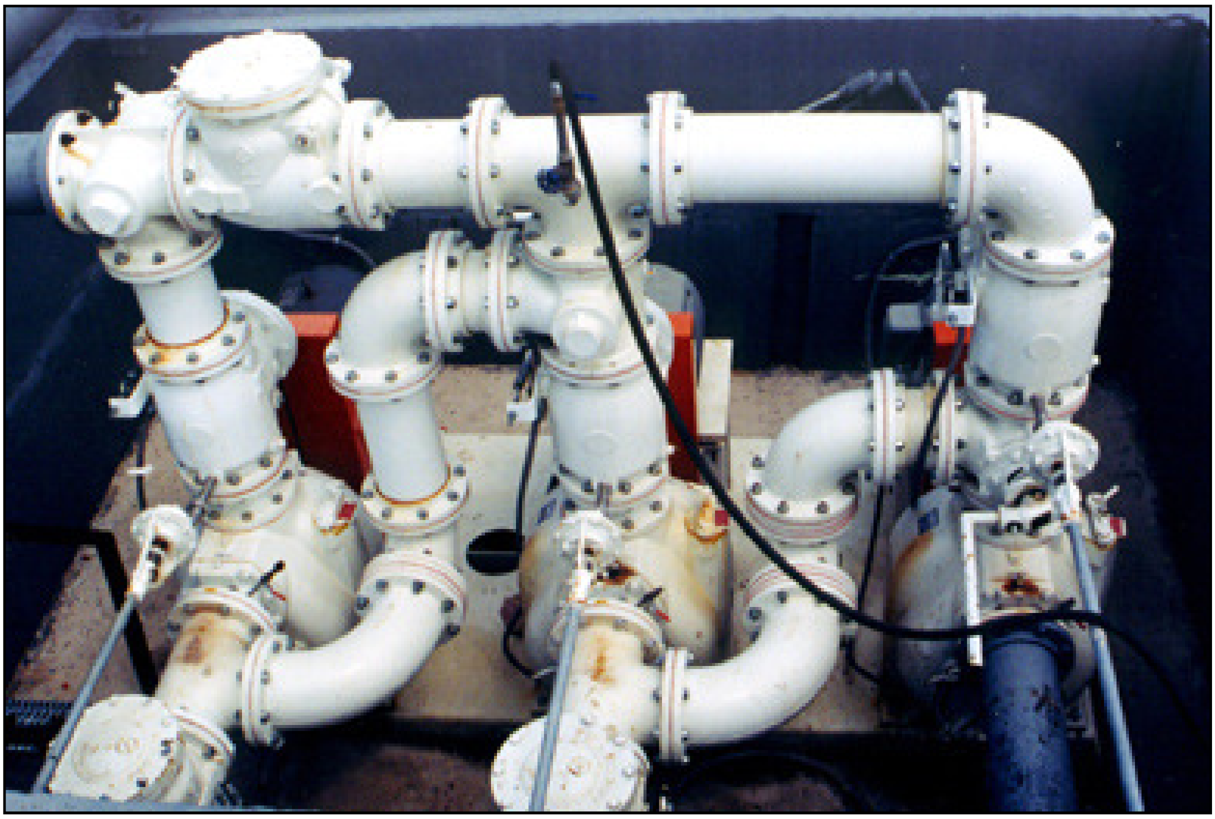
Now compare this to the result when we put the 2 pumps in series...



This is a massive 71% increase over the result if the 2 pumps were operating in parallel. Because this was a critical application, the design engineer added a 3rd pump to the system. Now if any 2 of the 3 pumps start (1&2, or 1&3, or 2&3) they will pump in series. Therefore, if one is not operational, the station can still pump at maximum capacity. This station is owned by San Antonio Water Systems, located in San Antonio, Texas.

Here is what the station looked like...





3. Lowering the life cycle cost

The above demonstrates how Gorman-Rupp self priming Ultra V and Super T series pumps can be used to overcome application issues associated with pumping at Peak Wet Weather Flows with or without available power. But the advantages do not end there for asset owners. Gorman-Rupp pumps are cheaper to own and operate over the life cycle of the station. Here is why...

a. Clearance adjustments are simple
b. Blockages are easy to remove
c. Servicing is faster and cheaper
d. Support inventory is much less

Clearance adjustment

Clearance adjustments on a Gorman-Rupp can be done in less than 5 minutes by 1 operator using 2 spanners. This enables operators to keep tolerances "tight", maintaining peak efficiency while minimising the chances of blockages.

Compare this to the submersible option. For the most, operators (requiring at least 2, or maybe 3 of them) leave adjustment till it gets critical because it requires wet well lids to be opened and safety screens to be pulled back. This exposes a confined space, so precautions need to be taken. The pump needs to be "craned" out of the pit (dripping in sewage), wear-rings need to be chiselled out and/or cooled while the casing is heated. If it needs to be taken back to the workshop, an electrician will be needed to disconnect the pump from its power source.

Before the lids are opened on a submersible station, an operator could have completed clearance adjustments on the Gorman-Rupp. What a difference.

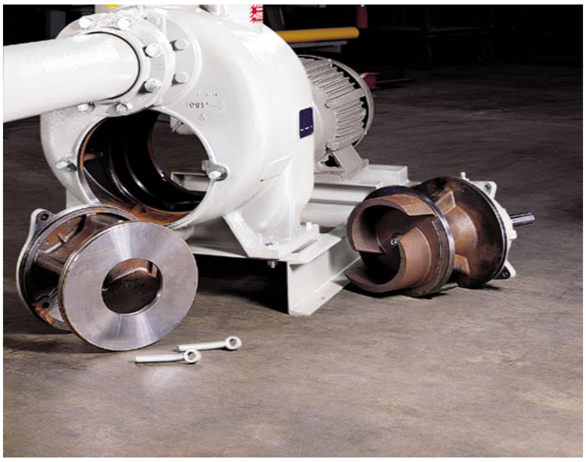
Removing Blockages

The same scenario here! Because the Gorman-Rupp is high and dry above the wet well, is easily accessed, and has a big removable cover-plate, chokes and blockages are easily removed.

The submersible option is not so easy. Operators (2 or 3 depending on the circumstances) once again need to remove wet-well covers, pull back safety screens, get a crane, pull the pump up from 6 metres or so (if it comes out easily), clean, remove blockage, then reverse the whole process.

Faster (and hence cheaper) servicing

Once again, the huge advantage for the Gorman-Rupp here, is being mounted many metres above the wet well. Contents of the pump can be gravity drained back to the sump and the pump is simple to work on. Pusher bolts help with removal of either the cover-plate or the rotating assembly. A complete overhaul can be accomplished in under an hour...



Less support inventory

Because there are only 8 Gorman-Rupp models covering flows from 10 l/s through to hundreds of litres per second and from 10 metres of head through to 90 metres of head, back-up support parts are very cheap to inventory compared to submersible pumps. To cover the same range as the Gorman-Rupp might take as many as 40-60 different submersible pump models – almost impossible to “cover for”.

4. Improving O.H.&S.

The above comments are painting the O.H.&S. picture already, but maybe some real pictures explain more fully. Which poses most risks? This above ground Gorman-Rupp station...?

Or maybe this submersible pit is a little more dangerous...

Or maybe here if someone has to go down here to repair guide rails or replace a duck-foot bend or try to dislodge a stuck submersible pump...

Or what about working in this submersible pump valve pit...

In Summary

Using Gorman-Rupp Ultra V or Super T series pumps can provide solutions to designers on difficult applications, such as coping with PWWF when power is on or off. They will also be a bonus for the asset owners because maintenance and servicing costs will be cheaper than any other pump option. Using them will also greatly improve the O.H.&S. for pump stations and almost alleviate confined spaces issues.

We trust this paper has been thought provoking and of value to you.

There are several other papers that Hydro Innovations can make available to designers of pumping systems. We also have information discs and presentations on these subjects.

Call us on 02 9647 2700 so you can have a real 'person' contact when you have ANY questions on pumps and their applications. We'll also arrange for you to receive priority advice on any new technical developments, new product releases, tips on cost savings and maintenance, etc. Our mission is to be a valuable resource to help YOU do your job better.

Hydro Innovations General Manager & author of the white paper series, Garry Grant