Lock 16, 17 & 18
Grand Canal

PUMP AUDIT SUMMARY REPORT

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Lock 16, 17 & 18 Grand Canal

PUMP AUDIT SUMMARY REPORT

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Content

1 Introduction

This report summarises the key findings of the Phase 1 pump station audit for Lock 16, 17 & 18 on the Grand Canal Pumping Station (PS). The 3no pump houses are used in a chain to supply water to the summit pound of the Grand Canal during dry periods to maintain navigable levels. This review is based upon the data provided by Waterways Ireland (WI) and a site visit undertaken on 17th September 2019.

Pump testing was undertaken at the site visit using calibrated instrumentation.

- Power (using Fluke power meter)
- Flow rate (using Panametrics PT878 ultrasonic flow meter)
- Levels and dimensions (laser/tape measure)
- Delivery pressure (using pressure logger) where possible

The measurement parameters taken at the site visit are shown in Table 1

Table 1 – Measured Parameters

PS Site	Power	Flow rate	Rising Main Entry Pressure	Levels / Dims
Lock 16	✓	✓	×	✓
Lock 17	✓	✓	✓	✓
Lock 18	✓	✓	✓	✓

The purpose of the site audit and pump performance testing is to estimate the existing pump performance, system curve (including rising main static head) and capture and evaluate key aspects of the existing arrangement in the context of assessing potential improvements.

2 System Description

2.1 Lock 16

Lock 16 is located near Digby Bridge, Sallins, Co. Kildare. The pump house is one of a chain of pumping stations along the Grand Canal designed to maintain an upstream level within the canal.

Figure 1 - Lock 16 on the Grand Canal PS (viewed from Digby Bridge)

Lock 16 PS comprises of 1no KSB Amarex fixed-speed submersible pump (Model: KRT K250-400/206UG-S). The pump station intake is direct from the Grand Canal downstream of Lock 16 via a 1500 mm wide concrete intake culvert. The intake is partially submerged and is protected with a 50 mm spaced bar screen.

The pump discharge pipework is is 250mm nominal diameter (DN250) and manufactured from 16 bar rated flanged ductile iron pipe (DI, PN16), and connects to a DN300 cast iron rising main via a concentric taper. The rising main free discharges to an outfall chamber approximately 10 m away from the pump house. The flow then gravitates approximately 20 m to the outfall into the canal via a 600 mm diameter cast iron pipe.

It was originally understood that the pumps discharged direct into the canal. The outfall chamber was only recently found in heavy undergrowth.

There are no isolation or check valves contained within the pump station. 1no Endress & Hauser ultrasonic level probe is located within the wet well for the purpose of low level protection.

Figure 2 Lock 16 PS Outfall

Table 2 – Pump Details

Parameter	Description
Pump	KSB Amarex KRT K250-400/206
No. of Pumps	1
Duty Configuration	Duty (Submersible)
Rated Motor Output	18 kW
Impeller Diameter	314 mm
Drives	Direct
Pipework	250 mm diameter, 16 bar rated (PN16)
Non-Return Valves	N/A
Wet Well Level Sensor	Endress & Hauser Prosonic T for Low level protection
Wet Well Level	75.19 mAD
Pump Centre Line	74.44 mAD

2.1.1 Rising Main

The Lock 16 rising main is approximately 10 m in length and manufactured from flanged cast iron past the pump station.

The rising main runs from the pump house and free discharges to an outfall box on the Grand Canal. It is reported that there are no isolation or check valves present on the rising main. However, this could not be confirmed during the survey due to the extensive vegetation.

The pipeline condition is unknown but there are no reports of bursts arising since construction and given the short length its surface condition (roughness) is not expected to have any significant impact on pumping head. The pipe roughness has been based on recommended design roughness value for normal condition uncoated cast iron pipe[1].

[1] Wallingford, H R (1990)

Table 3 – Pump Rising Main Details

Parameter	Description
Approx. Length	10 m
Elevation Rise	6.9 m
Pipe Diameter	300 mm
Discharge Level	78.90 mAD
Pipe Material	Cast Iron
Pipe Roughness	ks = 0.3 mm assumed

2.1.2 System Description

System curves have been derived for the following operating scenarios:

- 1no Pump operating only

The suction and delivery elevations have been based on the site recorded measurements as there is no SCADA data for Lock 16 PS. The estimated pipe losses have been based on an equivalent roughness value for that determined from site audit data for the Lock 17 and Lock 18 sites.

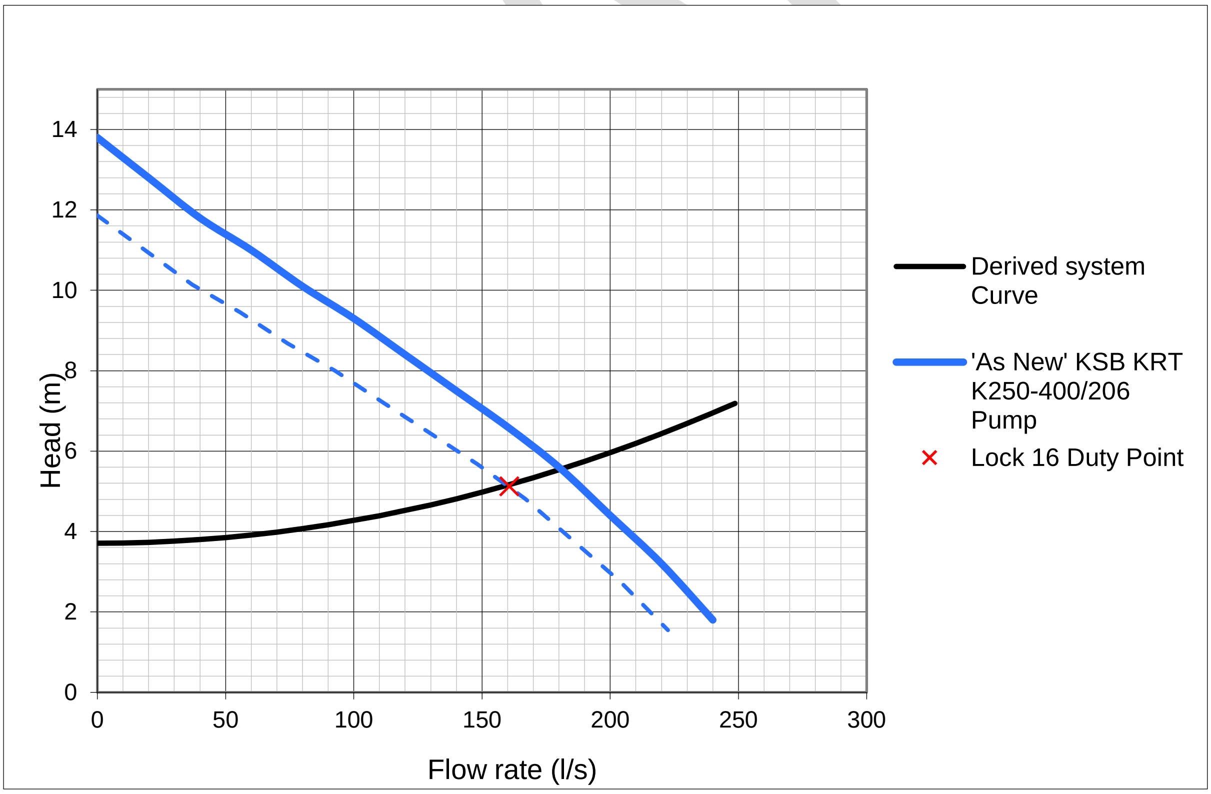


Figure 3 - Lock 16 Derived System Curve

1	INPUT DATA					
	Gravity, g	9.81	m/s2			
	Atmos pressure	101.3	kPa	Sump levels		
	Fluid	Water	[select]	TWL		mAOD
	Temperature	4	°c	Design	75.19	mAOD
				BWL		mAOD
	Kinem. viscosity	1.57E-06	m2/s			
	Density	1000.0	kg/m³			
	Vap pressure	0.0821	m			

Suction		Discharge	
Pump level:	74.44	mAOD	
Pump station located before reach:	1	[select]	

Assumed Hydraulic Discharge levels			
	TWL		mAOD
	Design	78.90	mAOD
	BWL		mAOD
Static lift	Minimum	0.00	m
	Design	3.71	m
	Maximum	0.00	m

Reach:		1	2	3	4	5	6	7	8	9	10	11	12	13
Description		DI pump discharge	DI pump discharge	DI rising main										
Length (m)		2	1	16										
Diameter (m)		0.263	0.315	0.315										
Flow area (m²)		0.05433	0.07793	0.07793										
Roughness (mm)	Low													
	Design	0.3	0.3	0.3										
	High													
Proportion of station flow		1.00	1.00	1.00										

Global head loss factor: % (added to friction and fittings losses throughout)

Fittings Losses:	k-value	Number of fittings: 1	2	3	4	5	6	7	8	9	10	11	12	13
Inlet (slightly rounded)	0.25	1												
Short R 90° bend	0.75	1												
Taper up (4:5)	0.03	1												
Short R 90° bend	0.75		2											
Swing check valve	1													
Gate valve	0.12													
Gate valve	0.12													
Expansion 2:3	0.35													
Expansion 3:4	0.2													
Outlet	1			1										
Elbow 45° bend	0.4			1										
Elbow 22.5° bend	0.2													
Additional K (other devices)														
Total K		1.03	1.50	1.40	0.00									

Figure 4 - Hydraulic Calculation Input Data for Lock 16 Pump

2.2 Lock 17

Lock 17 is located near Landenstown Bridge, near Donore, Co. Kildare. The pump house is one of a chain of pumping stations along the Grand Canal designed to maintain an upstream level within the canal.

Figure 5 - Lock 17 on the Grand Canal PS (viewed from Digby Bridge)

Lock 17 PS comprises 1no KSB Amarex fixed-speed submersible pump (Model: KRT K250-400/206UG-S). The pump station intake is direct from the Grand Canal downstream of Lock 17 via a 1500 mm wide concrete intake culvert. The intake is partially submerged and is protected with a 50 mm spaced bar screen.

The pump discharge pipework is PN 16 DN250 ductile iron to pump station floor level and connects to a DN300 cast iron rising main via a concentric taper. Unlike Lock 16, the rising main discharges into the canal over a weir board approximately 30 m away from the pump house.

There are no isolation or check valves contained within the pump station. 1no Endress & Hauser ultrasonic level probe is located within the wet well for purpose of low level protection.

Figure 6 Lock 17 PS Outfall

Table 4 – Pump Details

Parameter	Description
Pump	KSB Amarex KRT K250-400/206
No. of Pumps	1
Duty Configuration	Duty (Submersible)
Rated Motor Output	18 kW
Impeller Diameter	314 mm
Drives	Direct
Pipework	250 mm diameter, 16 bar rated (PN16)
Non-Return Valves	N/A
Wet Well Level Sensor	Endress & Hauser Prosonic T for Low level protection
Wet Well Level	78.15 mAD
Pump Centre Line	77.55 mAD

2.2.1 Rising Main

The Lock 17 rising main is approximately 30 m in length and manufactured from flanged cast iron past the pump station – based on the assumption that it does not change for the buried section.

The rising main runs from the pump house and free discharges to an outfall box on the Grand Canal. It is reported that there are no isolation or check valves present on the rising main, and no chambers were observed during the site visit to contradict this understanding.

The pipeline condition is unknown but there are no reports of bursts arising since construction and given the short length its surface condition (roughness) is not expected to have any significant impact on pumping head. the pipe roughness has been based on recommended design roughness value for normal condition uncoated cast iron pipe[2].

Table 5 – Pump Rising Main Details

Parameter	Description
Approx. Length	30 m
Elevation Rise	2.7 m
Pipe Diameter	300 mm
Discharge Level	80.85 mAD
Pipe Material	Cast Iron
Pipe Roughness	ks = 0.3 mm assumed

2.2.2 System Description

System curves have been derived for the following operating scenarios:

- 1no Pump operating only

The suction and delivery elevations have been based on the site recorded measurements as there is no SCADA data for Lock 17 PS. The pipe roughness has been estimated based on the site audit data.

[2] Wallingford, H R (1990)

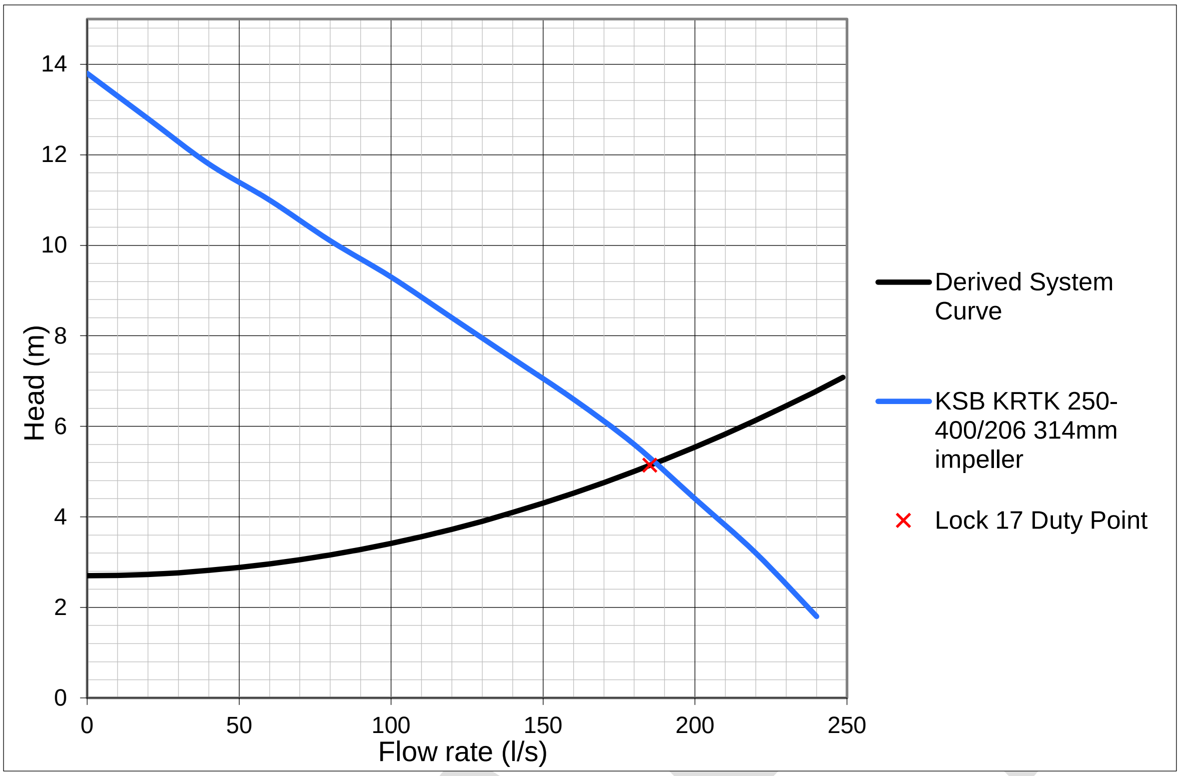


Figure 7 - Lock 17 Derived System Curve

1 INPUT DATA

Gravity, g	9.81	m/s2
Atmos pressure	101.3	kPa
Fluid	Water	[select]
Temperature	4	°c
Kinem. viscosity	1.57E-06	m2/s
Density	1000.0	kg/m³
Vap pressure	0.0821	m

Sump levels		
TWL	78.15	mAOD
Design	78.15	mAOD
BWL	78.15	mAOD

Suction | Discharge

Pump level:	77.05	mAOD
Pump station located before reach:	1	[select]

Assumed Hydraulic Discharge levels		
TWL	80.85	mAOD
Design	80.85	mAOD
BWL	80.85	mAOD

Static lift		
Minimum	2.70	m
Design	2.70	m
Maximum	2.70	m

Reach:		1	2	3	4	5	6	7	8	9	10	11	12	13
Description		DI pump discharge	DI pump discharge	CI rising main										
Length (m)		1.5	1	30										
Diameter (m)		0.253	0.308	0.308										
Flow area (m²)		0.05027	0.07451	0.07451										
Roughness (mm)	Low													
	Design	0.3	0.3	0.3										
	High													
Proportion of station flow		1.00	1.00	1.00										

Global head loss factor: % (added to friction and fittings losses throughout)

Fittings Losses:	k-value	Number of fittings: 1	2	3	4
Inlet (slightly rounded)	0.25	1			
Long R 90° bend	0.4	2			
Taper up (4:5)	0.03		1		
Short R 90° bend	0.75		2		
Swing check valve	1				
Gate valve	0.12				
Gate valve	0.12				
Expansion 2:3	0.35				
Expansion 3:4	0.2				
Outlet	1			1	
Elbow 45° bend	0.4			1	
Elbow 22.5° bend	0.2			1	
Additional K (other devices)					
Total K		1.05	1.53	1.60	0.00

Figure 8 - Hydraulic Calculation Input Data for Lock 17 Pump

2.3 Lock 18

Lock 18 is located near Goatstown, Denore, Co. Kildare. The pump house is the last of a chain of pumping stations along the Grand Canal designed to maintain an upstream level within the canal.

Figure 9 - Lock 18 on the Grand Canal PS (viewed from Canal Path)

Lock 18 PS comprises of 1no KSB Amarex fixed-speed submersible pump (Model: KRT K250-400/206UG-S). The pump station intake is direct from the Grand Canal downstream of Lock 18 via a 1500 mm wide concrete intake culvert. The intake is partially submerged and is protected with a 50 mm spaced bar screen.

The pump discharge pipework is PN16 DN250 ductile iron to pump station floor level and connects to a DN300 cast iron rising main via a concentric taper. The rising main free discharges to an outfall chamber approximately 10m away from the pump house. The flow then gravitates approx 20 m to the outfall into the canal via a 600 mm cast iron pipe.

It was originally believed that the pumps discharged direct into the canal until the outfall chamber was recently found in heavy undergrowth.

There are no isolation or check valves contained within the pump station. 1no Endress & Hauser ultrasonic level probe is located within the wet well for purpose of low level protection.

Figure 10 Lock 18 PS Outfall – located behind pumping station

Table 6 – Pump Details

Parameter	Description
Pump	KSB Amarex KRT K250-400/206
No. of Pumps	1
Duty Configuration	Duty (Submersible)
Rated Motor Output	18 kW
Impeller Diameter	314 mm
Drives	Direct
Pipework	250 mm diameter
Non-Return Valves	N/A
Wet Well Level Sensor	Endress & Hauser Prosonic T for Low level protection
Wet Well Level	81.49 mAD
Pump Centre Line	80.23 mAD

2.3.1 Rising Main

The Lock 17 rising main is approximately 10m in length and manufactured from PN16 flanged cast iron past the pump station.

The rising main runs from the pump house and free discharges to an outfall box on the Grand Canal. It is reported that there are no isolation or check valves present on the rising main; however, this could not be confirmed during the survey due to extensive vegetation.

The pipeline condition is unknown but there are no reports of bursts arising since construction and given the short length its surface condition (roughness) is not expected to have any significant impact on pumping head. The pipe roughness has been based on recommended design roughness value for normal condition uncoated cast iron pipe[3].

Table 7 – Pump Rising Main Details

Parameter	Description
Approx. Length	10 m
Elevation Rise	3.81 m
Pipe Diameter	300 mm
Discharge Level	85.1 mAD
Pipe Material	Cast Iron
Pipe Roughness	ks = 0.3 mm assumed

2.3.2 System Description

System curves have been derived for the following operating scenarios:

- 1no Pump operating only

The suction and delivery elevations have been based on the site recorded measurements as there is no SCADA data for Lock 18 PS. The pipe roughness has been estimated based on the site audit data.

[3] Wallingford, H R (1990)

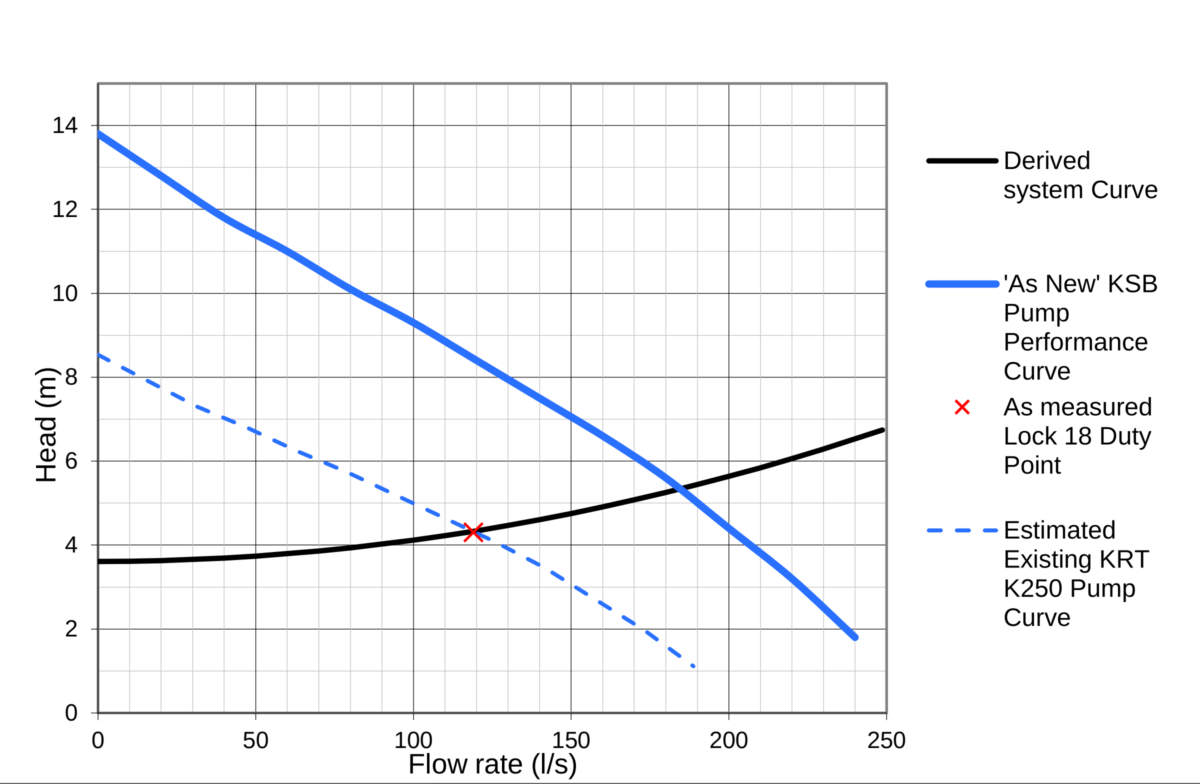
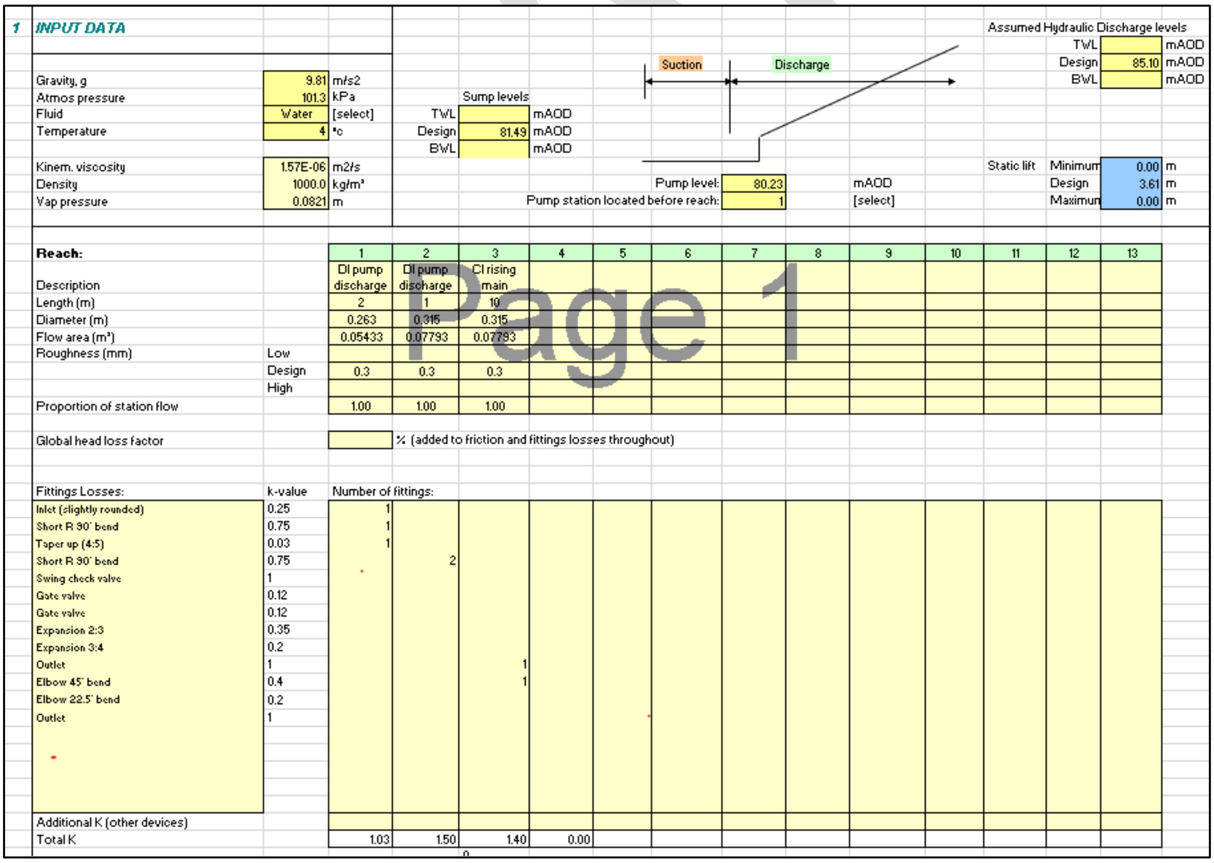


Figure 11 - Lock 18 Derived System Curve



1 INPUT DATA

Assumed Hydraulic Discharge levels: TWL — mAOD; Design 85.10 mAOD; BWL — mAOD

Suction | Discharge

Gravity, g	9.81	m/s2
Atmos pressure	101.3	kPa
Fluid	Water	[select]
Temperature	4	°c
Kinem. viscosity	1.57E-06	m2/s
Density	1000.0	kg/m³
Vap pressure	0.0821	m

Sump levels: TWL — mAOD; Design 81.49 mAOD; BWL — mAOD

Pump level: 80.23 mAOD

Pump station located before reach: 1 [select]

Static lift: Minimum 0.00 m; Design 3.61 m; Maximum 0.00 m

Reach:		1	2	3	4	5	6	7	8	9	10	11	12	13
Description		DI pump discharge	DI pump discharge	CI rising main										
Length (m)		2	1	10										
Diameter (m)		0.263	0.315	0.315										
Flow area (m²)		0.05433	0.07793	0.07793										
Roughness (mm)	Low													
	Design	0.3	0.3	0.3										
	High													
Proportion of station flow		1.00	1.00	1.00										
Global head loss factor			% (added to friction and fittings losses throughout)											
Fittings Losses:	k-value	Number of fittings:												
Inlet (slightly rounded)	0.25	1												
Short R 90' bend	0.75	1												
Taper up (4:5)	0.03	1												
Short R 90' bend	0.75		2											
Swing check valve	1													
Gate valve	0.12													
Gate valve	0.12													
Expansion 2:3	0.35													
Expansion 3:4	0.2													
Outlet	1			1										
Elbow 45' bend	0.4			1										
Elbow 22.5' bend	0.2													
Outlet	1													
Additional K (other devices)														
Total K		1.03	1.50	1.40	0.00									

Figure 12 - Hydraulic Calculation Input Data for Lock 18 Pump

2.4 Key Observations

2.4.1 General

The key observations from the derived system curves are as follows:

a) Rising Main losses – The actual condition and roughness equivalent of the mains for Lock 16 is unknown, and no pressure data was taken during the time of the pump audit. An assumed roughness of 0.3 mm was used. This is based on HR Wallingford Hydraulic Tables recommended design value for uncoated cast iron and is consistent with Lock 17 as measured rising main.

b) In order to align the site measured results (flow rate and pressure where measured) with the information obtained on the pump curve from KSB, the performance of the pump curves has been lowered from their "as new" published performance curves. The dashed line on the individual pump system curve represents an approximation applying affinity laws to the original pump curve.

c) It has been assumed that the motor efficiency has remained constant for each pump.

d) The pumps at Lock 16 and Lock 18 are significantly operating below the "as new" system curves provided by KSB. The Lock 17 pump performance does fall within ISO9906 pump test tolerances for a new pump..

There could be several reasons for the lower pump performance, with possibilities including:

- Increased rising main losses over that derived as pressure data could not be ascertained at the time of testing for Lock 16. This would not have affected Lock 17 & 18 as pressure measurements were undertaken
- Measurement or data inaccuracies taken from on-site data collection
- Impeller wear or damage
- Debris impinging on the impeller or delivery connection (floating vegetation/reeds in the canal was significant). Piles of reeds/vegetation were noticed on the bank at each of the intake screens, which indicates that they are regularly cleared and that debris is a known issue. Debris impingement appears at present to be a feasible option for the underperforming pumps at Lock 16 and Lock 18.

Figure 13 – Debris build up on the intake screen of Lock 18

e) During the site audit at Lock 17, there was significant over topping of the upstream lock gate - this was noted as a common occurrence (Figure 14). In addition, there was also significant leakage through the lock gate, it would be recommended that these gates be inspected as to limit the losses.

f) It should be noted the system curves do differ from those produced form the pump supplier. The expected flows and resulting head will differ from the predicted flows form KSB. It is possible that the intermediate chamber for Lock 16 and Lock 18 was not considered when these curves were produced as the chambers were only recently found.

g) For Lock 16 and 18, the static head is higher than initially thought but the dynamic losses are lessened, producing the "flatter" system curve that can be seen in Figure 3 - Lock 16 Derived System Curve when compared to the KSB pump curve shown in Appendix A.

h) The measured head for Lock 18 was significantly fluctuating due to a possible issue with the pump (Figure 15). Although averaged over a 20-minute period this fluctuation may be skewing the averaged pressure results and not giving a true representation of the operating pressure of the system.

i) During the site audit at Lock 18, the pump was vibrating significantly. It was recommended at the time that this be investigated. It should be noted that there was significant vegetation in the canal at the time of audit, which may have partially clogged the impeller. Alternatively, this could be early indication of something more significant.

j) During the site audit at Lock 16, the handrailing to the inlet screens was found to insecure, this was then taped off during the site visit to prevent access by ourselves and the public. As such the inlet screens at Lock 16 could not be investigated. It is recommended as the inlet screen is within a public area that this addressed and remedied.

Figure 14 – Over topping of lock gate at Lock 17

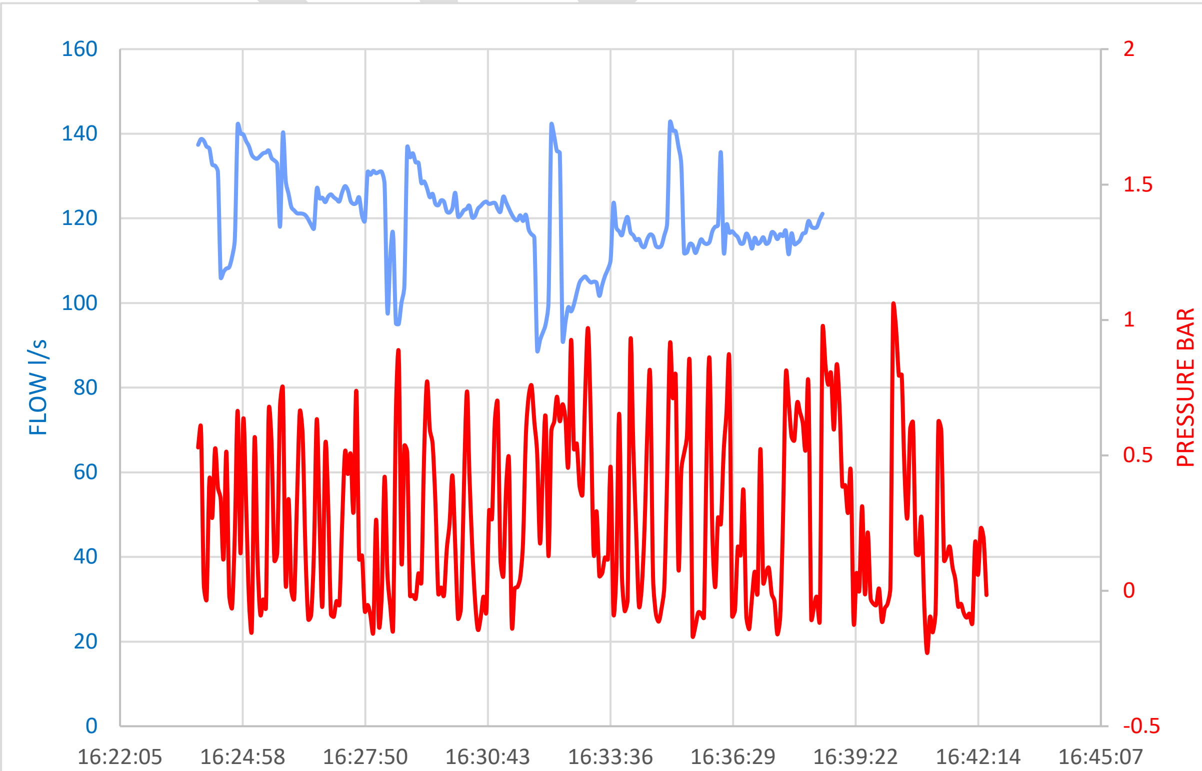


Figure 15 – Logged flow and pressure data for Lock 18 pump

3 Net Positive Suction Head (NPSH) & Submergence

NPSH calculations have been undertaken and the results suggest that there is approximately 7-9 m margin between NPSH required and NPSH available, based on the submergence depth between 0.75-1.2 m. This would be normally be considered sufficient.

As such this has not been investigated any further as there have been no reports found of any cavitation issues at this pumping station.

Initial ANSI-98 submergence calculations based on the levels indicated from the site audit have shown that there is marginally insufficient water coverage above the pumps at Lock 16 (*930 mm actual vs 1083 mm required*).

It should be noted that there is no historic level data for Lock 16, 17 and 18, so this submergence deficiency could be an isolated incident or be something more prevalent. Given the under performance of the pump at Lock 16, it is recommended that the impeller be checked for cavitation marks during the next inspection.

4 Energy Analysis

During the pump audit visit by Samatrix Ltd, a temporary "Fluke" power meter was connected at each individual pump starter compartment to record power into the drives.

From the measured power, flow recorded, and estimated head based on system curve, an analysis of pumping efficiency and the amount of energy needed to pump flows has been undertaken. Table 8, Table 9 & Table 10 summarises the measured input power, and derived efficiency and specific energy findings.

Table 8 – Lock 16 Input power, Efficiency and Specific Energy

Pump Configuration	Measured Flowrate (l/s)	Calculated Head (m)	Measured Power Factor	Measured power (kW)	Pump Efficiency	Specific energy (kWh/1000 m^3)
Lock 16	160.6	5.1	0.81	14.6	64	25.3
"As new" KSB Unit	**180**	**5.6**	**0.82**	**16.3***	**70.6**	**25.1**

Table 9 – Lock 17 Input power, Efficiency and Specific Energy

Pump Configuration	Measured Flowrate (l/s)	Measured Head (m)	Measured Power Factor	Measured power (kW)	Pump Efficiency	Specific energy (kWh/1000 m^3)
Lock 17	185.2	5.2	0.82	15.7	69	23.6
"As new" KSB Unit	**187**	**5.2**	**0.82**	**16.2***	**68.6**	**24**

Table 10 – Lock 18 Input power, Efficiency and Specific Energy

Pump Configuration	Measured Flowrate (l/s)	Measured Head (m)	Measured Power Factor	Measured power (kW)	Pump Efficiency	Specific energy (kWh/1000 m^3)
Lock 18	123.2	4.3	0.81	13.8	44	31.0
"As new" KSB Unit	**182**	**5.4**	**0.82**	**16.2***	**70.5**	**24.3**

**Measured power for the "as new" published KSB pump curves in Appendix A*

- Table 7 shows that the pump at Lock 16 is operating less efficiently than an "as new" pump, given the head within the system the expected flows would be approximately 187 l/s as opposed to 160 l/s. the deviation. This is a reduction in flow is equivalent to 7.3% wear on the impeller.

- Table 8 shows that the pump at Lock 17 is performing well in relation to the expected “as new” pump performance.
- Table 9 shows that the pump at Lock 18 is operating less efficiently than an “as new” pump, given the head within the system the expected flows would be approximately 202 l/s as opposed to 123 l/s. the deviation. This is a reduction in flow is equivalent to 21.4% wear on the impeller.
- As no previous data has been acquired for this site in terms of power and operation, it will difficult to ascertain a precise energy saving potential can be gained without further long-term study.
- The pump at Lock 16 and pump at Lock 18 both show a drop-in performance when compared to the “as new” published curve, it should be investigated to ascertain the reasons behind this. Possible explanations include:
    - Debris within the pump casing
    - Damage or wear to impeller
    - Bearing/seal wear within pump unit

5 Potential Areas for Improvement

5.1 Pump Control and Instrumentation

At present the pumps are effectively run manually in “hand” with the only control being an automatic stop from the low level ultrasonic contained within the wet well. This means that the pumps are likely pumping for periods of time where flow may not be required, and therefore wasting energy.

Operation upon level would necessitate an ultrasonic or radar type level sensor installed within a stilling well on the Grand Canal to measure the level and provide a signal back to the pump control panel and possibly SCADA. Predetermined level thresholds would be as set start and stop levels for the pumps.

With regard to the type of sensors, ultrasonic or radar type sensors are recommended. Using either ultrasonic or radar type level sensors would allow the following benefits:

- Non-contact, low maintenance measurement
- Unaffected by medium properties and fouling
- Freely adjustable measuring range
- Measured level outputs can be used for both information and control

Utilising the level sensor could limit the operational hours as it would stop the pump when the lock level is high and prevent overtopping recirculation of flow. This would be beneficial when looking at the 3no Pump houses as a whole system. At present the pump at Lock 18 is underperforming, and as Lock 17 is still performing as expected, it results in the over topping at Lock 17. If one pump was to then start underperforming, the level sensor would limit the impact on the other 2 pumping stations.

In addition, there is currently no instrumentation measuring pump performance such as a flow meter or pressure indicating device. Without any instrumentation there is little way of knowing how the pumps are performing and it gives no opportunity for any proactive maintenance or trends to be ascertained for the system.

It is recommended that a flow meter be installed on each rising main as a minimum to ascertain flows over time. It is appreciated that this may require significant Civil works for Lock 17 and may also require an ecological survey for Lock 16 and Lock 18 as currently the main lies underneath significant vegetation and hedgerows.

It is recommended that a threaded process tapping, for temporary pressure transducer measurement, be installed on each line. This enables measurement to be undertaken for future performance assessments. This could be included on any accessible section of pipework within the station for ease of access and cabling. The pump pressure could then be calculated from known levels and losses between the transducer and the pump.

An 'intelligent' monitoring system could be adopted at these sites to encompass parameters such as flow rate, pressure, power, efficiency, etc. This could be implemented based upon SCADA/telemetry data and programmed to allow automatic adaption and correction of operation, informative data analysis reporting, and preventative fault alarms to help save energy, reduce downtime and prevent pump blocking.

It should be noted that this option would require a capital investment to upgrade the EICA components within the pumping stations to achieve this.

5.2 Pump Selection

On initial findings, KSB Amarex K250 pumps, as installed, are suitably matched for the system. The closest Xylem alternative that could be found was a 15 kW NP3171 LT.603 with a 304 mm impeller with an IE2 motor. This pump, on paper, operates with a lower estimated specific energy than the KSB Amarex.

Table 11 – Comparison of alternative pump selections

CONFIGURATION	SELECTION	FLOW RATE (L/S)	PRESSURE (M)	INPUT POWER (KW)	PUMP AND MOTOR EFFICIENCY (%)	ESTIMATED SPECIFIC ENERGY* (KWH/1000 M^3)	REDUCTION IN SPECIFIC ENERGY (KWH/1000 M^3)	TOTAL KWH FOR PUMP STATION -PER YEAR* (KWH)
Duty (1-pump) Fixed Speed	XYLEM NP3171 LT 612.304	187.5	5.3	14.4	67.6	21.3	-3.7	53676
	KSB Amarex KRT K250-400/206UG-S	187	5.2	16.2	59	24.0	-	60480

**Based on estimated annual water requirement of 2520Ml*

6 Preliminary Recommendations

- Investigate the pumps at Lock 16 and 18 for loss of efficiency, potential debris in pump/ motor deficiencies/ etc.
- A more efficient option of pumping is available by examining the market for alternative pumps. For example, utilising a Xylem NP3171 LT612 may save 3.7kWh per 1000m^3 (or Ml) on paper. At this stage it is suggested that pump replacement is not an immediate priority.
- Install a level control system on the pumps potentially via a radar/ultrasonic level sensor in a stilling tube.
- Investigate the lock gates at Lock 17 for leakage and possible refurbishment.
- Install instrumentation (e.g. flow and pressure) on each rising main to allow for trend data and proactive maintenance.
- Install power monitoring.
- Install a SCADA / HMI system which can be used to remotely monitor the pumping stations and record data which can be used to optimise operation.
- A desktop review after a period of 1 year with instrumentation in operation to see if the potential for further gains can be ascertained.
- Although not part of the energy audit, it would also be recommended that the loose handrailing on the inlet screens at Lock 16 be addressed and remedied as it can be reached by the public.

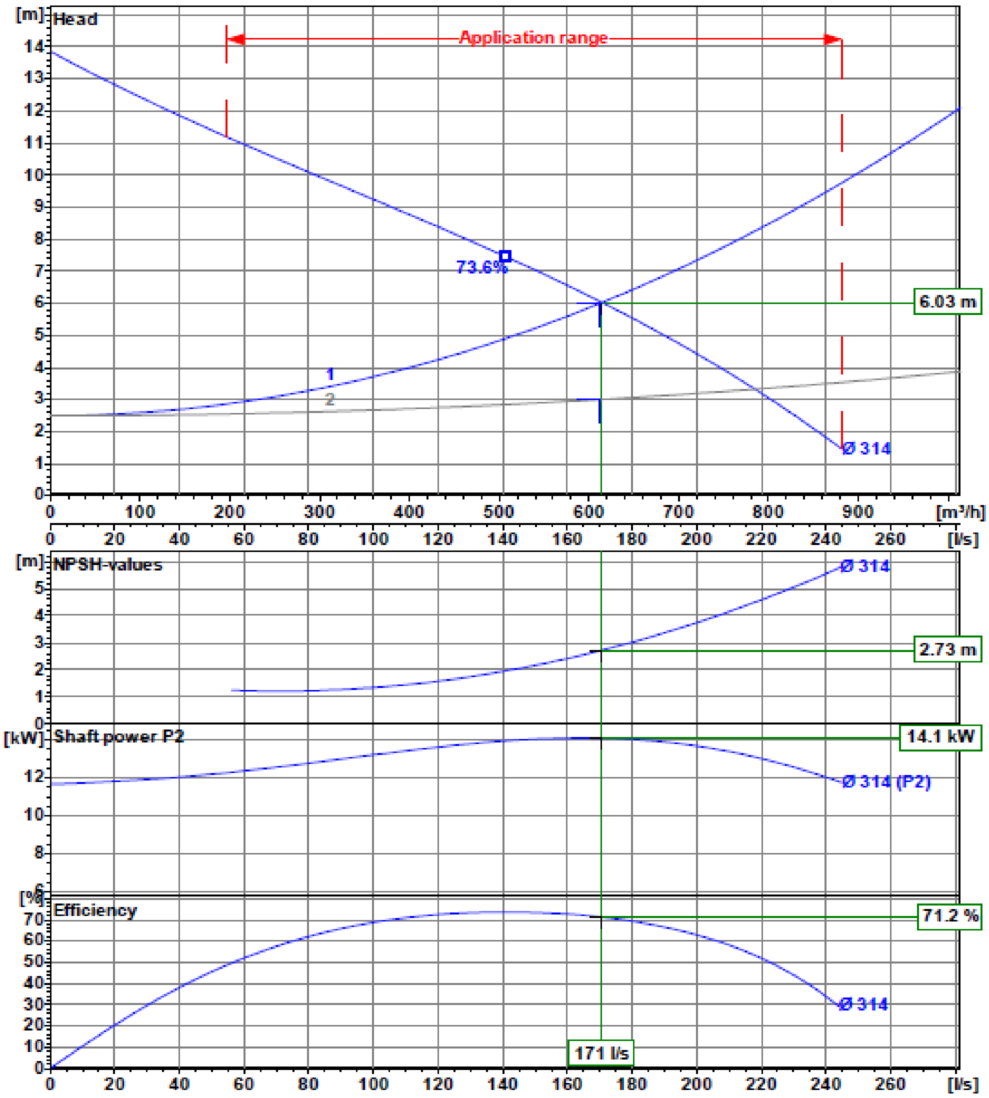
Appendix A

KSB AMAREX K250-400/206 PUMP Provided

Project	Waterways Ireland	
Customer pos.no		
Project ID	Locks 16,17,18 on the Grand Canal K Option	Page 3 / 5
Pos.no	1	2010-11-03
Created by	Houston, Chris	

Performance curve

Pump type **Amarex KRT K 250-400/206UG-S**



Impeller type	Multi channel impeller	Closed		Curve number	K41815/2
Free passage	85 mm	Density	0.9983 kg/dm³	Frequency	50 Hz
Impeller size	314 mm	Viscosity	1.005 mm²/s	Speed	960 1/min

KSB Aktiengesellschaft, Turmstrasse 92, 06110 Halle (Germany), Phone +49 (345) 48260, Fax +49 (345) 4826 4699, www.ksb.com

Appendix B

ALTERNATIVE PUMP SELECTION

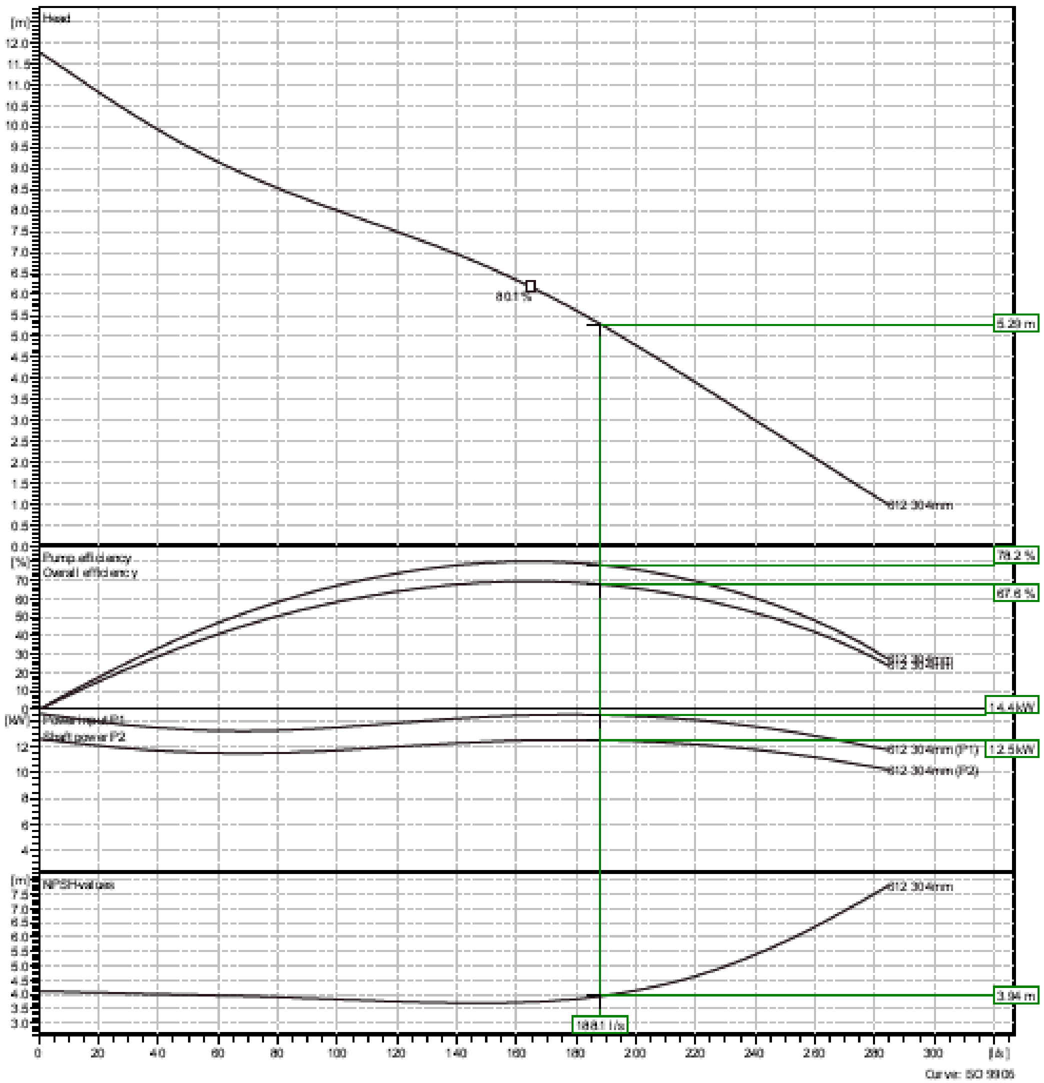
NP 3171 LT 3~ 612

Performance curve

Duty point

Flow	Head
188 l/s	5.29 m

Curves according to: Water, pure [100%],4 °C,999.9 kg/m³,1.569 mm²/s



Project	Created by		Last update	
Block	Created on	11/13/2019		

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