VNF Crissey Pumping Station

PUMP ASSESSMENT REPORT

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P2					

Content

1 Introduction

This report summarises the key findings of Arcadis' technical assessment for VNF Crissey Lock Pumping Station (PS) under Phase 1 on the Green WIN project. This is a desktop study review and is based upon the data provided by VNF via the Green WIN intranet site.

During 2020, VNF intend to resize the pumping station and implement one new pump as follows:

- Monoblock – centrifugal; submersible pump
- Targeted water flow: 0.6 m^3/s
- Motor IE3 or IE4 energy performance
- Smart water and energy monitoring
- Automation, supervision and telecontrol of pumping station operations
- Optimising of operations time periods

2 System Description

2.1 Pumping Station

Crissey pumping station is equipped with 2 RATEAU- Type: ID BV 57 pumps although these are out of service. Figures 1 and 2 describe the proposed and intended arrangement.

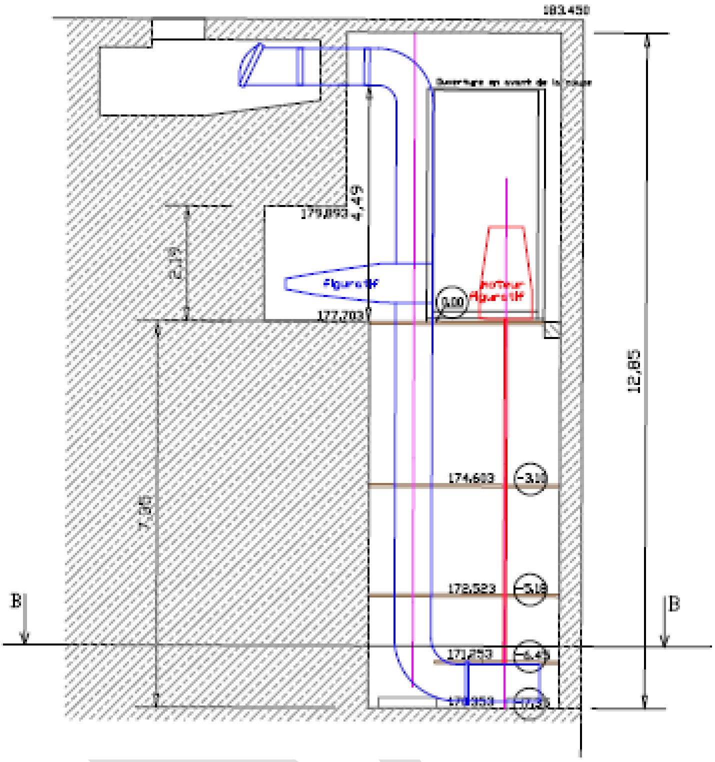

Figure 1 – Existing Pump Arrangement

Currently, the pumps are controlled using 2no upstream level sensors operating in a duty standby arrangement at 2no separate locations on the canal – as denoted in "Réhabilitation et modernisation de l'écluse 24 bis de Crissey sur le canal du centre" as the intermediate and far upstream sensors.

If the far upstream level measurement is not available, the immediate upstream level measurement is used; If no measurement is available, then control of the pumping system is not possible and a low emergency alarm is sent.

The automation of the pumping system is carried out via the API automatically. This operating range can easily be changed from the IHM, if the level measurement is functional. When the level falls below the low-level value (level to be determined), the sectioning valve opens completely. The operation of the pump continues and is controlled until the level passes beyond the high level of the sensor.

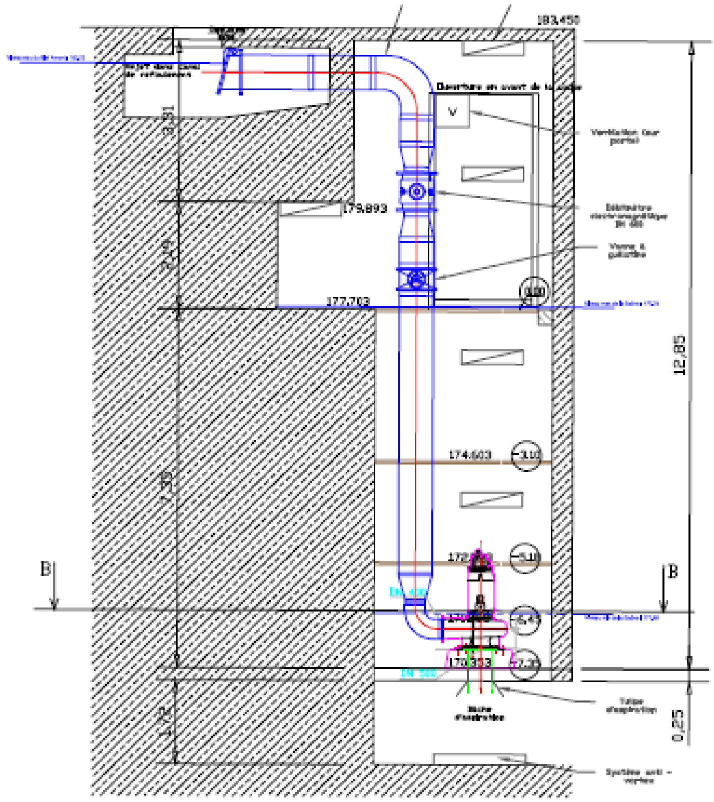

Figure 2 – Proposed Arrangement with Dry Well Submersible Pump and Flowmeter

In the future situation, a pump is required with a nominal flow of 0.6m^3/s and an automated gate valve. The pump and gate valve will need to be automated from the control desk with driven by signals from the upstream level measurement system.

2.2 Hydraulic Levels

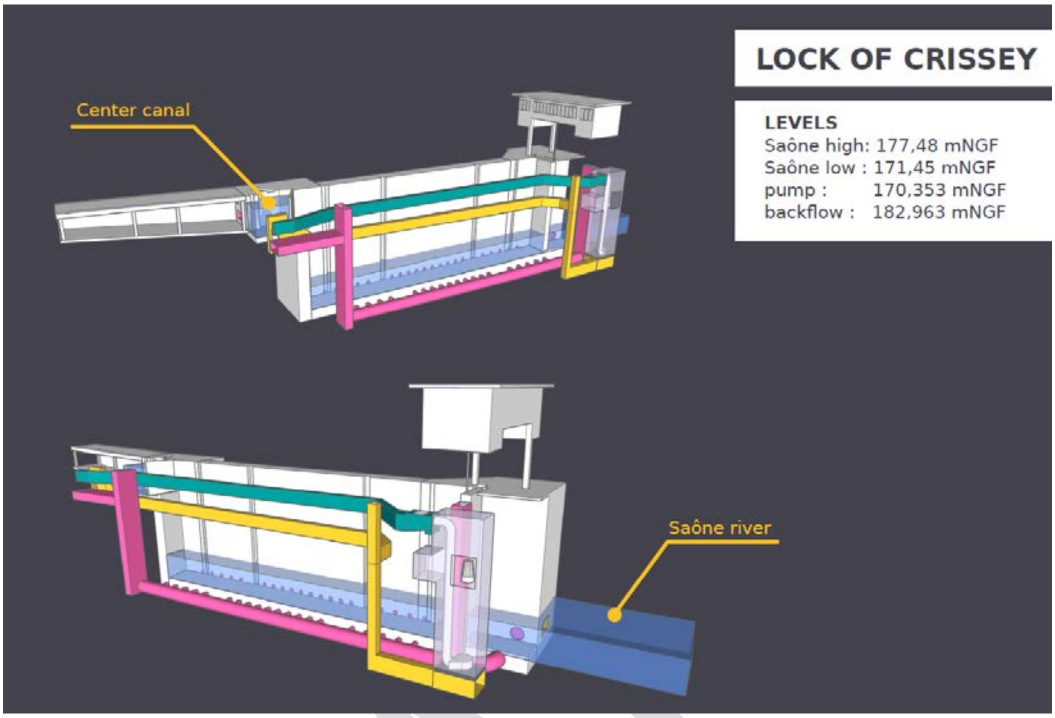

Figure 3 – Hydraulic Levels

From Figure 3, the level of River Saône can vary by six metres. This could have a significant impact on the performance of a fixed speed centrifugal pump, where there is varying relationship for lift and efficiency, against flow rate. In view of this, the river level data between January 2016 and November 2019 has been gathered, to get a better understanding of the lift conditions under which the pump will typically operate and for how long. Figures 4 and 5 show the graphical interpretations of the river level data.

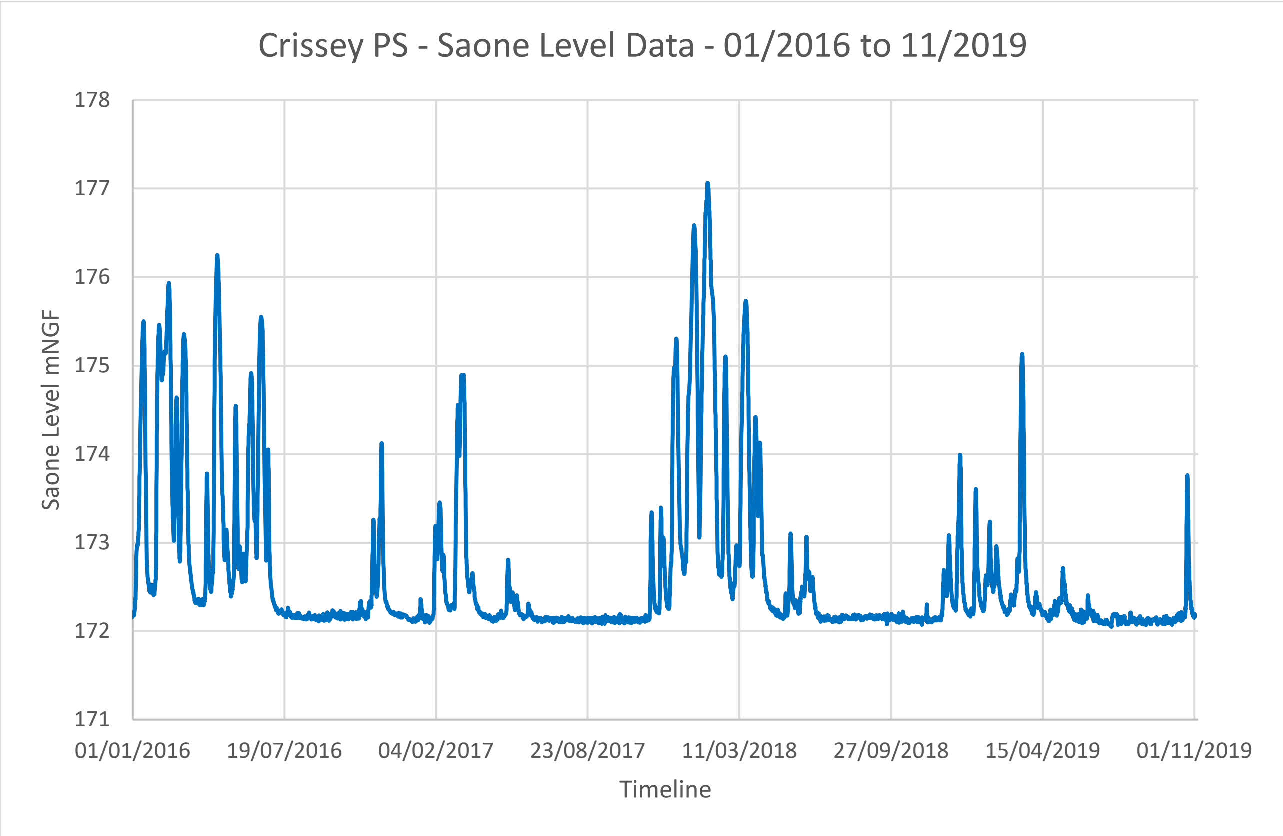

Figure 4 – River Saône Levels over time (2016 to 2019)

By rearranging the level data points taken between January 2016 and November 2019 form lowest to highest and expressing the data points as a % of total, a percentile chart has been generated in Figure 5. This shows that the level remains between 172.1m and 173.1m for 85% of the time. Therefore, operational efficiency is likely to be maximised for a pump selected on peak efficiency in this level range. A level of 172.3m has been selected by Arcadis for assigning its “design” duty lift.

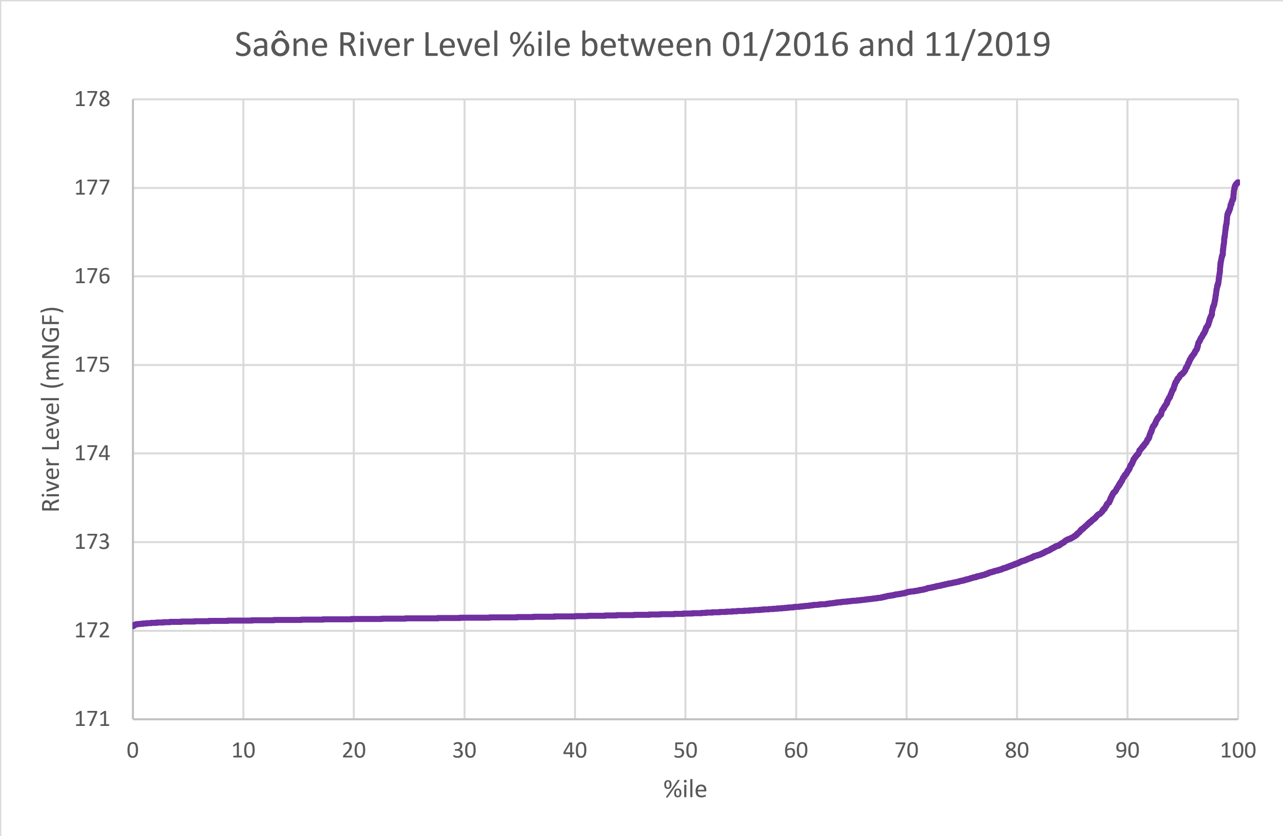

Figure 4 – River Saône Levels over time (2016 to 2019)

3 System Curves

From the provided data, system curves have been derived by Arcadis.

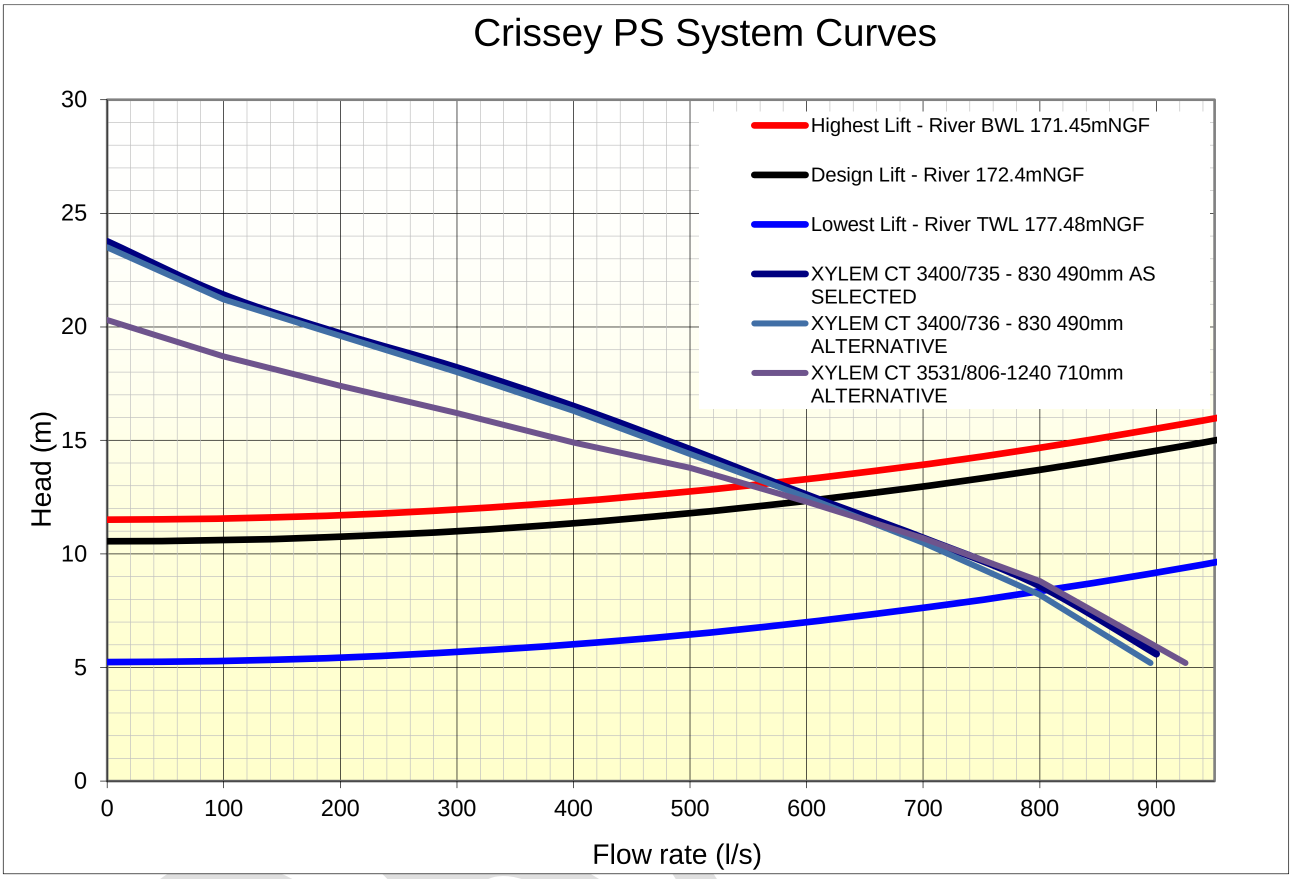

Figure 6 – Derived System Curves with Tabled and Alternative Xylem Selections at Design Head

Xylem have undertaken their assessment and advised the selection of CT3400/735 ~830 490 mm impeller pump to meet the nominal flow of 600 l/s.

The results of the Arcadis review indicate that Xylem have since introduced a newer 8-pole motor model CT3400/736 ~830 490 mm impeller which essentially achieves the same performance as the tabled offer.

A further alternative is the 12-pole motor pump from Xylem, model reference CT3531/806 ~1240 710 mm impeller.

From the system curve, the pumped flows would reach approximately 800 l/s at minimum lift condition when the river level is high under a fixed speed drive arrangement. However, this would not cause any issues with the pump itself.

4 Pump Selection Review

4.1 Xylem Selection Review

Arcadis has reviewed the pump selection using Xylem's pump selection tool to assess the specific energy performance of the existing pumps and to investigate if there are more energy efficient alternatives to the existing pumps.

Table 1 – Pump Selection Data (Fixed Speed)

Selection (Xylem)	Static Lift (m)	Flow Rate (l/s)	$NPSH_R$ (m)	Input Power (kW)	Overall Efficiency (%)	Specific Energy (kWh/1000 m^3)
CT3400/736 3~830 490mm	Design	610	4.25	95.4	77.5	43.5
	Minimum	803	8.22	96.2	67.3	33.3
CT3500/806 3~1240 710mm	Design	604	2.66	92.7	78.8	42.6
	Minimum	821	5.06	95.8	70.5	32.4

The available pumps have IE2 motors, and an IE3 high efficiency motor does not appear as option for these particular pump models.

It is noted that the CP3531 is a physically larger pump with a 12-pole motor and a power factor of approximately 0.52 to 0.6. The CT3400 unit has a 8-pole motor with a power factor of between 0.8 and 0.82.

The NPSH Required characteristic for the CT3400 model is higher, but NPSH margin is suitable for both pump models.

Both the CT3400 selection and CT3531 selections are considered suitable, with marginal efficiency differences. As the CT3400 has been proposed for installation by VNF, this model is considered only further within this report.

4.2 Pump Drive Review

From Table 1, the pump flow increases to approximately 800 l/s under the low lift conditions, with a corresponding reduction in pump efficiency.

With a variable speed drive (VSD) it would be possible to maintain flow rates around 600 l/s regardless of static lift condition. Figure 5 shows the variable speed performances of the CT3400 pump at high River Saône level representing the minimum lift system curve.

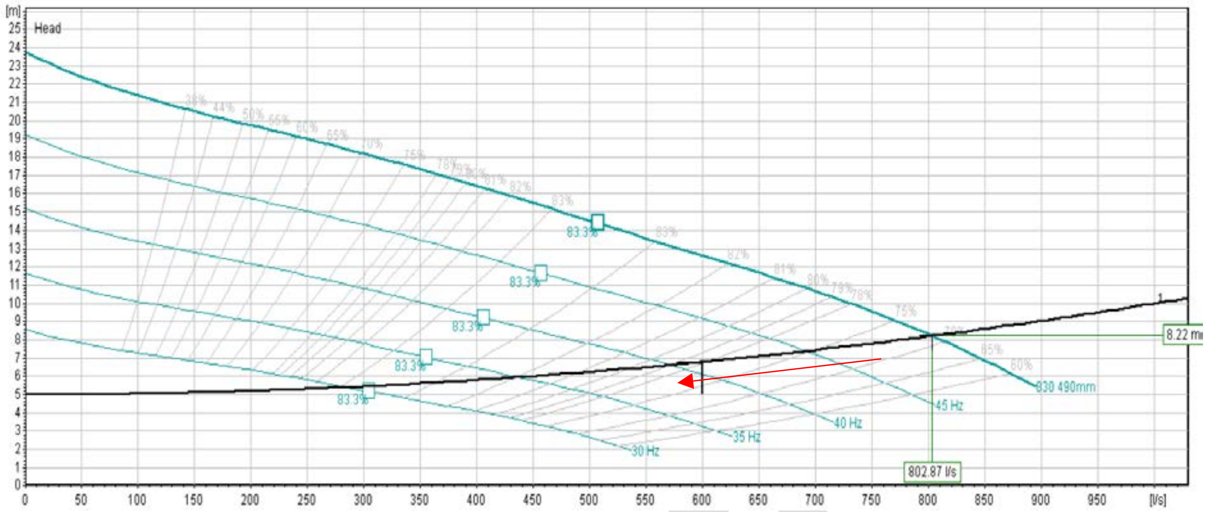

Figure 7 – Variable Speed Curve at Minimum Lift for CT3400 pump

The curves shown in Figure 7 indicate that reducing the pump speed under the low lift conditions would increase the pump efficiency as the duty point will move to the left and closer to the best efficiency point. An assessment of the energy performance both with and without VSDs has been undertaken and is presented in Table 2.

Table 2 – Energy Analysis of Fixed vs. VS Drives

Selection (Xylem)	**Static Lift (m)**	**Drive**	**Flow Rate (l/s)**	**Pump Overall Efficiency (%)**	**Assumed Drive Efficiency (%)**	**String Efficiency (%)**	**Specific Energy (kWh/1000 m³)**
CT3400/736 3~830 490 mm	Design	Fixed	610	77.5	100	77.5	43.5
	Design	VSD - 50 Hz	610	77.5	97	75.2	44.8
	Minimum	Fixed	803	67.3	100	67.3	33.3
	Minimum	VSD - 40 Hz	571	74.4	96	71.4	25.4

As it can be seen, there is a reduction in specific energy using VSDs at reduced speed under the lower lift conditions only (e.g. High Saône level).

However, there is additional consumption at the higher lift condition due to VSD efficiency losses. Therefore, the case for VSDs would depend on where the most common operating levels are likely and expected utilisation of pumping operations.

From Figures 4, and 5 the high level condition, say above 175mNGF, is expected to occur at 5% of the time, and predominantly outside the summer season. Therefore, the relative usage of the pump under high river level conditions is relatively low.

5 Energy Assessment

The VNF energy audit report[1] dated September 2018 has estimated that the existing pumping station delivers a specific energy of approximately 75 kWh/1000 m^3. However, this estimate has been made without the pump running time data and during times when the pumping station was not running for most of the time.

A separate audit report[2] dated November 2017 provides site measured power and flow rate survey results for the old (now disused) Crissey Pump. The results and derived specific energy are summarised below in Table 3.

Table 3 – Site Audit results for Old Pump

Measured Flow Rate (l/s)	**Running Current (A)**	**Voltage (V)**	**Motor Input Power (kW)**	**Hydraulic Power (kW)**	**Overall Efficiency (%)**	**Specific Energy (kWh/1000 m^3)**
880	300	380	166	99	60	52.4

VNF have advised Arcadis that the pump will used to reassemble 400 basins per year, or 880,000 m^3/year, or about 408 hours per year based upon 600 l/s pump rate.

Table 4 – Energy Comparison Old Pump vs Proposed Xylem CT3400 Pump

Pump	**Static Lift**	**Specific Energy (kWh/1000 m^3)**	**Annual Energy Consumption (kWh)**	**Annual Saving (kWh)**
Old Rateau Pump	Design	52.4	46,112	-
Xylem CT3400/736	Design	43.5	38,280	7,832

From Table 4, the running costs are typically low generally given the use. The new pumps provide modest energy saving.

[1] Diagnostic énergétique de la station de pompage de Crissey VF – 09/11//2018 (GEO ENERGIE ET SERVICES)

[2] Diagnostic de l'installation de pompage, élaboration de scénarios et des coûts prévisionnels associés - 003 41573 S T DIA 0001 C (setec tpi)

6 Preliminary Findings

6.1 Pump Selection

The current VNF proposed pump selection, a Xylem CT3400, is well matched to the system and range of operating levels. An IE3 high efficiency motor is not available for this pump model. Alternative Xylem models are available (e.g. CT3531) and it is suggested that Xylem confirm the selected model provides the lowest whole life cost.

6.2 Pump Drive

Although energy savings could be achieved through the use of VSDs at higher River Saône level, the energy costs are relatively low. Installing VSDs would incur a higher installation cost which might outweigh any operational cost benefit resulting in an increased whole life cost (although CO2 reductions could still be achieved).

For fixed speed drives power factor correction is recommended.

6.3 Pump Arrangement

The arrangement provided by VNF as shown in Figure 8 below.

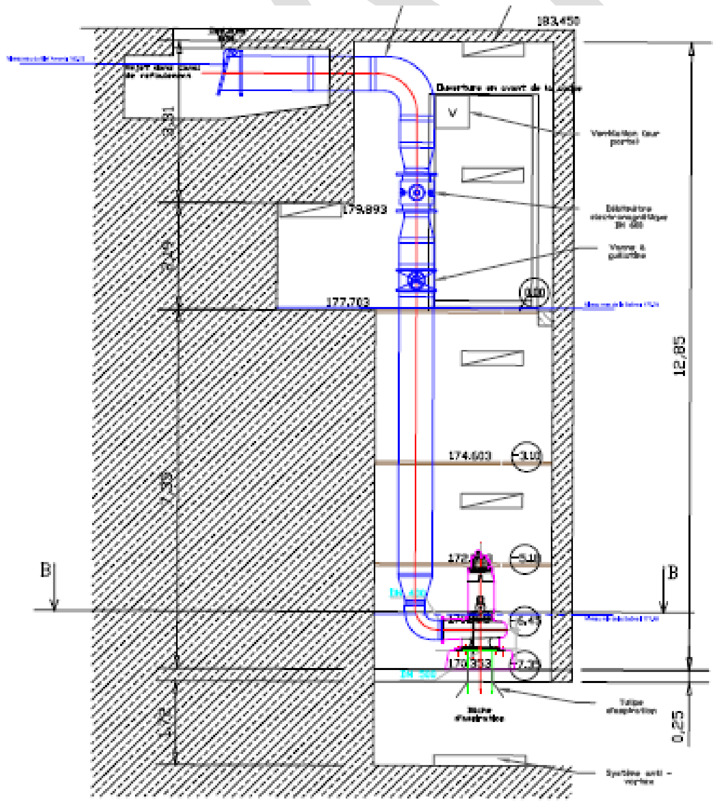

Figure 8 – Proposed Arrangement with Dry Well Submersible Pump and Flowmeter

Focusing on the highlighted DN700 section riser section upstream of the DN600 flowmeter, the following observations are given.

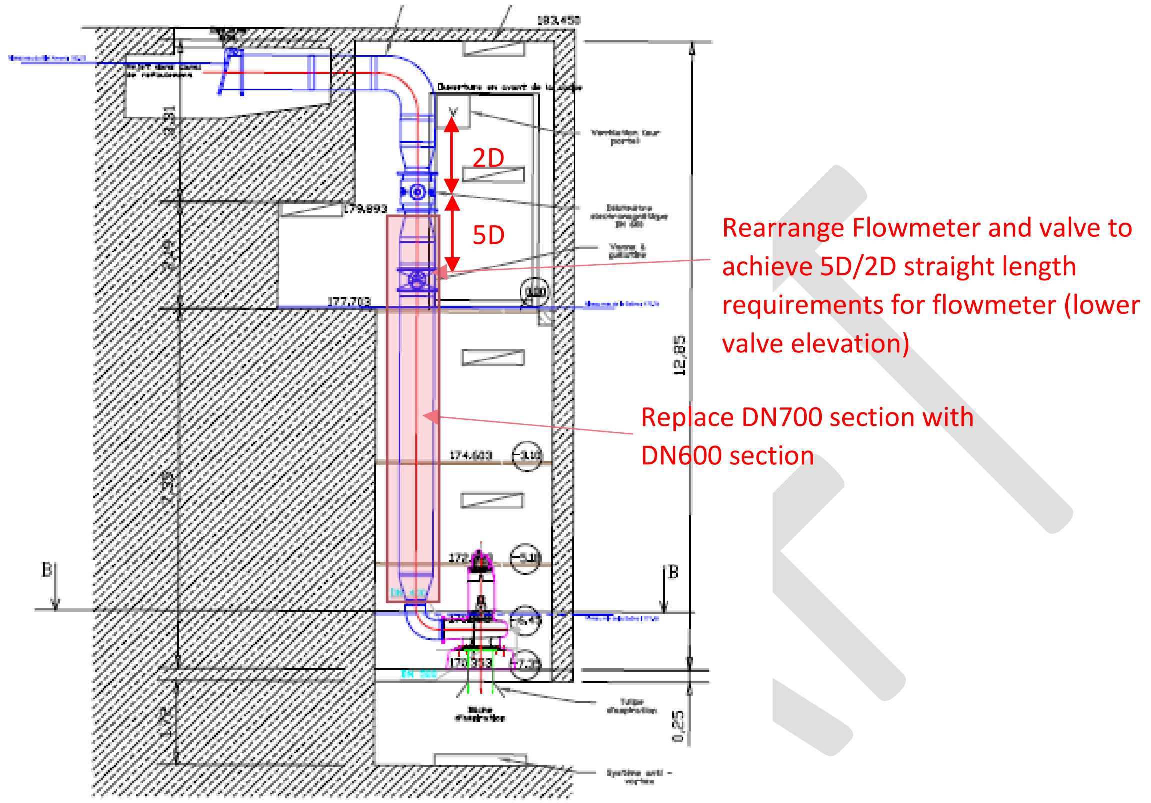

Figure 9 – Recommended Pipework improvements

1. The flowmeter requires a straight pipe section of 5 diameters upstream of the flowmeter is generally recommended. This section should be free of tapers and valves as shown. Therefore, it is suggested that valve position is moved to the landing level below that as shown, and therefore avoiding the potential to create any wake disturbances at the flowmeter measurement point.
2. It is noted that a 2.2 m/s velocity limit applies to VNF pumping station pipework in accordance with section 37 of CTCG Paper 73. At 800 l/s, a diameter of 700mm achieves this criterion, but 600 mm diameter pipe produces a velocity of 2.8 m/s. However, velocities below 3 m/s are still reasonable for short lengths, and we would recommend reducing the upstream pipework diameter to 600 mm as it will not adversely impact on the pump hydraulics and will achieve a better flow presentation to the flow meter. Also, it is expected that the additional friction losses from a smaller 600mm diameter pipe will be entirely offset by reduced point losses from reducing the expansion taper size and eliminating a reducer.

7 Recommendations

In order to improve the energy efficiency of the pumping station the following measures are recommended:

- Replace with proposed Xylem CT3400 pumps
- Continue with fixed speed drives.
- Install pipework of 600mm diameter upstream of 600mm diameter flowmeter
- Install an automated control system based on downstream (and upstream) level monitoring
- Install SCADA system and introduce performance metric reporting (e.g. pump power, flow data, etc.) and possible smart control adjustment.

Appendix A- Source Drawings and Documents

Document/Drawing Reference	Title or Description	Originator
TBC	TBC	TBC

Interreg North-West Europe Green WIN

Canal & River Trust
Making life better by water

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Ministerie van Infrastructuur en Waterstaat

Waterways Ireland
Uiscebhealaí Éireann Watterweys Airlann

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VLAAMSE LAND MAATSCHAPPIJ