# Drumshanbo PS

PUMP AUDIT SUMMARY REPORT

NICK TAYLOR

March 2020

# Drumshanbo PS

## PUMP AUDIT SUMMARY REPORT

**Author:** Nick Taylor **Organisation:** Arcadis

**Checker:** Jermaine Bernard

**Approver:** Niklas John

**Report No:** 10031024-00529

**Work Package:** Improving existing systems and processes T1

**Date:** March 2020

## Version Control

| Version Number | Date issued | Author | Checker | Approver | Changes |
|---|---|---|---|---|---|
| P1 | 10/12/2019 | N Taylor | J Bernard | N John | Issue for Comment |
| | | | | | |
| | | | | | |
| | | | | | |

# Content

# 1 Introduction

This report summarises the key findings of the pump station audit for Drumshanbo Pumping Station (PS). This review is based upon the data provided by Waterways Ireland (WI) and a site visit undertaken on 20th September 2019.

Pump testing was undertaken at the site visit and the following parameters measured:

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

# 2 System Description

## 2.1 Pump Station

Drumshanbo PS is located just outside Drumshanbo, County Leitrim. The pumping station lifts water from Lough Allen into the Lough Allen canal system to replenish the system during the summer months. Drumshanbo PS is part of a dual lock system. A dual lock allows for the variations in upstream water levels in Lough Allen, as during the winter months the Lough level exceeds the canal level and the lock works in the other direction.

*Figure 1- Drumshanbo Dual Lock Station*

Drumshanbo pump station comprises of 1 no. NP3171.181 15 kW, fixed-speed, submersible pump located within a dedicated wet well. Drumshanbo does not currently have an ABS HUP 302 pump as reported in the initial pump audit assessment, it was replaced due to repeated failure. The wet well has a submerged inlet, reportedly with a 50 mm trash screen, although this could not be confirmed at the time of the audit. It could not be confirmed if there is any low-level protection within the wet well.

The pump is operated manually in 'hand', with no other instrumentation present (flow meter, pressure transducer, etc.). Currently Drumshanbo cannot maintain a sufficient level within the Lough Allen canal system and additional flow is topped up from Drumleague PS.

The pump discharge pipework is DN300 ductile iron up to the pump house and connects into a 315 mm OD PE rising main. The material change point could not be ascertained as there are no historic drawings and the pipework is encased in concrete, but it has been deduced that the change occurs within a 2 m section immediately downstream of the wet well. It should be noted that the PE rising main diameter has been estimated as the pipework could not be fully exposed for the pump audit since the pipework is fully encased in concrete.

*Figure 2 -Drumshanbo PS Wet well– Concrete top covers*


*Figure 3 -Drumshanbo PS – Outfall*

*Table 1 – Pump Details*

| Parameter | Description |
|---|---|
| **Pump** | Xylem NP 3171.181 |
| **No. of Pumps** | 1 |
| **Duty Configuration** | Duty (Submersible) |
| **Rated Motor Output** | 15 kW |
| **Impeller Diameter** | 304 mm |
| **Drives** | Fixed speed Star-Delta |
| **Pipework** | 300 mm diameter |
| **Non-Return Valves** | Flap Valve on outlet |
| **Wet Well Level Sensor** | Unknown – covers could not be lifted |
| **Wet Well Level** | 43.63 mAD |
| **Ground Level** | 46.0 mAD |
| **Pump Centre Line** | 42.0 mAD |

## 2.2 Rising Main

The 315 mm OD PE rising main is approximately 15 m in length and has a submerged discharge into the canal. The main consists of 1no Gate valve (cap top) for isolation and a flap valve on the outlet into the Lough Allen canal system to prevent backflow. No other check valves are present within the system.

There are no reports of bursts arising since construction, and no instrumentation could be found at the time of audit relating to the pump station but the wet well itself was not inspected during this audit.

*Table 2 – Pump Discharge Main Details*

| Parameter | Description |
|---|---|
| **Approx. Length** | 15 m |
| **Elevation Rise** | -0.3 m* |
| **Pipe Diameter** | 300 mm |
| **Discharge Level** | 43.57 mAD |
| **Pipe Material** | PE (unconfirmed) |
| **Pipe Roughness** | ks = 0.003 mm (assumed) |

**Based on site measurements, the high point of the system is located immediately downstream of the wet well and the main descends to the outlet*

# 3 System Description

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 3, summarises the measured input power, and derived efficiency and specific energy findings.

The suction and delivery elevations, pipe roughness values have been based on the site recorded measurements as there is no SCADA data for Drumshanbo PS.

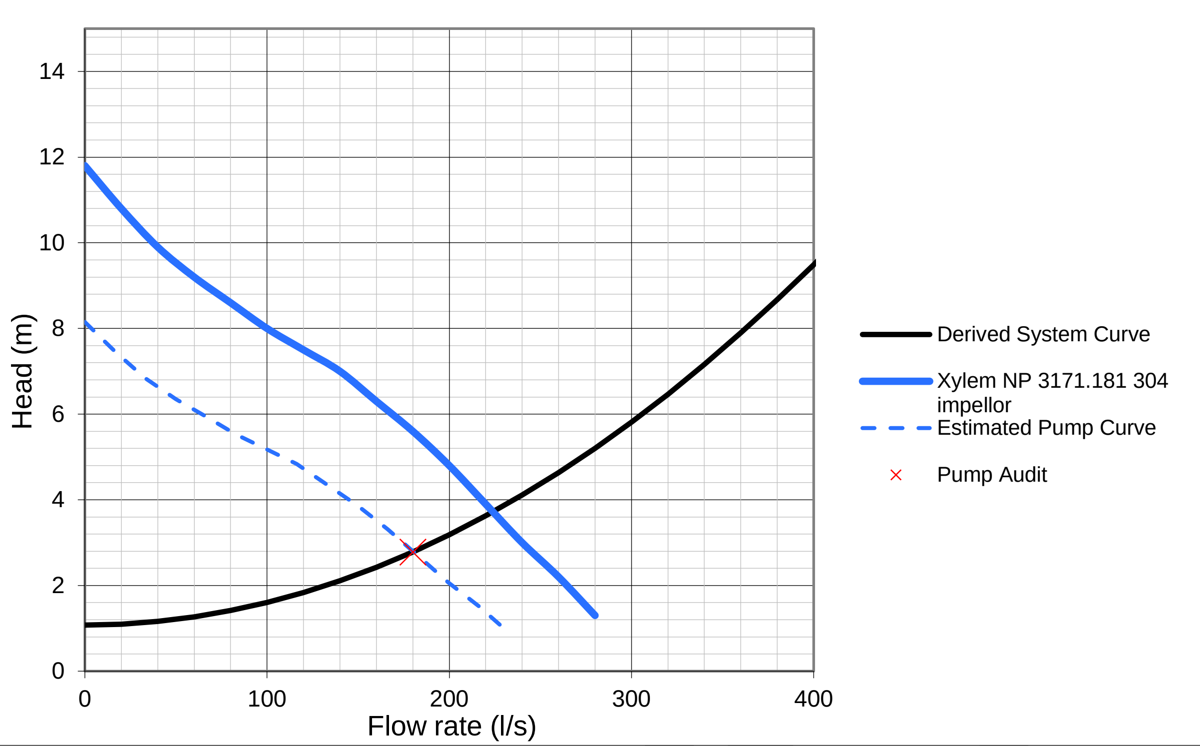



*Figure 4 -Derived System Curve – Drumshanbo PS*

**/ 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 | | mAOD |
| Design | 43.573 | mAOD |
| BWL | | mAOD |

Suction | Discharge

| | | | |
|---|---|---|---|
| Pump level: | 42.5 | (est) | mAOD |
| Pump station located before reach: | 1 | | [select] |

Assumed Hydraulic Discharge levels

| | | |
|---|---|---|
| TWL | | mAOD |
| Design | 44.65 | mAOD |
| BWL | | mAOD |

| Static lift | | |
|---|---|---|
| Minimum | 0.00 | m |
| Design | 1.08 | m |
| Maximum | 0.00 | m |

| Reach: | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Description | | CI pump discharge | CI pump discharge | PE rising Main | | | | | | | | | | |
| Length (m) | | 0.5 | 2 | 15 | | | | | | | | | | |
| Diameter (m) | | 0.25 | 0.3 | 0.3336 | | | | | | | | | | |
| Flow area (m²) | | 0.04909 | 0.07069 | 0.08741 | | | | | | | | | | |
| Roughness (mm) | Low | | | | | | | | | | | | | |
| | Design | 0.3 | 0.3 | 0.003 | | | | | | | | | | |
| | 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 | | | | | | | | | | | | |
| Long R 90° bend | 0.4 | 1 | | | | | | | | | | | | |
| Taper up (4:5) | 0.03 | 1 | | | | | | | | | | | | |
| Short R 90° bend | 0.75 | | 1 | 1 | | | | | | | | | | |
| Swing check valve | 1 | | | | | | | | | | | | | |
| Gate valve | 0.12 | | | | | | | | | | | | | |
| Gate valve | 0.12 | | | 1 | | | | | | | | | | |
| Expansion 2:3 | 0.35 | | | | | | | | | | | | | |
| Expansion 3:4 | 0.2 | | | | | | | | | | | | | |
| Outlet | 1 | | | 1 | | | | | | | | | | |
| Elbow 45° bend | 0.4 | | | | | | | | | | | | | |
| Flap valve | 1.5 | | | 1 | | | | | | | | | | |
| Additional K (other devices) | | | | | | | | | | | | | | |
| Total K | | 0.68 | 0.75 | 3.37 | 0.00 | | | | | | | | | |

*Figure 5 - Hydraulic Calculation Input Data*

## 3.1 Key Observations

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

a) Flow rate – the flow rate is ascertained from the Panametrics flow sensor. This sensor is required to know the diameter of the pipework and this could not be measured as the pipework was half encased in concrete. In addition, the Panametrics flowmeter also requires a fixed distance between the sensing equipment which due to the constraints of the exposed pipework could not be met. The flow rate measurements obtained were consistent at 180 l/s ± 0.8% over the 34-minute duration of the audit, but it should be noted that the factors listed above may be skewing the measurements providing a lower measured flow rate than actual. (Figure 6).

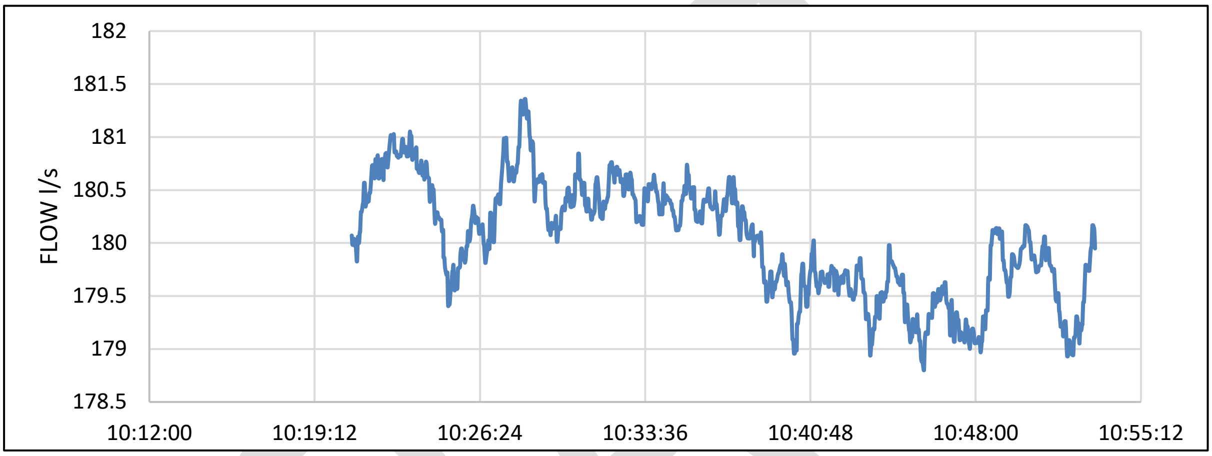



*Figure 6 - Hydraulic Calculation Input Data*

b) In order to align the site results with the information obtained on the pump curve from Xylem, the performance of the pump curves has been lowered from their ideal published performance curves. The dashed line on the individual pump system curve (Figure 4) presents how an ideal pump is required to be reduced in output using the affinity laws , to indicate wear or smaller impeller diameter.

c) It has been assumed in this instance that the motor efficiency has remained constant for each pump, which may not be case. The likely scenario is that there is some degradation of both pump and motor, but this cannot be confirmed without direct inspection and rig testing.

d) From the pump audit data, the pump is currently underperforming by approximately 17%.

There could be several reasons for this, with possibilities including:

- Increased rising main losses over that derived as pressure data could not be ascertained at the time of testing.
- Physical defects such as wear on the impeller.
- Measurement or Data inaccuracies taken from on-site data collection.

# 4 Net Positive Suction Head (NPSH) & Submergence

NPSH calculations have been undertaken and the results suggest that there is approximately 10 m margin between NPSH required and NPSH available, based on the 1 m submergence depth.  This would be normally be considered sufficient.

Initial ANSI-98 submergence calculations based on the levels indicated from the site audit have shown that there is sufficient water coverage above the pump to find that submergence and the formation of vortices does not appear to be an issue at this station.

# 5 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 star delta 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 3 summarises the measured input power, and derived efficiency and specific energy findings.

*Table 3 – Input power, Efficiency and Specific Energy*

| Pump Configuration | Measured Flow rate (l/s) | Calculated Head (m) | Measured Power Factor | Measured power (kW) | Pump Efficiency | Specific energy (kWh/1000 m³) |
|---|---|---|---|---|---|---|
| **Duty** | 180 | 2.7 | 0.85 | 17 | 32% | 26.3 |
| **Ideal Unit*** | 225 | 3.6 | 0.86 | 14 | 65.9 | 14.9 |

**Ideal unit based on factory curve*

- Table 3 indicates that the pump at Drumshanbo is underperforming.
- There is a difference between the measured power (17 kW) from the fluke meter and the ideal operating power of the pump (14 kW).
- 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.
- As the pump shows a drop-in performance when compared to the ideal, 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
    - Motor inefficiencies

# 6 Potential Areas for Improvement

## 6.1 Pump Control and Instrumentation

The existing control does not automatically vary duty configuration or flow rate based on lock flight level. It is suggested that pumping configuration could be tailored according to a level scale, rather than a simple ON/OFF type operation to improve energy consumption. However, the practical feasibility would depend on the specific characteristics of the canal system and pumping capacity.

At present the pump is 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 pump is likely to be pumping for periods of time where flow may not be required, and therefore wasting energy.

Operation upon level would necessitate a level sensor, e.g. ultrasonic or radar type installed within a stilling well, on the Lough Allen 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 pump.

With regards 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 the pump could be used to "top up" as required during quieter periods and limit the operating time of the pump.

In addition, there is currently no instrumentation measuring pump performance such as a flow meter or pressure indicating device. With no instrumentation there is little way of knowing how the pump is operating day-to-day and 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 the rising main as a minimum as to ascertain flows over time. This could be included on the straight above ground sections immediately downstream of the gate valve to minimise excavation works as the pipework is already half exposed. Ideally, the flowmeter would be housed within an 1800 mm concrete manhole for ease of access. A typical example of a chambered flow meter installation can be found in Figure 7.

It is recommended that a pressure transducer be installed to ascertain pressure over time. 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.

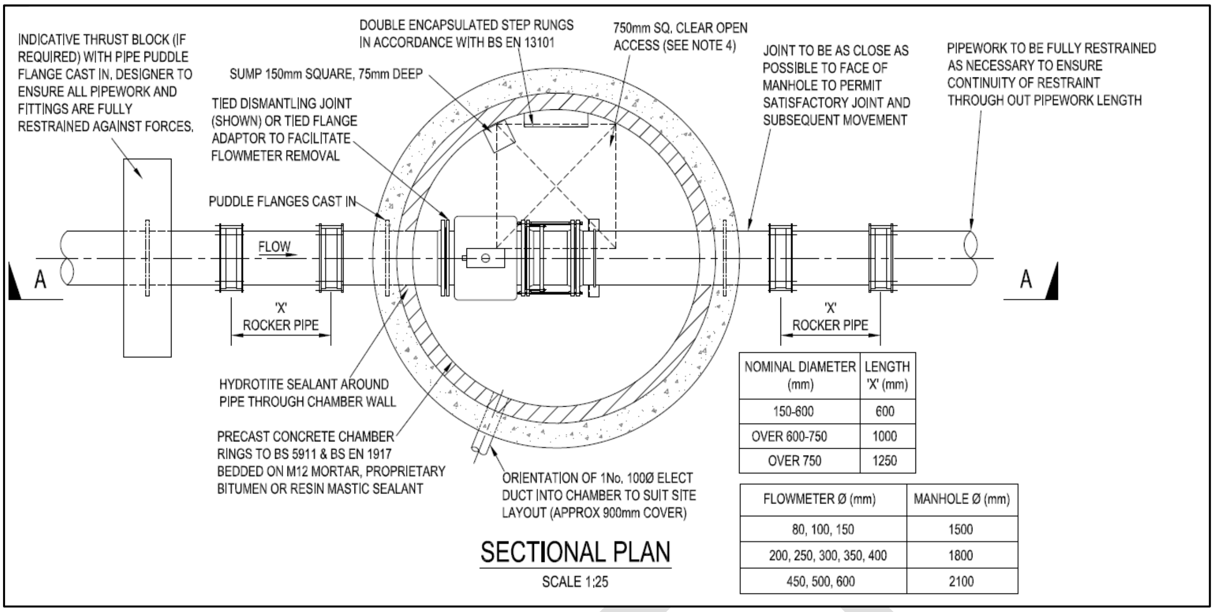



*Figure 7 – Typical Flowmeter installation including circular concrete chamber*

An 'intelligent' monitoring system could be adopted at this site 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 pump station to achieve this.

## 6.2 Pump Selection

On initial findings, the NP3171.181 as installed, is suitably matched for the system as calculated. Upon comparison, the performance of the IE3 motor and the standard Xylem motor are very similar. In this instance there may not be sufficient benefit to opt for the IE3 option, but this should be looked at from a full Totex comparison to confirm.

*Table 4 – Comparison of alternative pump selections*

| CONFIGURATION | SELECTION (XYLEM) | FLOW RATE (L/S) | PRESSURE (M) | INPUT POWER (KW) | PUMP AND MOTOR EFFICIENCY (%) | ESTIMATED SPECIFIC ENERGY (KWH/1000 M$^3$) | SAVING ON SPECIFIC ENERGY (KWH/1000 M$^3$) | TOTAL KWH FOR PUMP STATION -PER YEAR* |
|---|---|---|---|---|---|---|---|---|
| **Current - Duty (1-pump) Fixed Speed** | NP3171 MT 181.304 | 180 | 2.7 | 17 | 32 | 26.3 | - | 49,891 |
| **Factory - Duty (1-pump) Fixed Speed** | NP3171 MT 181.304 | 226 | 3.63 | 14 | 66.8 | 17.1 | -9.2 | 32,439 |
| **Duty (1-pump) Fixed Speed with IE3 motor** | NP3171 MT 181.304 | 227 | 3.66 | 14 | 66.6 | 17.1 | -9.2 | 32,439 |

**Based on estimated annual water requirement of 1897Ml*

## 6.3 Pump Selection – Duty/Standby Arrangement

In looking into the arrangement of Drumshanbo pump station it was suggested that the station should be upgraded to improve the resilience of the system. There is physical space to incorporate a duty standby pump arrangement (Figure 8 and Figure 9) at Drumshanbo given the dimensions of the wet well (3.1 m x 2.3 m). This option would require extensive civil works to convert, it would likely require as a minimum: -

- Topographical survey to ascertain existing services – as reported on site the hydraulic lines and electrical cables for the lock gates operation pass close to existing wet well.
- Relocation of a substantial portion of the rising main
- Non-return and isolation valves in either the vertical outlet legs within the wet well (noting this would be difficult to access and maintain) or within a valve chamber located near the wet well (subject to existing services).
- New penetrations within the wet well wall to incorporate new pipework
- Adaptation of any benching within wet well.
- Pump access arrangements and covers would need to be redesigned to accommodate the extra pump.

The alternative to the duty/standby arrangement would be to keep a maintained boxed spare within reasonable proximity to the station. It would be recommended that estimates are obtained for each option and a full cost comparison undertaken, but there will likely need to be a trade between cost and resilience.

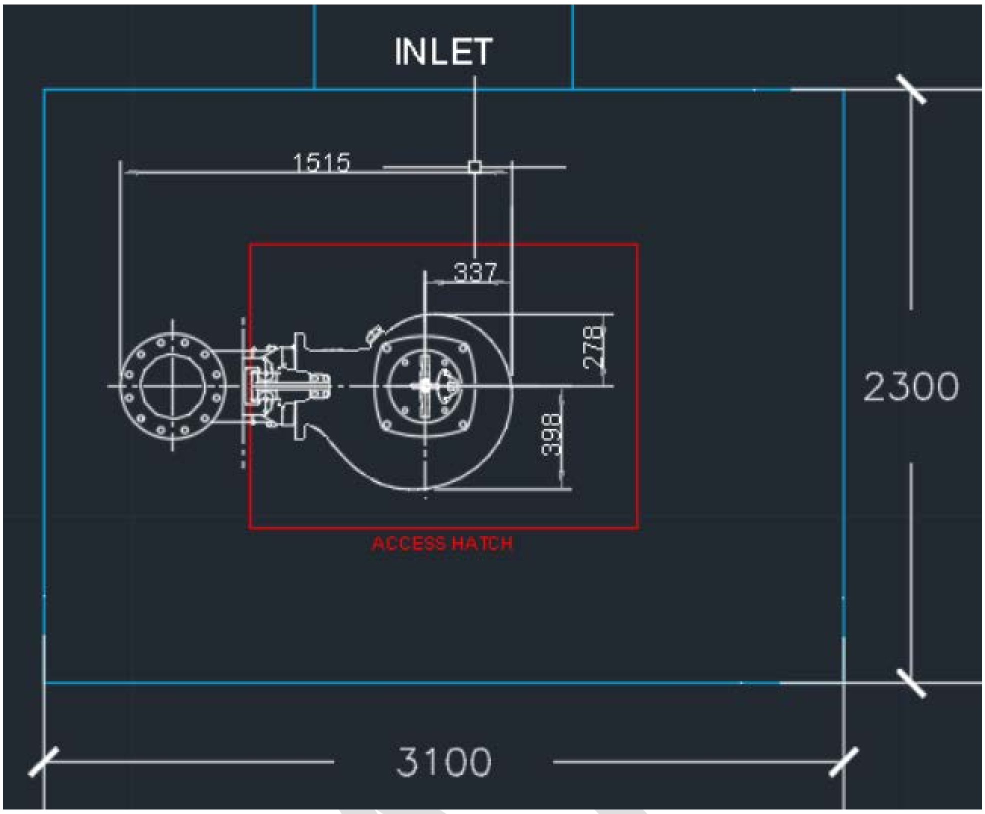



*Figure 8 – Current pump arrangement at Drumshanbo*

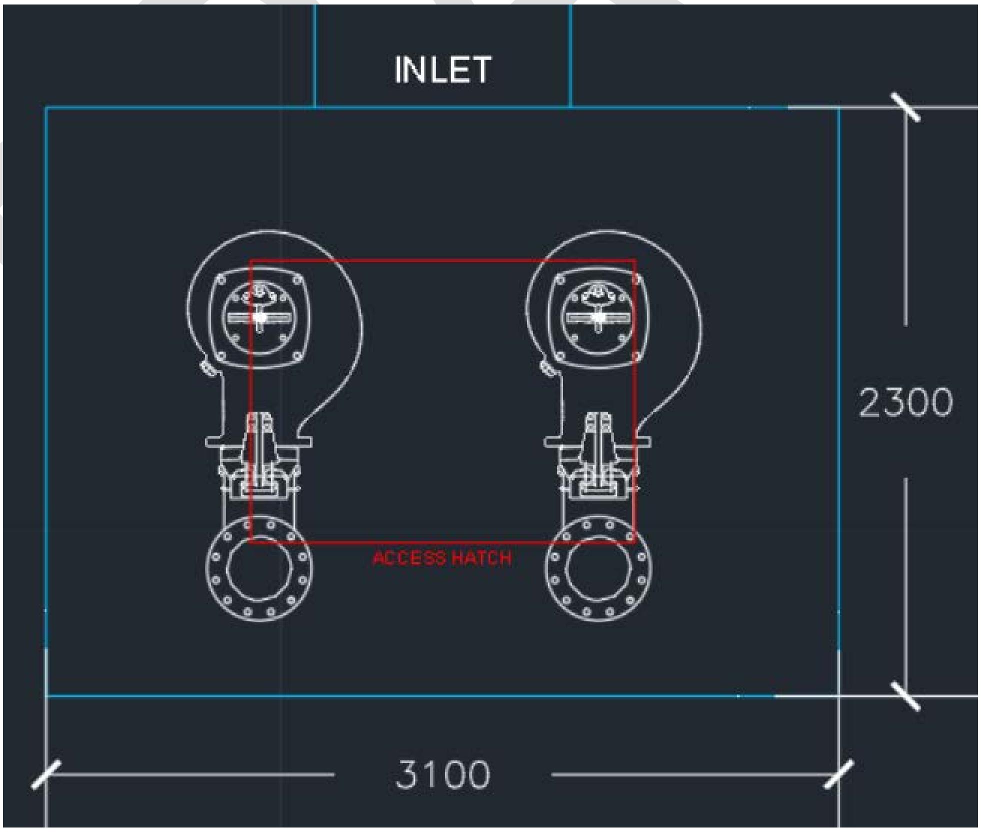



*Figure 9 – Possible Duty/standby pump arrangement at Drumshanbo*

# 7 Preliminary Recommendations

- Install instrumentation (e.g. flow/pressure) on the rising main to allow for trend data and proactive maintenance. The data can be used to assist with future pump selection.
- A more efficient option of pumping is available by either refurbishing or replacing the current NP3171.181 pump at Drumshanbo. This could result in a potential energy saving of 9.2 kWh/1000 $m^3$ which equates to an energy reduction of approximately 35% based on current energy usage
- Install a level control system for the pumping station, potentially via a radar/ultrasonic level sensor in a stilling tube.
- Install power monitoring
- Install a SCADA / HMI system that can be used to remotely monitor the pumping station and record data which then can be used to optimise operation.
- Create a cost benefit analysis to compare between utilising a duty/standby system and a boxed spare.

# APPENDIX A

## XYLEM NP3171.181

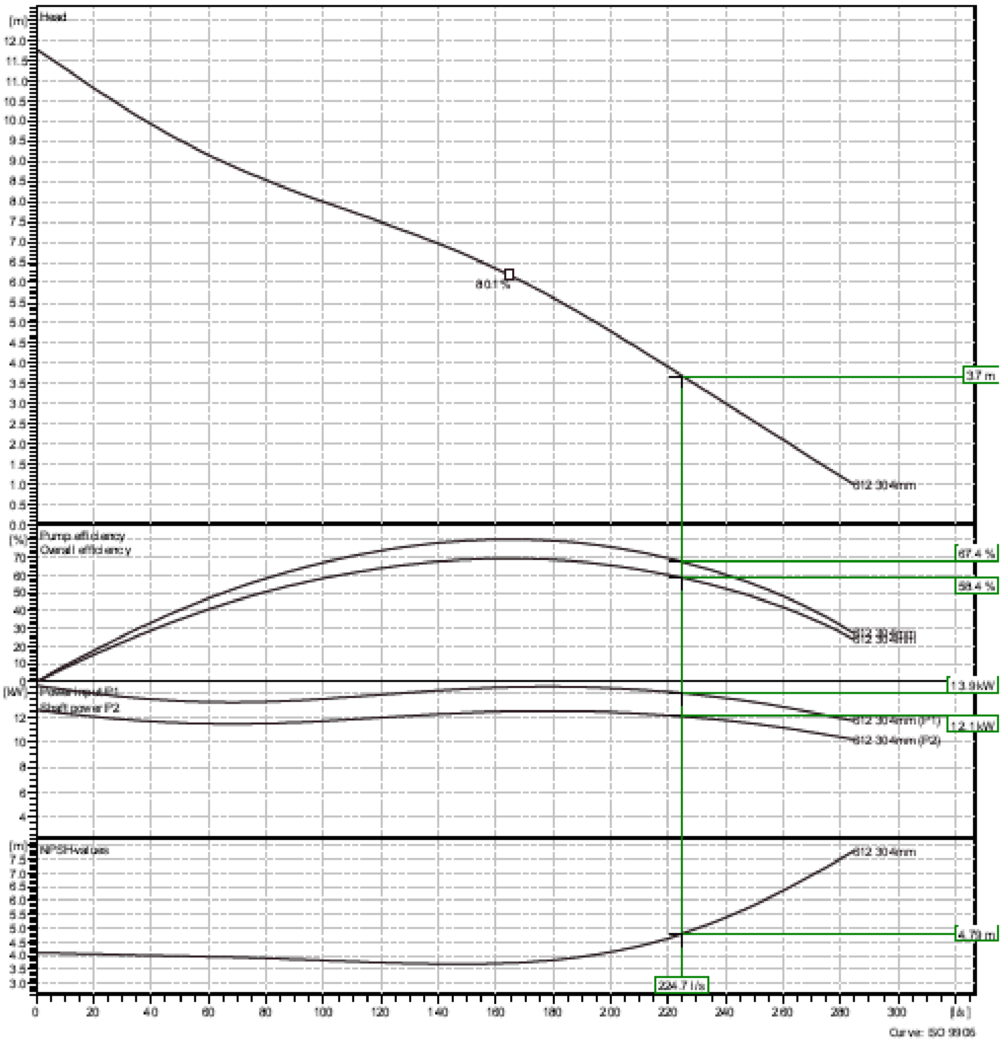
## NP 3171 LT 3~ 612

Performance curve

### Duty point

| Flow | Head |
| --- | --- |
| 225 l/s | 3.7 m |

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




| | | | |
| --- | --- | --- | --- |
| Project | Created by | | Last update |
| Block | Created on | 11/25/2019 | |

Interreg
North-West Europe
Green WIN
European Regional Development Fund

Canal & River Trust
Making life better by water

LIÈGE université

Ministerie van Infrastructuur en Waterstaat

Waterways Ireland
Uiscebhealaí Éireann
Watterweys Airlann

vnf
Voies navigables de France

VLAAMSE LAND MAATSCHAPPIJ