# Trial Site Audit Summary Report

PHASE 2

NIKLAS JOHN

July 2023

# Trial Site Audit Summary Report

PHASE 2

**Author:** Niklas John

**Organisation:** Arcadis

**Checker:** Jermaine Bernard

**Approver:** Andrew Gifford

**Report No:** 10031024-00537

**Work Package:** Long Term LT

**Date:** July 2023

## Version Control

| Version Number | Date issued | Author | Checker | Approver | Changes |
|---|---|---|---|---|---|
| **P1** | 07.07.2023 | N John | J Bernard | A Gifford | DRAFT FOR COMMENT |
| **P2** | 25.07.2023 | N John | J Bernard | A Gifford | CLIENT COMMENTS |
| | | | | | |
| | | | | | |

# Content

# Abbreviations

| Abbreviation | Definition |
|---|---|
| **AC** | Asbestos Cement |
| **AI** | Artificial Intelligence |
| **API** | Automate Programmable Industriel |
| **BEP** | Best Efficiency Point |
| **DN** | Diamétre Nominal (Nominal Diameter) |
| **FLC** | Full Load Current |
| **GPRS** | General Packet Radio Service |
| **Green WIN** | Greener Waterway Infrastructure |
| **GSM** | Global System for Mobile communications |
| **HDPE** | High Density Polyethylene |
| **HMI** | Human Machine Interface |
| **HPPE** | High Performance Polyethylene |
| **N/A** | Not Applicable |
| **NPSH** | Net Positive Suction Head |
| **NPSHr** | Net Positive Suction Head Required |
| **NRV** | Non-Return Valve |
| **NWE** | North West Europe |
| **OD** | Outside Diameter |
| **PE** | Polyethylene |
| **PLC** | Programmable Logic Controller |
| **PN** | Pression Nominal (Nominal Pressure) |
| **PS** | Pumping Station |
| **PVC** | Polyvinyl Chloride |
| **PVC-U** | Unplasticised Polyvinyl Chloride |
| **SCADA** | Supervisory Control and Data Acquisition |
| **SDR** | Standard Dimensional Ratio |
| **SME** | Small and Medium-sized Enterprise |
| **TBC** | To Be Confirmed |
| **TT** | Terre-Terre |
| **UK** | United Kingdom |
| **UoL** | University of Liège (Université de Liège) |
| **VNF** | Voies Navigables de France |
| **VSD** | Variable Speed Drive |
| **WI** | Waterways Ireland |
| **WMO** | Waterway Management Organisation |

# Symbols & Units

| Symbol / Unit | Definition |
|---|---|
| **%** | Percent |
| € | Euro |
| **A** | Ampere (Amp) |
| **$CO_2$** | Carbon Dioxide |
| **Hz** | Hertz |
| **km** | Kilometre |
| **kg** | Kilogram |
| **kW** | Kilowatt |
| **kWh** | Kilowatt-hour |
| **l** | Litre |
| **m** | metre |
| **$m^3$** | Cubic metre |
| **Ml** | Megalitre |
| **mm** | Millimetre |
| **s** | Second |

# 1 Introduction

Project Green WIN is a collaborative project being undertaken by Waterway Management Organisations (WMOs) and partner organisations across North West Europe (NWE) with the aim of addressing excess energy use and high carbon emissions causes. The participating partner organisations are:

- Canal and River Trust, United Kingdom (UK) – Lead Partner.
- Waterways Ireland, Ireland.
- Ministerie van Infrastructuur en Waterstaat, Netherlands.
- Université de Liège, Belgium.
- Voies Navigables de France, France.
- Vlaamse Landmaatschappij, Belgium.

The WMOs rely on pumping equipment and systems to keep waterways operational but need to adapt and make this infrastructure more carbon efficient. Cost pressures restrict WMOs from taking such steps. The project will tackle this by jointly trialling such technologies on their behalf and seeking more efficient ways of deploying them. Pumping water has a substantial carbon impact across NWE, accounting for an estimated 25 % to 33 % of WMO's annual electricity use and circa 20 % of total emissions.

The project focuses on waterways in Belgium, France, Ireland, The Netherlands, and UK, which are used for freight and for recreational uses and has three stages:

1. Audit current equipment/scope for improvement.
2. Pilot technologies and test their potential for adaptation.
3. Investment, procurement, and business planning guidelines.

From energy savings, Green WIN aims to demonstrate net changes of 65-tonnes $CO_2$ equivalent ($CO_2e$) emissions reduced per annum. Main outputs and pilots will be an infrastructure audit, technology trials, investment, procurement, and business planning guidelines (a Greener Pumping Technologies Toolkit) and an established support network.

Arcadis Consulting (UK) Ltd (Arcadis) have been appointed by The Canal and River Trust (the Trust) as a technical consultant to support the Green WIN project. This report summarises the findings of Phase 2 and improvements at the trial sites as of June 2023 and follows the Phase 1 stage which focussed on audits of the current equipment at the nominated trial sites, and potential scope for improvement.

Further details of particular site assessments can be found on the site-specific audit assessment reports provided in Table no. 1.

| **Waterway Partner** | **Site Names** | **Report Reference** |
|---|---|---|
| **Canal and River Trust** | Caen Hill Pumping Station (PS) | 10031024-00516<br>10031024-00536 |
| | Tinsley PS | 10031024-00519 |
| | Seend PS | 10031024-00517 |
| | Calcutt PS | 10031024-00518 |
| **Waterways Ireland** | Leinster Aqueduct PS | 10031024-00524 |
| | Locks 16,17,18 on Grand Canal | 10031024-00525 |
| | Shannon Harbour Locks 35 and 36 | 10031024-00526 |
| | Richmond Harbour PS | 10031024-00527 |
| | Drumleague PS | 10031024-00528 |
| | Drumshanbo PS | 10031024-00529 |
| **Voies Navigables de France** | Crissey PS | 10031024-00522 |
| | Briare PS | 10031024-00521 |
| | Stock PS | 10031024-00523 |

*Table no. 1: Site Specific Audit Assessment Reports*

# 2 Canal and River Trust Audit Findings

## 2.1 Caen Hill Pumping Station

### 2.1.1 Description

Caen Hill PS is located near Devizes, Wiltshire, UK. Its purpose is to supply water up from Lock 22 to Lock 50 on the Kennet and Avon Canal.

*Figure no. 1: Caen Hill PS Photos*

Constructed in 1996, Caen Hill PS is of a dry well construction, housing two dry well submersible pumps that normally run in duty only mode but can run in duty/assist operation. The pumps are automatically controlled based on canal level.

### 2.1.2 Phase 1 Identified Possible Improvements

A 15 % reduction in energy requirement was considered achievable pending further investigations. A summary of potential solutions/considerations for improvement is provided in Table no. 2.

| Item or Issue | Potential Improvement Action | Potential Impact on Energy/$CO_2$ |
|---|---|---|
| **Rising Main Head Loss** | Inspect intermediate check valves for condition and if in bypass. Remove or replace if defective. | -7 % |
| **Pump Selection** | Review Flygt selection, drives, and impeller diameter based on minimum peak flow rate needed. | -5 % to -10 % |
| **Pump Motor** | Consider premium efficiency motor. | -2.3 % |
| **Pump Control** | Implement a 2-level pump control system which allows pump flow rate to vary with Lock 50 flight levels. For example, reducing flow rate when levels are approaching the existing "Stop pump" level. | -5 % |
| **Pipework Failures** | Replace the existing ball check valves with a resilient hinge disc check valve and redesign pipework branches to achieve a better separation of pump and non-return valve (NRV) if possible. | Reduced call outs |
| **Vibration** | Urgently review pump plinth construction, including a structural assessment. Depending on the existing structural design, the new plinths need to be integrated into the existing foundations. | Reduced failures and associated carbon footprint of transportation/and premature replacement parts. |
| **Silt Build up & Blockages** | Provide benching improvements to minimise dead spots.<br><br>Review potential for reducing existing screen bar spacing. | Reduced call outs |

*Table no. 2: Caen Hill PS Potential Solutions*

### 2.1.3 Phase 2 Investigations and Actions

The following actions were undertaken for Caen Hill PS.

1. An investigation at the intermediate check valve locations.
2. Removal of intermediate check valves.
3. Service of Pump #1 undertaken by the pump manufacturer.
4. Specialist vibration survey.
5. Rebuild of PS pipework and plinths (in progress June 2023).

A follow up audit test was undertaken in November 2021 see find the outcome of the actions undertaken on hydraulic and energy performance.

### 2.1.4 Phase 2 Energy Assessment

The Phase 2 energy assessment is based upon the Phase 2 site audit findings.

| Item | Estimated Phase 1 Specific Energy ($kWh/m^3$ x 1000) | Estimated Phase 2 Specific Energy ($kWh/m^3$ x 1000) | Comment | Estimated Impact on Energy/$CO_2$ |
|---|---|---|---|---|
| **Pump 1** | 310 | 294.2 | At 48 Hz | -5.1 % |
| **Pump 2** | 296 | 301.3 | At 48 Hz | +1.8 % |
| **Pump 1 and 2** | 347.6 | 336.6 | At 48 Hz | -3.2 % |
| **Duty/Standby Operation** | 347.6 | 297.8 | | -14.3 % |

*Table no. 3: Caen Hill PS Phase 2 Specific Energy Assessment*

The removal of intermediate NRVs resulted in an improvement by lowering head losses resulting in an improvement in Specific energy as well as increasing flow rate. The refurbishment/servicing of Pump 1 also gave an efficiency improvement. Pump 2 did not undergo a service and appears to have slightly degraded in performance.

In addition to the works at Caen Hill undertaken by the Trust, the construction of a new pumping station at Crofton, on the other (east) side of the summit of the Kennett and Avon canal has taken place, commencing service in July 2023. Crofton PS will assist in the supply of water to the summit of the canal.

Because of Crofton PS, Caen Hill PS will revert to a duty/standby operation rather than duty/assist as was the case during the Phase 1 investigations. Operating under a duty/standby mode (i.e., 1-pump operation) produces a lower specific energy as it will operate closer to its best efficiency point.

The total volume pumped from Caen Hill should also reduce. However, as it is not measurable at this stage, the annual pumped volume has been kept the same for the energy calculations.

The overhaul of Pump 2 is also planned for 2024 which should result in a further reduction to specific energy as found with the overhaul undertaken for Pump 1.

## 2.2 Seend Pumping Station

### 2.2.1 Description

Seend PS is situated near Devizes, Wiltshire, UK. Its purpose is to supply water up from Lock 17 to Lock 21 on the Kennet and Avon Canal.

*Figure no. 2: Seend PS Photos*

Constructed in 1986, it consists of a wet well housing two Xylem submersible pumps that normally operate in duty/assist mode.

### 2.2.2 Phase 1 Identified Possible Improvements

A 10 % reduction in energy requirement is considered achievable pending further investigations. A summary of potential solutions/considerations for improvement is provided in Table no. 4.

| Item or Issue | Potential Improvement Action | Potential Impact on Energy/$CO_2$ |
|---|---|---|
| **Pump Selection** | Review pump selection (including cooling jacket, duty/standby vs duty-assist configuration), drives, and impeller diameter based on minimum peak flow rate needed. Assess the cost-benefit opportunities for these options. | -5 % to -10 % |
| **Pump Motor** | Consider premium efficiency motor. | -2.3 % |
| **Pump Control** | Confirm the levels and flowrates needed to maintain the system in operation before finalising the pump selection and duty configuration.<br>Implement a pump control system which allows pump flow rate to vary with Lock 21 flight | -5 % |

| Item or Issue | Potential Improvement Action | Potential Impact on Energy/$CO_2$ |
|---|---|---|
| | levels. For example, reducing flow rate when levels are approaching the existing "Stop pump" level. | |
| **Rising Main** | The rising main diameter should also be further investigated to confirm the assumptions within this report. | |
| **Vibration** | Investigate the vibration issues on Pump 2 and assess the pump stool fixing. | Reduced failures and associated carbon footprint of transportation/and premature replacement parts. |
| **Instrumentation Monitoring** | Inspect and potentially recalibrate the existing flowmeter and SCADA values. | |

*Table no. 4: Seend PS Potential Solutions*

### 2.2.3 Phase 2 Investigations and Actions

No further actions have been undertaken at Seend PS due to the relatively low potential for energy savings in contrast to capital expenditure. Therefore, further actions for energy saving will be considered at the time of end-of-life pump replacement.

## 2.3 Tinsley Pumping Station

### 2.3.1 Description

Tinsley Pumping Station PS is situated in the Northeast of Sheffield, UK and is located downstream of Tinsley No 9 Lock on the Sheffield & Tinsley Canal, which is part of the Sheffield and South Yorkshire Navigation.

*Figure no. 3: Tinsley PS Photos*

Tinsley PS comprises two fixed-speed, submersible pumps that are provided with soft-start drives and are automatically controlled on upstream level on a duty/standby basis.

Water is abstracted from the River Don via an intake with a bar screen and a 70 m long culvert that connects to the wet well. The level in the Tinsley Top Lock (Upper Flight) No.1 is monitored with a signal transmitted back to Tinsley PS. A PLC controller runs the duty pump when the upper flight level signal falls to a pre-set low level. The controller stops the duty pump upon a pre-set high level being reached.

### 2.3.2 Phase 1 Identified Possible Improvements

A 23.2 % reduction in energy requirement is considered achievable pending further investigations. A summary of potential solutions/considerations for improvement is provided in Table no. 5.

| Item or Issue | Potential Improvement Action | Potential Impact on Energy/$CO_2$ |
|---|---|---|
| **Pump Selection** | Purchase Hidrostal F06G-EMU1+FEVV4-GSEK1AA pumps and retrofit into the well, modifying the existing pipework to accommodate as required. | -21.6 % |

| Item or Issue | Potential Improvement Action | Potential Impact on Energy/$CO_2$ |
|---|---|---|
| **Pump Drives** | Install VSDs for optimum control. | -1.6 % |
| **Pump Control** | Develop control algorithms/function blocks to monitor performance and automatically run at maximum efficiency / lowest specific energy or during off-peak tariff periods. | TBC |
| **Rising main** | Consider feasibility of options to replace rising main. | -16,000 kWh per annum *(Estimated based on 1.3 km long, 600 mm internal diameter HDPE/PE100 pipe)* |
| **Silt/Debris Build up & Blockages** | Provide wet well benching to minimise dead spots.<br><br>Review intake bar screen maintenance procedures. | Reduced call outs |
| **Wet well hydraulics** | Monitor pump performance and efficiency of new installation – review the wet well/intake hydraulics and pump orientation to find if potential improvements to the arrangement can be made should issues arise/persist. | TBC |

*Table no. 5: Tinsley PS Potential Solutions*

### 2.3.1 Phase 2 Investigations and Actions

The following actions were undertaken for Tinsley WPS.

1. Installation of Hidrostal F06G-EMU1+FEVV4-GSEK1AA pumps into the well, modifying the existing pipework to accommodate.

The estimated savings have been derived on the system with the original pumping main and Hidrostal pumps. Due to subsequent rising main failures from land slippage. changes to the rising main have been made since and new pumping arrangements are under review. Therefore, further assessments will be undertaken following completion.

### 2.3.2 Phase 2 Energy Assessment

The Ph2 energy assessment is based upon the derived system curve (original main) and from the SCADA site data.

| Item | Estimated Phase 1 Specific Energy (kWh/m$^3$ x 1000) | Estimated Phase 2 Specific Energy (kWh/m$^3$ x 1000) | Comment | Estimated Impact on Energy/$CO_2$ |
|---|---|---|---|---|
| **Pump 1** | 134.4 | 110.7 | Power estimated from desktop assessment. | -22 % |
| **Pump 2** | 150.4 | | | |

*Table no. 6: Tinsley PS Phase 2 Specific Energy Assessment*

## 2.4 Calcutt Pumping Station

### 2.4.1 Description

Calcutt PS is situated near Southam, Warwickshire, UK and is the last in the chain of a series of eleven pumping stations along the Grand Union Canal.

*Figure no. 4: Calcutt PS Photo*

Calcutt PS comprises a single, fixed-speed submersible pump within a wet well with a valve chamber and a flow meter.  The pump is automatically controlled on level. Level probes are located within the in wet well and pressure transducers are provided for measurement of downstream and upstream canal water levels in the lower and upper pound.

A PLC controller runs the duty pump when the upper pound level signal falls to a pre-set low level. The controller stops the duty pump upon a pre-set high level being reached in the upper pound. The pump is also inhibited upon a pre-set low level being reached in the lower pound.

### 2.4.2 Phase 1 Identified Possible Improvements

In Phase 1, up to a 41 % reduction in energy requirement was considered achievable pending further investigations.

A summary of potential solutions/considerations for improvement is provided in Table no. 7.

| Item or Issue | Potential Improvement Action | Potential Impact on Energy/$CO_2$ |
|---|---|---|
| **Rising Main Head Loss** | Confirm specification details/diameter of existing plastic pipework and consider upsizing existing pipework upstream of flowmeter to lower head losses. | TBC |
| **Pump Selection** | Provide fixed speed duty only (single) pump or duty/standby pump installation. | -39 % to -41 % |
| **Pump Drives** | Provide premium efficiency motor (IE3). | TBC |
| **Pump Control** | Consult with University of Liege and finalise the levels and flowrates needed to maintain the system in operation before finalising the pump selection and duty configuration. | TBC |

*Table no. 7: Calcutt PS Potential Solutions*

### 2.4.3 Phase 2 Investigations and Actions

The following actions have been undertaken for Calcutt PS.

1. Pump review study and redesign of pumping station arrangement.
2. Purchase of Hidrostal F10K pump.
3. Purchase of Control Panel c/w variable speed drive.
4. Testing of above pump and panel on the Green WIN Test Bench at University of Liege.
5. Replacement and upsizing of the existing pipework.

From the Laboratory testing and review of site needs the pump will be aet up to run at 180l/s @ 9.5m at a VSD frequency of approx. 47.5Hz. At this duty condition, the pump operates within 5% of its best efficiency point. The overall efficiency is anticipated to be 67.8% with a specific energy of 38.2kWh/Ml.

The Phase 1 original estimate of 41% saving was based on an initial pump selection at a flow rate of 120l/s. Following a pump design study, this option was not selected as it did not meet the minimum required flow rate.

### 2.4.4 Phase 2 Energy Assessment

The Phase 2 energy assessment is based upon the derived system curve, from the Phase 2 site audit.

| Item | Estimated Phase 1 Specific Energy (kWh/m³ x 1000) | Estimated Phase 2 Specific Energy (kWh/m³ x 1000) | Comment | Estimated Impact on Energy/$CO_2$ |
|---|---|---|---|---|
| **Pump 1** | 52.3 | 38.2 | Based on UoL Laboratory Pump Test; 180l/s flow rate and 47.5Hz | - 27 % |

*Table no. 8:  Calcutt PS Phase 2 Specific Energy Assessment*

# 3 Waterways Ireland Audit Findings

## 3.1 Leinster Aqueduct Pumping Station

### 3.1.1 Description

Leinster Aqueduct PS is situated on the River Liffey, approximately 2 km northeast of Donore, Co. Kildare. The pumping station lifts water from the River Liffey into the Grand Canal Lock system to replenish the system during the summer months.

*Figure no. 5: Leinster Aqueduct PS (viewed from Grand Canal)*

Leinster Aqueduct PS comprises three KSB Amarex fixed speed, 18.5kW rated submersible pumps, each located within dedicated pump bays. The pumps are protected by a 50 mm spaced bar screen and low-level suction protection probes.

The pumps are controlled in 'hand', with no other instrumentation present (flow meter, pressure transducer, etc.).

The pump station typically operates between approximately March and September with the sluice gate drain in operation for the remainder, draining excess water from the canal network. The sluice is manually operated.

### 3.1.2 Phase 1 Identified Possible Solutions

A summary of potential solutions/considerations for improvement is provided in Table no. 9.

| Item or Issue | Potential Improvement Action | Potential Impact on Energy/$CO_2$ |
|---|---|---|
| **Pump Performance** | Lift and investigate Pump 2 and Pump 3 impellers. Remove any soft blockages. | |
| **Instrumentation and Controls** | Install level sensors on discharge canal flight.<br><br>Install magnetic flowmeters on all three-pump delivery lines c/w check valves.<br><br>Install threaded process connection on all three-pump delivery lines to allow pressure readings on future tests.<br><br>Install a 'smart' pump controller including power metering that can automatically control the pumps using inputs from the above instrumentation measurements together with optimised efficient running and callouts. | TBC |
| **SCADA / Telemetry** | Install 'smart' controller (as above) with communication capability and remote data access via GPRS/GSM signal in lieu of more expensive SCADA and telemetry at PS. | |
| **Return Sluice Gate** | Repair leakage from sluice gate. | -2.5 % |

*Table no. 9: Leinster Aqueduct Potential Solutions*

### 3.1.3 Phase 2 Investigations and Actions

The following actions have been undertaken for the Liffey Aqueduct pumping station.

1. Lift and removal of debris from pump impellers.
2. Automation of PS based upon upstream pound level.
3. Replacement of existing KSB pump with Xylem NX3202 submersible pump for P1 only.
4. Procurement and installation of variable speed drive for P1.
5. Adaption of 3no. rising mains to include flowmeters and check valves.
6. Introduction of smart controller for all three pumps and remote accessibility of PS data via GSM link and 3rd party hosted website.

This PS was chosen for a new variable speed pump installation by WI to allow a direct comparison with the existing fixed speed pumps.

### 3.1.4 Phase 2 Energy Assessment

The Phase 2 installation is yet to be completed at the time of writing. The Ph2 energy assessment is based upon the derived system curve, from the Phase 1 site audit, and manufacturers performance data from the procured Xylem NX3202 pump data and Danfoss Variable Speed Drive.

The return sluice gate is also understood to be repaired.

| **Item** | **Estimated Phase 1 Specific Energy (kWh/m$^3$ x 1000)** | **Estimated Phase 2 Specific Energy (kWh/m$^3$ x 1000)** | **Comment** | ***Estimated Impact on Energy/$CO_2$** |
|---|---|---|---|---|
| **Pump 1** | 49.8 | 49.8 | Replaces KSB Amarex for Pump 1 (Assumed 50% of flow as 1st duty) | - |
| **Pump 2** | 53.7 | 49.8 | Replace former Pump 1 in Pump 2 location (Assumed 25% of flow as 1st Assist) | -2 % |
| **Pump 3** | 52 | 52 | Assumed 25% of flow as 2nd Assist) | |
| **Sluice Gate repair** | | | Avoids recirculation of flow | -10 % |
| **Automatic Controls** | | | Optimizes Pump Usage based on Canal Level. TBC | |
| | | | Combined | -11.8% |

*Table no. 10: Leinster Aqueduct PS Phase 2 Specific Energy Assessment*

** To be confirmed following installation of solution and monitoring*

## 3.2 Grand Canal Locks 16. 17, 18 Pumping Stations

### 3.2.1 Description

For Locks 16, 17 & 18 on the Grand Canal, three pump houses operate in a chain to supply water to the summit pound of the Grand Canal during dry periods to maintain navigable water levels.

The Phase 1 assessment is based upon the data provided by WI and a site audit visit undertaken in September 2019.

Lock 16 is located near Digby Bridge, Sallins, Co. Kildare and discharges across the Lock gate towards Lock 17.

Lock 17 is located near Landenstown Bridge, near Donore, Co. Kildare.

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 no. 6: Lock 16 on the Grand Canal PS (viewed from Digby Bridge)*

All three pumping stations comprise a wet well with fixed intake bar screen housed within the confines of a superstructure building. All three sites each comprise a single KSB submersible pump, of the same model and size, which date back to around 2010. The delivery pipework is comprised of 250 mm diameter ductile iron flanged pipework. There are no isolation or check valves contained within the pump stations.

The rising main arrangements differ between the three sites.

At Lock 16, the 300 mm diameter 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.

Unlike Lock 16, the rising main for Lock 17 discharges into the canal over a weir board approximately 30 m away from the pump house.

Lock 18 rising main is similar in nature to that of Lock 16 with the rising main free discharging 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.

### 3.2.2 Possible Improvements

A summary of potential solutions/considerations for energy improvement provided in Table no. 11.

| **Item or Issue** | **Potential Improvement Action** | **Potential Impact on Energy/$CO_2$** |
|---|---|---|
| **Pump Performance Uncertainty** | Investigate the pumps at Lock 16 and 18 for loss of efficiency, potential debris in pump/ motor deficiencies/ etc.<br>A more efficient pumping option is available by examining the market for alternative pumps. For example, utilising a Xylem NP3171 LT612 may save 3.7 kWh/Ml on paper. *At this stage it is suggested that pump replacement is not an immediate priority.* | -8 % |
| **Instrumentation and Controls** | Install level sensors on discharge canal flight.<br>Install magnetic flowmeters on all three-pump delivery lines.<br>Install a 'smart' pump controller including power metering that can automatically control the pumps using inputs from the above instrumentation measurements together with optimised efficient running and callouts. | -5 % to -10 % |
| **SCADA / Telemetry** | Install 'smart' controller (as above) with communication capability and remote data access via GPRS/GSM signal in lieu of more expensive SCADA and telemetry at PS. | |
| **Lock Gates** | Investigate the lock gates at Lock 17 for leakage and possible refurbishment. | -2.5 % |

*Table no. 11: Lock 16,17 & 18 Grand Canal Potential Solutions*

### 3.2.3 Phase 2 Investigations and Actions

The following actions have been undertaken for the pumping stations at Lock 16, 17, and 18.

1. Laboratory Performance Testing of KSB Amarex Pump (as installed at all three PSs) at the University of Liège Test Bench.
2. Lift and removal of debris from pump impellers.
3. Automation of all three PSs based upon upstream pound level.
4. Addition of variable speed drives at L16 and L18 (sites chosen to investigate impact of VSDs).
5. Adaption of rising mains to include flowmeters.
6. Introduction of smart controllers and remote accessibility of PS data via GSM link and 3rd party hosted website.

### 3.2.4 Phase 2 Energy Assessment

The Phase 2 installation is yet to be completed at the time of writing. The Phase 2 energy assessment is based upon the derived system curves, from the Phase 1 site audit, the laboratory performance results of the KSB Amarex Pump, and the Danfoss Variable Speed Drive published efficiency data.

| **Item** | **Estimated Phase 1 Specific Energy ($kWh/m^3$ x 1000)** | **Estimated Phase 2 Specific Energy ($kWh/m^3$ x 1000)** | **Comment** | *** Estimated Impact on Energy/$CO_2$** |
|---|---|---|---|---|
| **Lock 16** | 25.3 | 24.3 | VSD datasheet states 98% efficiency | -4% |
| **Lock 17** | 23.6 | 22.7 | No VSD | -4% |
| **Lock 18** | 31 | 23.4 | VSD datasheet states 98% efficiency | -24% |
| **Automatic Controls** | | | Optimizes Pump Usage based on Canal Level. TBC | -10% |
| | | | Combined | -14.8% |

*Table no. 12: Grand Canal Locks 16 to 18 PSs Phase 2 Specific Energy Assessment*

** To be confirmed following installation of solution and monitoring*

## 3.3 Shannon Harbour Locks 35 and 36

### 3.3.1 Description

Two pumping stations are used in a chain to supply water to the Grand Canal from the River Shannon/River Bresna confluence during dry periods to maintain navigable levels.

*Figure no. 7: Lock 36 PS on the Grand Canal*

The audit assessment was based upon the following inputs:

- Initial Technical Assessment paper by WI.
- Existing pump datasheet.
- A site audit investigation and pump performance testing by Arcadis and Samatrix in September 2019.

Both pumping stations are very similar in layout and construction, and are essentially identical, from a pump hydraulic perspective. Each pumping station comprises one ABS fixed-speed submersible pump.

The pump discharge pipework is 150 mm nominal diameter (DN150) flanged DI pipe. The DI pipework connects to a 250 mm diameter rising main of unknown material, suspected to be asbestos cement. The discharge points are concealed and not accessible from the surface.

There are no isolation or check valve contained within the pump station. An ultrasonic level probe is located within the wet well and for purposes of pump suction protection. No sustained reverse flow was observed following cessation of pumping.

*Figure no. 8: Lock 35 PS on the Grand Canal*

Both pumping stations operate under manual control and run continuously where possible. This is reportedly because of the pumping system being unable to quickly recover levels should the upstream level drop significantly, especially if the boat repair dry dock is in operation.

There are no operational telemetry or SCADA facilities associated with the two pumping stations.

Waterways Ireland are considering a new additional pump station at Lock 34. There are reports of substantial leaks in the system between Lock 31 and Lock 34, therefore increasing pump capacity to 150 l/s is preferred from Lock 36.

### 3.3.2 Phase 1 Identified Possible Improvements

A summary of potential solutions/considerations for improvement provided in Table no. 13.

| Item or Issue | Potential Improvement Action | Potential Impact on Energy/$CO_2$ |
|---|---|---|
| **Pump Performance** | SHORT TERM - Check the existing pumps, notably Lock 35, for signs of blockage, impeller damage, and impeller to bottom plate gap, adjusting as necessary.<br><br>Temporary testing of an alternative pump with a known performance curve would help find the system requirements so that a permanent pump selection can be made with further confidence.<br><br>Replace pumps with DN250 outlet alternative as per highlighted Xylem / Sulzer performance and non-clog impellers and sized for 150 l/s duty flow rate. | -40 % across both PSs |

| Item or Issue | Potential Improvement Action | Potential Impact on Energy/$CO_2$ |
|---|---|---|
| | Replace existing DN150 pipework with DN250 pipework to reduce piping pressure losses. | |
| **Instrumentation and Controls** | Install level sensors on discharge canal flight.<br><br>Install magnetic flowmeter on pump delivery lines.<br><br>Install a 'smart' pump controller including power metering that can automatically control the pumps using inputs from the above instrumentation measurements together with optimised efficient running and callouts. | -10% to 30 % |
| **SCADA / Telemetry** | Install 'smart' controller (as above) with communication capability and remote data access via GPRS/GSM signal in lieu of more expensive SCADA and telemetry at PS. | |
| **Lock Gates** | Investigate the lock gates for leakage and possible refurbishment. | -2.5 % |
| **Asset Data Information** | Conduct a design survey, possibly point cloud survey, and outline design of the existing wet well to confirm the feasibility of accommodating larger DN250 pipework and pumps. | |

*Table no. 13: Shannon Harbour Potential Solutions*

### 3.3.3 Phase 2 Investigations and Actions

The following actions have been undertaken for the pumping stations at Lock 35 and Lock 36.

1. New control panels at both PSs.
2. Automation of both PSs based upon upstream pound level.
3. Design and proposed construction of new wet well, pipework and 2 no. Xylem NP3153 LT pumps at L36.
4. Adaption of rising mains to include flowmeters.
5. Introduction of smart controllers and remote accessibility of PS data via GSM link and 3rd party hosted website.

### 3.3.4 Phase 2 Energy Assessment

The Phase 2 installation is yet to be completed at the time of writing. The Ph2 energy assessment is based upon the derived system curves, from the Phase 1 site audit, and published data from the manufacturer of the procured pumps at Lock 36.

| Item | Estimated Phase 1 Specific Energy (kWh/m³ x 1000) | Estimated Phase 2 Specific Energy (kWh/m³ x 1000) | Comment | * Estimated Impact on Energy/$CO_2$ |
|---|---|---|---|---|
| **Lock 35** | 50.6 | 50.6 | Automatic controls only | - |
| **Lock 36** | 45 | 18.2 | New 2-pump PS | -59.5% |
| **Automatic Controls** | | | Optimizes Pump Usage based on Canal Level. TBC | -10% |
| | | | Combined | -40.6% |

*Table no. 14: Grand Canal Locks 35 and 36 PS Phase 2 Specific Energy Assessment*

** To be confirmed following installation of solution and monitoring*

## 3.4 Richmond Harbour Pumping Station

### 3.4.1 Description

Richmond Harbour is located near Cloondara, County Clondra. The pump house is the first in a chain of pumping stations along the Royal Canal designed to maintain an upstream level within the canal from the River Camlin.

The energy consumed in 2016 was 78,554 kWh.

*Figure no. 9: Richmond Harbour PS (Left); Richmond Harbour PS Outfall (Right)*

There is no historic performance data or drawings available for Richmond Harbour. A site visit and was undertaken in September 2019.

Richmond Harbour comprises of one KSB fixed-speed axial flow pump. The pump station intake is direct from the River Camlin via a concrete intake culvert. The intake is fully submerged and is protected with a 100 mm spaced bar screen. Electrode level probes are located within the wet well and operate for low level protection.

The pump discharge pipework is PN16 DN300 cast iron and includes a gate isolation valve complete with pedestal. The pipework is located below ground level and can be accessed by an inspection hatch located on the pump house floor.

The rising main discharges directly into Richmond Harbour; the exact nature of the discharge could not be ascertained as it was submerged, but it is reported to have a flap valve on the exit.

The rising main runs from the pump house to Richmond Harbour and discharges fully submersed via a flap valve. It is reported that there are no other isolation or check valves present on the rising main. The pipeline condition is unknown but there are no reports of bursts arising since construction.

### 3.4.2 Phase 1 Identified Possible Improvements

A summary of potential solutions/considerations for improvement provided in Table no. 15.

| Item or Issue | Potential Improvement Action | Potential Impact on Energy/$CO_2$ |
|---|---|---|
| **Pump Performance** | Consider like for like replacement with new vertical pump and premium efficiency motor. | -11 % |
| **Pumping Station Resilience** | Consider design and construction of new wet well pumping station off-line c/w 2no. submersible pumps. | - |
| **Instrumentation and Controls** | Install level sensor on discharge canal flight.<br><br>Install magnetic flowmeter on pump delivery line.<br><br>Install threaded process connection on pump delivery line to facilitate future pump audit testing.<br><br>Install a 'smart' pump controller including power metering that can automatically control the pumps using inputs from above instrumentation measurements together with optimized efficient running and callouts. | TBC (-50 %) |
| **SCADA / Telemetry** | Install 'smart' controller (as above) with communication capability and remote data access via GPRS/GSM signal in lieu of more expensive SCADA and telemetry at PS. | |
| **Asset Data Information** | Conduct a design survey, possibly point cloud survey of the inlet culvert should be undertaken to determine dimensions and facilitate future works | |

*Table no. 15: Richmond Harbour Potential Solutions*

### 3.4.3 Phase 2 Investigations and Actions

The following actions have been undertaken for the pumping station:

1. New replacement pump and motor (replaced 2022).
2. New control panel.
3. Automation based upon upstream pound level.
4. Adaption of rising main to include flowmeter.
5. Introduction of smart controller and remote accessibility of PS data via GSM link and 3rd party hosted website.

### 3.4.4 Phase 2 Energy Assessment

The Phase 2 electrical and controls installation is yet to be completed at the time of writing. However, a new pump and motor were installed in 2022. The Phase 2 energy assessment is based upon the derived system curves, from the Phase 1 site audit, and published data from the manufacturer of the newly installed pump.

| Item | Estimated Phase 1 Specific Energy ($kWh/m^3$ x 1000) | Estimated Phase 2 Specific Energy ($kWh/m^3$ x 1000) | Comment | * Estimated Impact on Energy/$CO_2$ |
|---|---|---|---|---|
| **Pump & Motor** | 16.4 | 13.8 | Estimated Motor efficiency of 92% | -15% |
| **Automatic Controls** | | | Optimizes Pump Usage based on Canal Level. TBC | -10% |
| | | | Combined | -24.4% |

*Table no. 16: Richmond Harbour PS Phase 2 Specific Energy Assessment*

** To be confirmed following installation of solution and monitoring*

## 3.5 Drumleague Pumping Station

### 3.5.1 Description

Drumleague PS is situated on the Lough Allen Canal, between Deffier and Lustia, Carrick-on-Shannon, County Leitrim. The pumping station is supplementary to Drumshanbo and was made operational as Drumshanbo PS is unable to maintain the level in the Lough Allen canal system. Drumleague PS has only been operating for approximately 12-months and had been out of commission for a period.

A site visit was undertaken in September 2019.

*Figure no. 10: Drumleague PS*

Drumleague PS comprises one Xylem 15 kW, fixed-speed, submersible pump (Model: NP3171.181). The pump is situated at the bottom of a circa 3.5 m deep wet well.

The pump is operated manually in 'hand', with no other instrumentation present (flow meter, pressure transducer, etc.) on the system. It was reported that the pump currently operating at Drumleague had been sat in dry dock for several years before and its condition was unknown.

### 3.5.2 Phase 1 Identified Possible Improvements

A summary of potential solutions/considerations for improvement provided in Table no. 17

| Item or Issue | Potential Improvement Action | Potential Impact on Energy/$CO_2$ |
|---|---|---|
| **Pump Performance** | Inspect existing pump for any blockage or damage to the impeller. Photograph and record nameplate on pump and motor to confirm pump model.<br><br>Temporary testing of an alternative pump with a known performance curve would help find the system requirements so that a permanent pump selection can be made with further confidence.<br><br>Review required flow rate in conjunction with Drumshanbo PS and change pump to suit if needed. | TBC (-50%) |
| **Rising Main** | Inspect the rising main for any potential issues with a camera survey, such as blockage, collapse, or partially closed valves. It is also recommended that the Ferrer flap valve is inspected to ensure free movement over the full range of opening. | |
| **Instrumentation and Controls** | Install level sensor on discharge canal flight.<br><br>Install magnetic flowmeter on pump delivery line.<br><br>Install threaded process connection on pump delivery line.<br><br>Install a 'smart' pump controller including power metering that can automatically control the pumps using inputs from the above instrumentation measurements together with optimised efficient running and callouts. | TBC (-50 %) |
| **SCADA / Telemetry** | Install 'smart' controller (as above) with communication capability and remote data access via GPRS/GSM signal in lieu of more expensive SCADA and telemetry at PS. | |

*Table no. 17: Drumleague PS Potential Solutions*

### 3.5.3 Phase 2 Investigations and Actions

No changes have been made under Phase 2 with the focus on Drumshanbo on this section of the canal system.

## 3.6 Drumshanbo Pumping Station

### 3.6.1 Description

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 no. 11: Drumshanbo Dual Lock Station*

There are no known drawing records. A site audit visit undertaken in September 2019.

Drumshanbo pump station is comprised of one 15 kW, fixed-speed, submersible pump (Model: Xylem NP3171.181) located within a 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 mains encased in concrete. 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.

### 3.6.2 Phase 1 Identified Potential Areas for Improvement

A summary of potential solutions/considerations for improvement provided in Table no. 18.

| Item or Issue | Potential Improvement Action | Potential Impact on Energy/$CO_2$ |
|---|---|---|
| **Pump Performance** | Inspect existing pump for any blockage or damage to the impeller. Photograph and record nameplate on pump and motor to confirm pump model. Replace if damaged.<br><br>Temporary testing of an alternative pump with a known performance curve would help find the system requirements so that a permanent pump selection can be made with further confidence.<br><br>Review required flow rate in conjunction with Drumleague PS and change pump to suit if needed. | -26 % |
| **Pump Drives** | Provide premium efficiency motor (IE3) if pump replaced | -2 % |
| **Pumping Station Resilience** | Survey wet well and consider modification with an additional pump, commencing with feasibility study. Consider box spare pump as lower cost (and less resilient) alternative choice. | N/A |
| **Rising Main** | Inspect the rising main for any potential issues with a camera survey, such as blockage, collapse, or partially closed valves. It is also recommended that the Ferrer flap valve is inspected to ensure free movement over the full range of opening. | TBC |
| **Instrumentation and Controls** | Install level sensor on discharge canal flight.<br><br>Install magnetic flowmeter on pump delivery line.<br><br>Install threaded process connection on pump delivery line.<br><br>Install a 'smart' pump controller including power metering that can automatically control the pumps using inputs from the above instrumentation measurements together with optimised efficient running and callouts. | TBC (-50 %) |
| **SCADA / Telemetry** | Install 'smart' controller (as above) with communication capability and remote data access via GPRS/GSM signal in lieu of more expensive SCADA and telemetry at PS. | |

*Table no. 18: Drumshanbo PS Potential Solutions*

### 3.6.3 Phase 2 Investigations and Actions

The following actions have been undertaken for the pumping station:

1. New (additional) submersible pump.
2. Adaption of wet well and pipework to accommodate 2 pumps instead of one pump.
3. New control panel.
4. Automation based upon upstream pound level.
5. Adaption of rising main to include flowmeter.
6. Introduction of smart controller and remote accessibility of PS data via GSM link and 3rd party hosted website.

### 3.6.4 Phase 2 Energy Assessment

The Phase 2 electrical and controls installation is yet to be completed at the time of writing. However, a new pump and motor were installed in 2022. The Phase 2 energy assessment is based upon the derived system curves, from the Phase 1 site audit, and published data from the manufacturer of the newly installed pump.

| Item | Estimated Phase 1 Specific Energy ($kWh/m^3$ x 1000) | Estimated Phase 2 Specific Energy ($kWh/m^3$ x 1000) | Comment | * Estimated Impact on Energy/$CO_2$ |
|---|---|---|---|---|
| **Pump & Motor** | 26.3 | 22.8 | | -13.3% |
| **Automatic Controls** | | | Optimizes Pump Usage based on Canal Level. TBC | -10% |
| | | | Combined | 22% |

*Table no. 19: Drumshanbo PS Phase 2 Specific Energy Assessment*

** To be confirmed following installation of solution and monitoring*

# 4 Voies Navigables de France Audit Findings

## 4.1 Crissey Pumping Station

### 4.1.1 Description

The audit assessment was based upon the following inputs:

- Desktop study review.
- Data provided by Voies Navigables de France (VNF) via the Green WIN intranet site.


*Figure no. 12: Crissey Lock Pumping Station*

Crissey PS was built in 1960s and is located at the eastern end of the Canal du Center, at the junction with the Saône. The canal is supplied with water by the reserve ponds located around Le Creusot (between Montchanin and Montceau-les-Mines), and by the Dheune (which runs along the Mediterranean side between Chagny and Montchanin).

The pumping station is designed to allow water to be raised from the Saône to the forebay (towards Reach 34-34 bis) in order to make river navigation possible.

Prior to Green WIN, Crissey PS comprised two Rateau type ID BV 57 pumps each located on either side of the lock. The automation of the pumping system is carried out via the Automate Programmable Industriel (API), i.e. the industrial programmable controller, and the operating range can be adjusted from the HMI.

### 4.1.2 Phase 1 Identified Possible Improvements

- Install the current VNF proposed pump selection, a Xylem CT3400.
- Continue with fixed speed drives.
- Introduce an improved automated control system utilising latest technology based on downstream (and upstream) level monitoring, including consideration of 'smart' controllers.
- Introduce performance metric reporting and possible smart control adjustment.

### 4.1.3 Phase 2 Investigations and Actions

The following actions have been undertaken for the pumping station:

1. New replacement Xylem pumps and motor (replaced 2021).
2. Electrical modernisation.
3. Automation improvements to both pumps based upon upstream pound level.
4. Flood resilience improvements.

### 4.1.4 Phase 2 Energy Assessment

| **Item** | **Estimated Phase 1 Specific Energy (kWh/m$^3$ x 1000)** | **Estimated Phase 2 Specific Energy (kWh/m$^3$ x 1000)** | *** Estimated Impact on Energy/$CO_2$** |
|---|---|---|---|
| **Pump & Motor** | 52 and 81 | 42 | -36.8% |

*Table no. 20: Crissey PS Phase 2 Specific Energy Assessment*

## 4.2 Briare Pumping Station

### 4.2.1 Description

Briare PS is equipped with six pumps although it operates with only two pumps for most of the time and up to three if necessary.

The project considerations for this pumping station for implementation 2020 are as follows:

- Automation, supervision and telecontrol of pumping operations.
- Optimising of operations time periods.
- Implementing at least one new pump.
- Motor IE3 or IE4 energy performance, VSD.
- Smart water and energy monitoring.

Arcadis' Phase 1 assessment was a desktop study review based upon the data provided by VNF via the Green WIN intranet site.

### 4.2.2 Phase 1 Identified Possible Improvements

- Undertake on site flow and pressure monitoring assessment to determine actual system characteristics.
- Assuming curves are as expected, select Xylem CP3231 pump model as proposed and consider use of an IE3 motor for new pumps.
- Continue with fixed speed drives.
- Introduce an automated control system based on downstream (and upstream) level monitoring, including consideration of 'smart' controllers.
- Introduce performance metric reporting and possible smart control adjustment.

### 4.2.3 Phase 2 Investigations and Actions

No further actions have been undertaken at this time.  Further actions for energy saving will be considered at the time if end-of-life pump replacement.

## 4.3 Stock Pumping Station

### 4.3.1 Description

Stock PS is located on the east bank of the Stock Pond and is vital for the water supply of the Marne to the Rhine Canal and the Saar Canal. It is equipped with four pumps and allows the transfer of water to raise the level of the pond towards the canal in order to feed the Vosges sharing bay, and thus the Marne to the Rhine Canal, as well to Strasbourg as to Nancy, and the Saar Canal.

Arcadis undertook a desktop study review in Phase 1 based upon the data provided by VNF via the Green WIN intranet site.

The pumping station is reported to be able to deliver approximately 171,000 $m^3$ over 24-hours with three pumps operating simultaneously and 230,000 $m^3$ with four pumps, although only three can be operated at the same time due to electrical restrictions.

The existing pumps appear to be horizontal, axially split, double suction, centrifugal pumps that are long coupled to 110 kW slip ring motors. It is understood that the motors were refurbished in 2003.

### 4.3.2 Phase 1 Identified Possible Improvements

Consideration of new pumps, similar to the units identified below:

- Bedford SB45.12.06 390 mm impeller - **suspended submersible pump**.
- Xylem 20 x 18 WLS 518 mm impeller - **horizontal split case pump**.

| Pump | Duty Point | Motor Rating (kW) | Pump Efficiency at duty point (%) | Motor Efficiency* (%) |
|---|---|---|---|---|
| **Bedford** | 600 l/s at 11.4 m | 90 | 87.5 | 95.2 |
| **Xylem** | 600 l/s at 11.0 m | 90 | 88.9 | 95.2 |
| **IE3 motor minimum efficiency* | | | | |

*Table no. 21: Comparison of potential alternative pump selections*

Other potential improvements include:

- Automation of pumping e.g. use of 'smart' pump controller.
- Installation of premium efficiency motors to new and/or existing pumps.
- Consideration of variable speed drives.
- Installation of flow meter on common main to provide automation of pump flow control as well as the facility for remote monitoring.
- Investigate energy recovery feasibility for return flows.

### 4.3.3 Phase 2 Investigations and Actions

No further actions were undertaken at this time. Further actions for energy saving will are being considered based on the Phase 1 investigations. Considering the final configuration that is finally chosen, an estimated energy efficiency savings ratio of 30 % between the previous and new pumping equipment from Stock pumping station modernisation should allow annual savings of around 2300 kg$CO_2$e emissions.

# 5 VLM Audit Findings

Further to the Phase 1 established trial sites, several existing Land Remediation Management (LRM) pumping stations in the VLM region were assessed by Arcadis during Phase 2 for possible energy improvements through a change of pump.

Table 24 in Appendix A describes the breakdown of the assessment calculations. The outcome of the assessment was that an estimated energy and carbon saving of 6.7 % may be realised by reselection of the pump matched to the particular system characteristics.

# 6 Pump Summary

## 6.1 Phase 1 Trial Sites

From the audit assessments of the trial sites, a summary of the installed pump model and its performance is provided, together with the required post-improvement flow rate and head.

| Trial Site | Partner | Original Pump Model | Estimated Phase 1 Flow Rate (l/s) | Estimated Phase 1 Head (m) | Improvements In progress / Completed | Phase 2 Pump Model (Blank if no change) | Estimated Phase 2 Flow Rate (l/s) | Estimated Phase 2 Head (m) | University of Liege Laboratory Testing |
|---|---|---|---|---|---|---|---|---|---|
| **Caen Hill PS** | Canal & River Trust | Xylem CT3240 | 133 | 84 | Reduce Main Losses | | 138.2 | 83 | No |
| **Tinsley PS** | | Xylem NP3301 HT | 109 | 26 | New Hidrostal Pumps and VSD | Hidrostal F06G-EMU1+FEVV4-GSEK1AA | 155 | 28.2 | No |
| **Seend PS** | | Xylem NP3301 | 165 | 19 | - | | | | No |
| **Calcutt PS** | | KSB KRT200-330 modified | 245 | 14.5 | New Pumps<br>New Pipework<br>VSDs | Hidrostal | 195 | 10.5 | Yes |
| **Leinster Aqueduct** | Waterways Ireland | KSB KRT200-401 | 119 | 12 | P1 Pump & VSD Control Regime | Xylem NX3202 (1 pump of 3) | 130 | 13.7 | No |
| **Locks 16,17,18 Grand Canal** | | KSB KRT250-400 | 160 | 5.3 | VSD (L16, L18) Control Regime | | 161,169,166 | 5.8, 5.3, 5.5 | Yes |
| **Shannon Harbour** | | ABS AFP1521 M150 4-32 | 83 & 98 | 5 & 6.1 | New Pumps<br>Enlarge Pipework<br>Control Regime | Xylem NP3153 | 147 | 4.5 | No |
| **Richmond Harbour** | | KSB PLZ300 | 226 | 3.8 | New Pumps<br>New Well (TBC)<br>Control Regime | KSB | 225 | 3.7 | No |
| **Drumleague PS** | | Xylem NP3171 | 50 | 9.5 | - | | | | No |
| **Drumshanbo PS** | | Xylem NP3171 | 180 | 2.7 | New Pumps<br>Control Regime | Additional Xylem NP3171 | 212 | 5.95 | Yes |
| **Crissey PS** | Voies Navigables de France | - | - | - | New Pumps<br>Flowmeter | Xylem | 600 | 12.5 | No |
| **Briâre PS** | | Xylem NP3231 | 210 | 48 | - | | | | No |
| **Stock PS** | | Rateau EPB41 | 410 | 8.2 | - | | | | No |

*Table no. 22: Trial Site Pump Summary Table*

# 7 Energy Assessment

## 7.1 Energy and Carbon Saving Assessment

Table no. 23 summarises Arcadis' Phase 2 assessment of the energy improvement as a result of implementing the proposed improvements. It is recognised that Phase 2 site audits are still to be completed at various sites, so a range has been estimated based on University of Liege laboratory testing.

| Trial Site | Partner | Estimated Annual Energy Usage (Phase 1) | Improvement Undertaken/In Progress | Phase 1 Estimated Potential Change in Energy Usage | | Phase 1 Potential Carbon Emission Change | Phase 2 Estimated Potential Change in Energy Usage | | Phase 2 Potential Carbon Emission Reduction | Emission Factor 2021* |
|---|---|---|---|---|---|---|---|---|---|---|
| | | (kWh) | | (%) | (kWh) | ($kgCO_2e$/year) | (%) | (kWh) | ($kgCO_2e$/year) | ($kgCO_2e$/kWh) |
| **Caen Hill PS** | Canal & River Trust | 1,488,100 | NRV removal to lower rising main head loss / pump service<br>Conversion to duty/standby operation | -15.2 | -226,700 | -66,038 | -14.3 | -213,400 | -62,163 | 0.29130 |
| **Tinsley PS** | | 541,120 | Install Hidrostal F06G-EMU1+FEVV4-GSEK1AA Pumps | -23.2 | -125,780 | -36,640 | -22.0 | -119,046 | -34,678 | 0.29130 |
| **Seend PS** | | 223,593 | No Action | -22.4 | -50,082 | -14,589 | - | - | - | 0.29130 |
| **Calcutt PS** | | 203,693 | Install Hidrostal Pumps, pipework upgrade and variable speed drives | -40.6 | -82,608 | -24,121 | -27.0 | -54,915 | -15,997 | 0.29130 |
| **Leinster Aqueduct** | Waterways Ireland | 133,182 | Repair Sluice Gate / implement automatic level control and flow measurement with smart controllers / Replace Pump 1 with new Xylem Pump and VSD / Investigate and solve pump 2 reduced efficiency (suggest swap with Pump 1 when replaced) | -10 | -13,318 | -4,834 | -11.8 | -15,715 | -5,705 | 0.363 |
| **Locks 16,17,18 Grand Canal** | | 201,348 | Recondition Lock 16 and 18 pumps / implement automatic level control and flow measurement using smart controllers / Install VSDs at Lock 16 and 18 | -14.25 | -28,692 | -10,415 | -16.2 | -32,625 | -11,843 | 0.363 |
| **Shannon Harbour** | | 286,748 | Install new wet well and pipework and Xylem NP3171 pumps at Lock 36 / Install new control panels, automatic level control and flow measurement using smart controllers. | -70.3 | -201,563 | -73,167 | -40.6 | -116,350 | -42,235 | 0.363 |
| **Richmond Harbour** | | 78,554 | Install KSB PNW A4 300 pump / Install new control panels, automatic level control and flow measurement using smart controllers. | -9.0 | -8,045 | -2,920 | -23.5 | -18,460 | -6,701 | 0.363 |
| **Drumleague** | | 49,016 | No action | -73.0 | -35,806 | | - | - | - | |
| **Drumshanbo** | | 49,891 | Install new Xylem NP3171 MT181 pump and reconfigure pipework for 2 pumps (duty/standby) / Install new control panels, automatic level control and flow measurement using smart controller. | -28.5 | -14,227 | -5,164 | -22 | -10,976 | -3,984 | 0.363 |
| **Crissey PS** | Voies Navigables de France | 199,500** | Install new Xylem CT3400/736 pumps | -17.0 | -33,915 | -2,272 | -36.8 | -73,500 | -4,925 | 0.067 |
| **Briâre PS** | | 1,011,636 | No action | -1.2 | -11,629 | | - | - | - | 0.067 |
| **Stock PS** | | 493,000** | Proposed pump replacement as VNF/Arcadis assessment | -30 | -147,900 | -9,909 | -30 | -147,900 | -9,909 | 0.067 |
| **W6, W7, W8, W9, W13 combined** | VLM | 177,105 | Pump replacement | - | - | - | -6.7 | -11,931 | -1,837 | 0.154 |
| | **TOTAL** | **5,136,486** | | **-** | **-980,265** | **-250,069** | **-** | **-814,818** | **-199,977** | **-** |

**Emission factors based on 2021 values*
*EU: https://www.eea.europa.eu/data-and-maps/daviz/co2-emission-intensity-12/download.csv*
*UK: Updated UK Government (BEIS) greenhouse gas conversion factors database 2022 | CSH Networks (sustainablehealthcare.org.uk)*
*** Updated 2020 volume*

*Table no. 23: Trial Site Energy and Carbon Assessment Summary*

# 8 Phase 2 Conclusions

Implementation of the scope of works based on the recommendations from Phase 1 is estimated to reduce emissions by approximately 200 tonnes $CO_2$ equivalent ($CO_2e$) per annum based on 2021 emission factors. This comfortably exceeds the original target of 65 tonnes equivalent per annum.

By partner, the key actions undertaken at the trial sites are summarised as:

**Canal and River Trust**

- Reducing specific energy and increasing pump efficiency at Caen Hill PS by changing to single pump operation (duty / standby).
- Changing pumps to operate near best efficiency and upsizing local pipework at Calcutt PS
- Changing to more efficient pumps at Tinsley PS

**Waterways Ireland**

- Introducing automation by means of flow and level monitoring with smart controllers at all trial sites to allow remote monitoring and optimizing pump use.
- Upsizing local pipework and replacing pumps at Shannon Harbour Lock 36.
- Introducing VSDs to explore and optimise pumped flow rates.

**Voies Navigables de France**

- Replacing pumps based on duty and energy requirements and upgrading automation at Crissey PS and Stock PS.

**VLM**

- Replacing existing pumps with more modern and efficient pumps.

Due to limited potential improvements at Seend PS and Briâre PS which would have a long payback period, no action was taken for Phase 2 of the project.

Following the implementation of the improvements is completed it is recommended for the partners to continue monitoring the performance of the trial assets and audit other pumping station assets for potential improvement in energy consumption and $CO_2e$ emissions.

## Appendix A – LRM Pumping Station Assessment Summary for VLM

| LRM pumping stations in VLM project region | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | W 6 | | W 7 | | W 8 | | W 9 | | W 13 | |
| **Parameters** | **Existing Pumps** | **Proposed Pumps** | **Existing Pumps** | **Proposed Pumps** | **Existing Pumps** | **Proposed Pumps** | **Existing Pumps** | **Proposed Pumps** | **Existing Pumps** | **Proposed Pumps** |
| **Pumps & Motors Model** | Melotte – no further specification available | **Xylem -LOWARA Z612 01-4OS M; 0.55kW** | P1: Flygt CP3127-180, 5,9 kW, cast iron impeller, P2: Flygt CP3152-181, 13,5 kW | **P1: FLYGT Concertor N150-4900, 5.5 kW P2: Flygt NP 3153 LT 3~ 411, 13.5kW (200mm)** | P1 + P2: Flygt CP3127-180MT, 5,9 kW, cast iron impeller | **P1 + P2: FLYGT Concertor N150-4900, 5.5 kW** | Melotte 2C 71ZZ, 2,2 kW, bronze impeller | **Grundfos SPE 30-2; 2.2kW, 2,2 kW, bronze impeller** | Melotte 2F 239, 11 kW, bronze impeller | **LOWARA Z895 02/2A-L6W - 13kW** |
| **No. & Configuration** | 1 - (Duty / Standby) | 1 - (Duty / Standby) | 2 - Duty / Standby | **2 - Duty / Standby** | 2 – Duty / Standby | **2 – Duty / Standby** | 1 - (Duty / Standby) | 1 - (Duty / Standby) | 1 - (Duty / Standby) | 1 - (Duty / Standby) |
| **Drives** | Fixed | Fixed | Fixed | Fixed | Fixed | Variable Speed Control | Fixed | Fixed | Fixed | Fixed |
| **Estimated Duty Flow Rate (m³/h)** | 10 | **10.26** | 219.6 | **251.5** | 219.6 | **234.0** | 23.4 | **28.6** | 73.8 | **77.76** |
| | | | 320.4 | **392.8** | | | | | | |
| **Estimated Duty Head (m)** | 9.9 | **10.02** | 5.0 | **5.6** | 4.8 | **5.01** | 15.30 | **15.50** | 32.00 | **32.50** |
| | | | 7.2 | **7.7** | | | | | | |
| **Estimated Overall Efficiency** | 34.1% | **53.8%** | 51.9% | **62.7%** | 51.9% | **63.1%** | 52.5% | **54.0%** | 58.5% | **61.2%** |
| | | | 43.5% | **67.9%** | | | | | | |
| **Est. Specific Energy (kWh/m³)** | 0.0804 | **0.0804** | 0.0260 | **0.0243** | 0.0252 | **0.0216** | 0.0794 | **0.0782** | 0.1490 | **0.1447** |
| | | | 0.0392 | **0.0308** | | | | | | |
| **Pumped volume in 2019 (m³)** | 45,540 | **45,540** | 777,123 | 777,123 | 1,376,665 | 1,376,665 | 205,968 | 205,968 | 651,225 | 651,225 |
| **Annual Energy Consumption (kWh)** | 3,662 | **3,662** | 25,346 | **21,401** | 34,695 | **29,785** | 16,363 | **16,110** | 97,038 | **94,216** |
| **Annual Difference In Energy Consumption with proposed pumps (kW-hr)** | | **0** | | **-3,945** | | **-4,910** | | **-253** | | **-2,823** |
| **Annual Saving (%)** | | **0.00%** | | **15.57%** | | **14.15%** | | **1.55%** | | **2.91%** |
| **Emissions (gCO2) @ Emission Factor (154 gCO2/kWh)** | 563,924 | 563,924 | 3,903,257 | 3,295,683 | 5,343,052 | 4,586,949 | 2,519,962 | 2,480,989 | 14,943,900 | 14,509,211 |

| | Existing Pumps | Proposed Pumps | % Saving |
|---|---|---|---|
| **Emission Factor (154 gCO2/kWh)** | **27,274,093** | **25,436,756** | 6.7 |

*Table 24 – LRM Pumping Station Assessment Summary for VLM*

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