



The Application
Of
Fish Friendly
Pumps

For
The Land Drainage
Pump Stations



- Passionate about Pumps



A Discussion Document on the Application of **FISH FRIENDLY PUMPS**

For Land Drainage Pump Stations

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SYNOPSIS

The purpose of this document is to promote discussion on the subject of Fish Friendly pumps and their application for land drainage pump stations.

The document advises that simply installing a fish friendly pump in lieu of an axial-flow pump into an existing installation will not deliver the low fish mortality rates that are required from the investment. The reason being there are numerous components and design features in a traditional land drainage pumping installation that is a cause of fish damage.

To achieve low/minimal fish damage a fish friendly pumping system is required.

The paper also proposes an alternative approach to replacing large axial-flow pumps with even larger fish friendly pumps. This alternative involves installing some means of diverting the fish away from the main lift pump to an area where a small but well proven fish transfer pump is installed to transfer the fish and eels to the down stream water course.



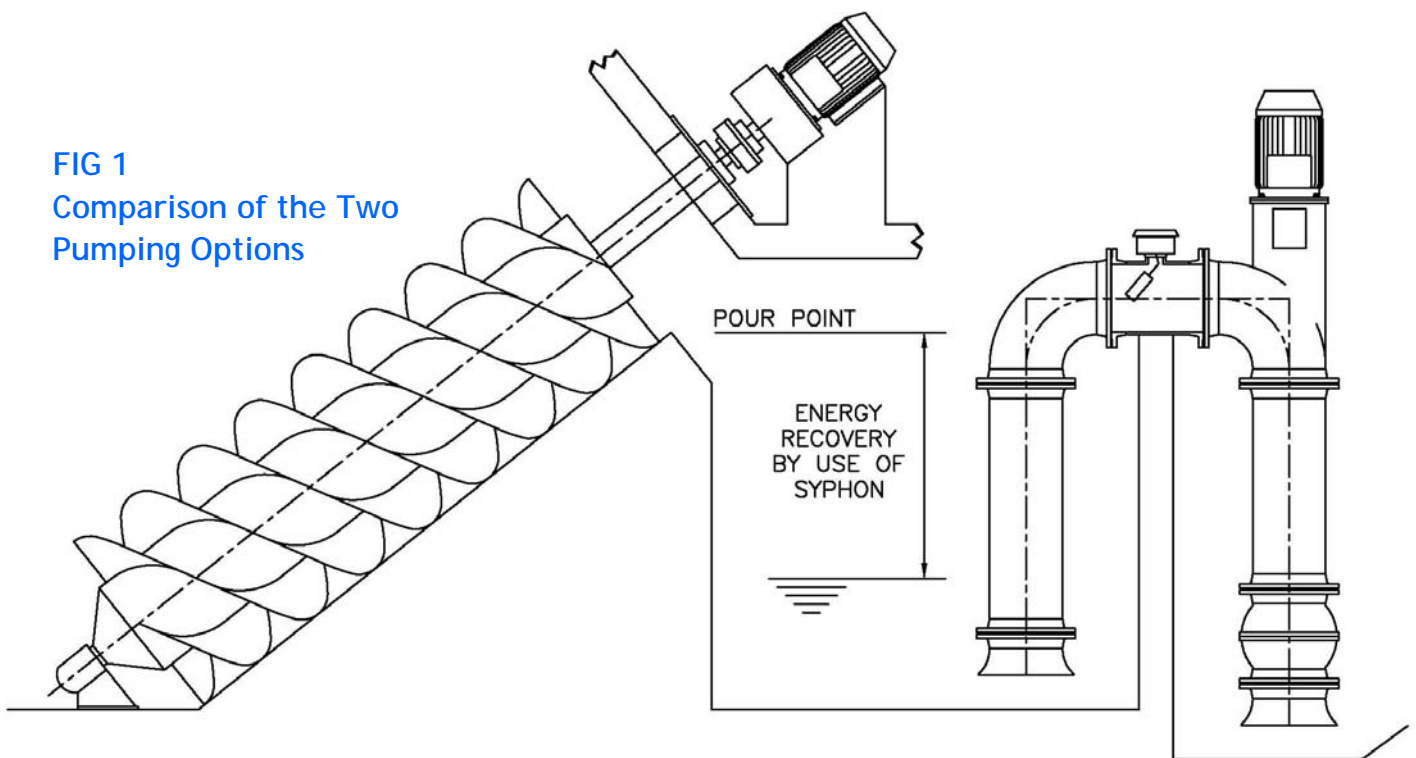
INTRODUCTION

Land Drainage pump stations are typically low lift and require pumps to lift the water over a range of heads from say 0.5m to 6.0m. The types of pumps which fulfil these requirements are either Archimedean screw pumps or axial-flow pumps. In the UK the axial-flow is the preferred choice where as in other countries the Archimedean screw pump is the norm.

In many of the UK land drainage pump stations the discharge side is tidal or is influenced by tidal conditions further downstream as a result there is a large variation in head. If Archimedean screw pumps were employed the station would have to be designed so that the discharge or “pour point” was always above the max discharge water level irrespective of the downstream water level. This would result in excessive amounts of energy being wasted every time the pump station operated, except for the most extreme design case which may never occur in the life of the pump station.

The problem of excessive energy consumption of the Archimedean screw pump is solved by using vertically suspended axial flow pumps operating with a siphon incorporated into the discharge pipework. The invert of the siphon being placed at the same level as the “pour point” of an Archimedean screw pump. This being the level required to prevent back flow under the most extreme conditions.

FIG 1
Comparison of the Two
Pumping Options



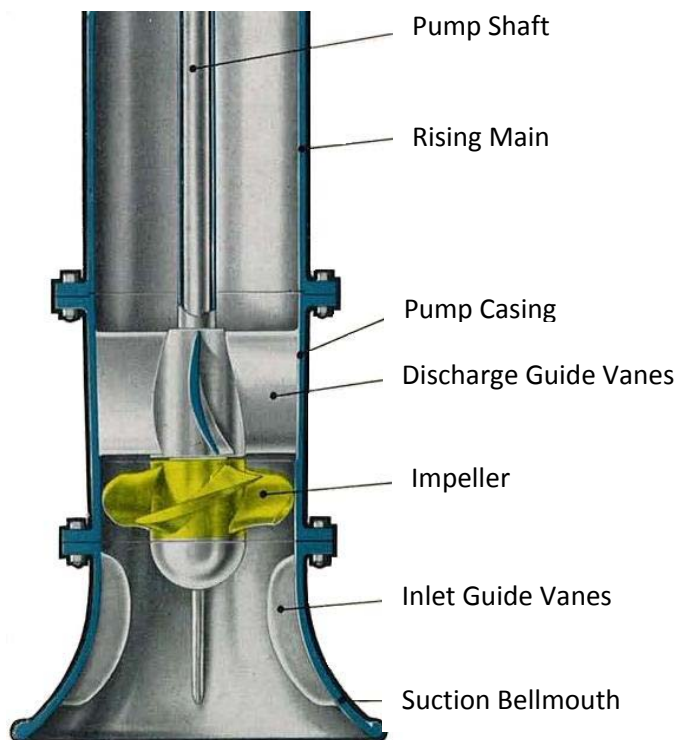
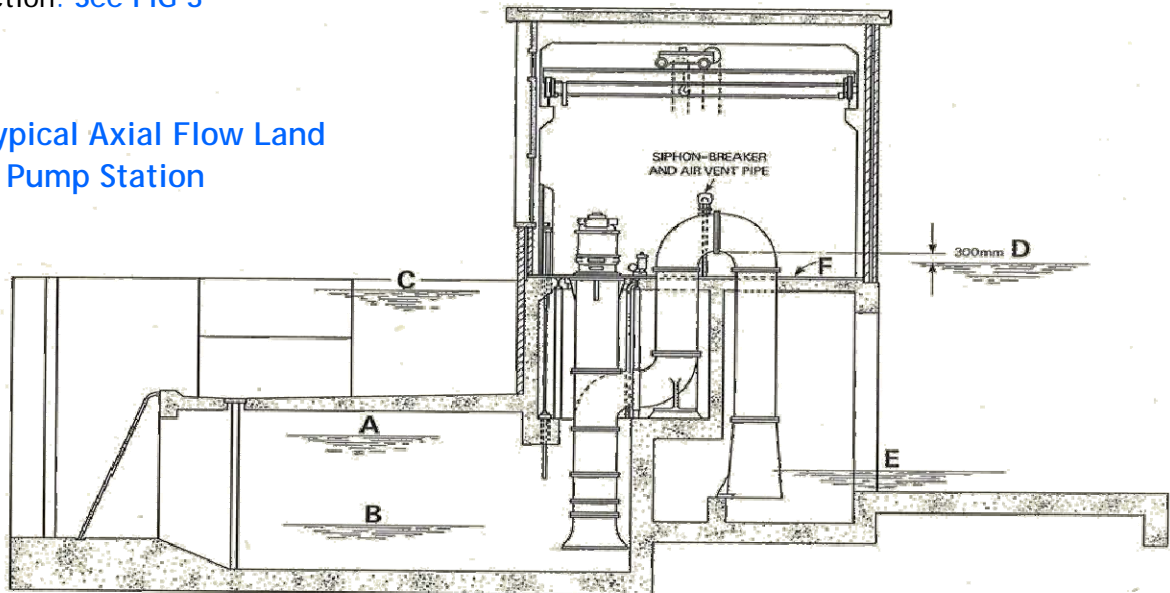
The use of a siphon recovers energy as the water flows down the discharge side of the siphon so the axial flow pump only has to pump against the difference in water levels on each side of the pump station plus the friction losses in the pipe work, thus minimising energy consumption.



AXIAL FLOW PUMPS FOR LAND DRAINAGE

An axial-flow pump is simple in construction and relatively easy to install and does provide the most cost effective solution for land drainage applications. The draw back as regards fish friendliness is its construction which consists of an impeller which will have 3 or 4 blades which sits in front of the diffuser or guide-vane casing which will have between 5 and 7 guide-vanes which turn the flow into an axial direction. See FIG 3

FIG 2 Typical Axial Flow Land Drainage Pump Station



A	Lowest start water level
B	Lowest stop water level
C	Suction flood water level
D	Discharge high water level
E	Discharge low water level
F	Motor floor level

FIG 3 Typical Axial-Flow Pump Construction

SUBMERSIBLE AXIAL FLOW

The Modern Approach to Land Drainage

The development of submersible electric motors has lead to submersible axial flow pumps becoming an economic alternative to the traditional axial flow land drainage pump. The compact nature of the submersible axial flow pump means all of the important mechanical and electrical parts are contained in a single unit which can be easily installed and withdrawn from the steel tube which acts as the pump support and discharge pipe. See FIG 4 for typical arrangement.

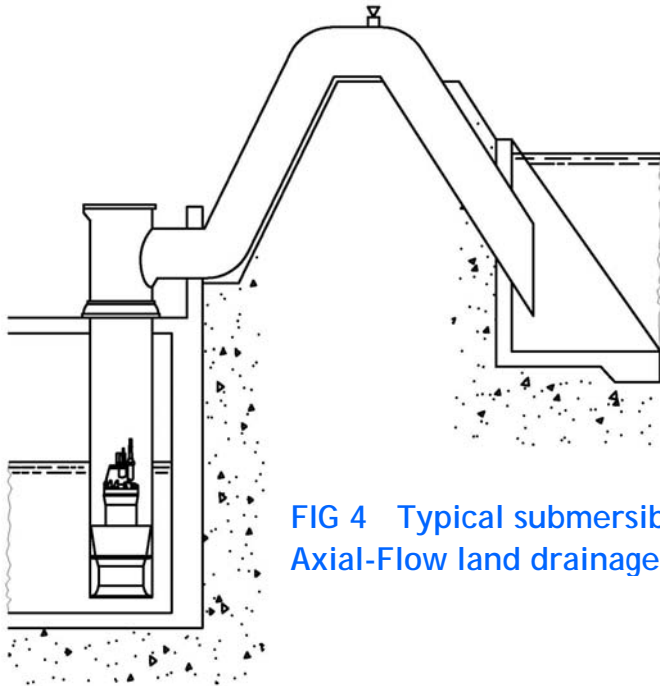


FIG 4 Typical submersible Axial-Flow land drainage

If the pump is to work in combination with a siphon or a discharge line, a pressure-tight discharge elbow must be used. The elbow shown here permits both fast installation and easy retrieval of the pumps.



FIG 5a View into Suction showing Axial Flow Impeller



FIG 5b View into Guide Vane Casing showing the Guide Vanes behind the Impeller

Such a construction can easily become blocked with weed and other debris and has to be protected by screens which require to be raked on a regular basis.

Most important of all it offers any fish or eels swept into the pump no prospect of a safe passage. The only certainty is "guaranteed death or serious injury".



FISH FRIENDLY PUMPS

DEFINITION

A fish friendly pump is a pump which is designed to pump clean water but have the capability to pass live fish and eels without them incurring any external or internal damage or loss of scale.

When the fish are discharged into open water they should display their normal behaviour and quickly swim away. They should not be stunned or appear to be lethargic or distressed in any way. Survival rates after 24 hours should be in the region of 99% to 100%.

CONSTRUCTION

A typical Hidrostat fish friendly pump is shown in FIG 6. The volute type construction with a closed screw-centrifugal or spiral vane impeller offers the ultimate performance in gentle handling, guaranteeing virtually 100% fish survival. To obtain this high level of survivability the pump has to be correctly applied to ensure the pump is operating close to its best efficiency point. The impeller has a single spiral vane offering large free passages which gives the possibility of handling large quantities of weed and other debris

This type of pump construction offers plenty of scope as to the type of installation that will be employed. The pumps are available as submersible units or as dry installed end suction for horizontal or vertical mounting fitted with high efficiency TEFV motors. If there is a prospect of the dry well becoming flooded an immersible motor can be supplied offering continuous operation in a dry or flooded installation.

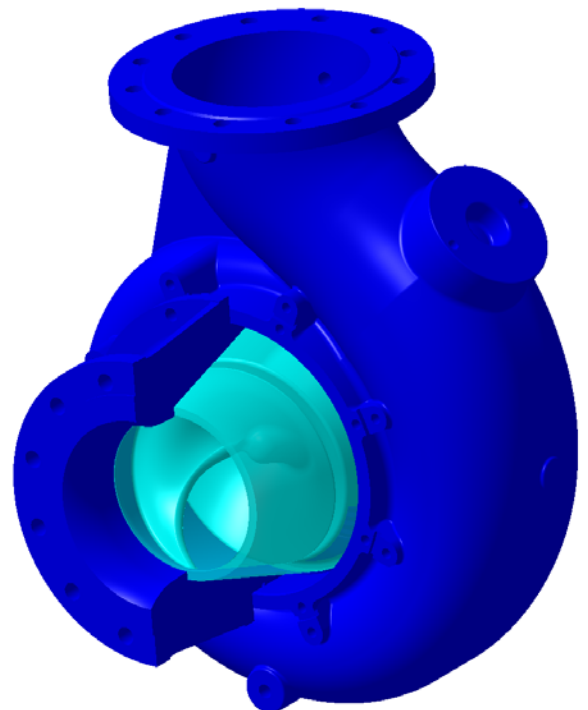


FIG 6 Typical Fish Friendly pump



TYPICAL FISH FRIENDLY PUMPS



FIG 7a 36" (900mm) Fish Friendly pump installed at Red Bluff, California
Duty 2850 l/s @ 7m



FIG 7b 2 off L12V pumps installed at EL Smith WTP, Saskatchewan River, Canada



FIG 7c 3 off L20V-HD pumps installed at Sask Water Corporation, Buffalo Pound Lake, Canada



FISH TRANSFER PUMPS

We would like to point out that Hidrostal have another family of pumps that we would like to define as Fish Transfer Pumps.

Hidrostal's first patent for what we now refer to as a fish friendly or fish transfer pump was granted to Mr Martin Stahle (the founder of the company) in 1960. Since that time many variants of the original design have been produced for specific applications.

The early designs were to transfer large volumes of dead fish without damage as they were to be canned for human consumption and involved pumping from the hold of the fishing boat to the quayside or direct to the processing plant.

Since those early days the designs have been refined and applied to transferring large quantities of live fish on fish farms, and in more recent times, returning fish that have congregated at the inlet screens on the water intake to large power plants back to the safety of the river, as well as harvesting shrimps and prawns from lagoons.

DEFINITION

A fish transfer pump is designed to pump live fish in such a manner that it ensures very high long term survivability ie in the region of 99.5% or better.

CONSTRUCTION

A typical example of this revolutionary range of pumps is shown in [FIG 8](#).

These pumps are selected for each application according to the largest dimensions of fish to be pumped. The volume of water pumped is purely a consequence of that design.

Our range of high performance "F-Type" fish transfer pumps range from 100mm to 250mm branch diameter and will successfully handle fish from 50 grams to salmon up to 4.5kg and 700mm in length. Like the fish friendly pumps described above these units are available in a submersible or end suction configuration permitting wet or dry installations to be used

We will refer again in this document as to how these relatively small pumps might be applied to land drainage applications.



FIG 8 Sectional view of Typical Fish Transfer pump

FISH FRIENDLY PUMP STATIONS

A Fish friendly pump station consists of more than installing a fish friendly pump. Simply replacing an axial-flow pump with a fish friendly pump will no doubt reduce the fish kill, but it will fall well short of the ultimate aim of virtually 100% survivability. To achieve the desired aim a fish friendly pumping system is required.

The easiest way to describe a [fish friendly pumping system](#) is to describe what is “unfriendly” in a typical land drainage pump station.

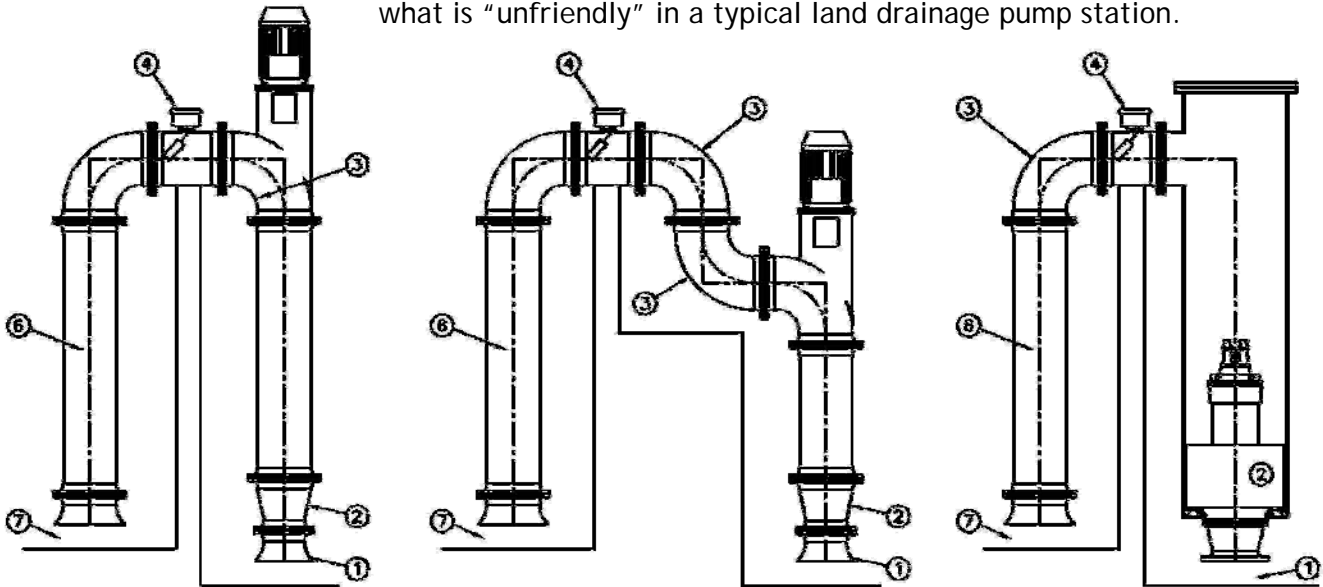


FIG 9 Fish unfriendly features of Typical Axial-Flow pump stations

1. Tight turn with high velocities into pump suction. A fish friendly pump requires a suction with low velocities and a gentle turn from the radial to axial direction so fish are lined up with the flow on entry to the impeller.
2. Axial-flow pumps definitely not fish friendly. Guarantees fish death or serious injury.
3. All 90 degree bends must be long radius, not short radius as is the norm.
4. The paddle on the siphon breaking valve is a potential cause of fish impact damage.
5. [The effect of subjecting the fish to a partial vacuum as they pass through the syphon needs to be examined.](#) This subject needs to be considered to determine if there is a limit to a partial vacuum to avoid internal fish damage and a decision taken if siphons can be used in this application. [A matter for the Environmental Agency or other scientific organisation.](#)
6. The velocities in the pipework should be limited to less than 2.0m/sec when the pump is operating at max capacity ie when pumping against the minimum static head. This limit may cause problems in priming the siphon which requires a velocity of circa 1.9m/sec.
7. The exit of the discharge pipe at high velocity onto a concrete slab in close proximity to the end of the pipe cannot be fish friendly. Some work needs to be done in this aspect of pump station construction to arrive at an acceptable design that prevents fish damage.



IF A PARTIAL VACUUM CAUSES FISH DAMAGE

If it is subsequently determined a partial vacuum is an issue the following solutions will have to be considered.

- Discharge directly through the water retaining structure and employ a means of preventing back flow, ie flap valves on the pipe exit, non-return valves in the pipe system. Both options would require to be backed up by a secure means of isolation. The question then arises do these devices themselves cause fish damage.
- Eliminate the siphon and pump to the high point, ie the invert of the siphon, and let the flow gravitate into the discharge channel. Clearly this is at odds with the “Green Environment” which is to save energy as it will increase running costs as there will be no energy recovery in the siphon.
- An alternative would be to keep the fish away from the axial-flow drainage pump by some means, ie a system that scares the fish away or attracts them to a safe location. If it is not necessary for the fish to be transferred that would be the solution. On the other hand if the fish are migrating and have to be transferred a system that directs them to a safe location could be used and a smaller fish transfer pump, previously described, could be installed in this location.

FISH TRANSFER SYSTEM FOR LAND DRAINAGE PUMP STATIONS

Fish transfer pumps have been in use for many years in fish farming and aqua culture. They have an excellent track record in damage free handling. Typical examples are trout and salmon farms where a fish may have been pumped up to six times before it is presented on a dinner plate in a restaurant. It is not unusual to pump thousands of smolts per hour through a single pump with no fish mortality and only minimal scale on the surface of the receiving tank or raceway. See typical examples below:



FIG 10a 3 off FO5F Fish handling pumps supplied to Marine Harvest in Scotland



FIG 10b Hidrostat Fish Pump in use on a Hatchery Raising Smolts in Scotland

FIG 10c H06F Pumping at Exmoor Trout Farm - Feeding a fish grader



NOTE: Having previously raised the issue of the potential for internal damage to a fish passing through a siphon, operating with several metres of vacuum.

Most of the fish farming applications subject the fish to circa 1.0m of vacuum on the suction side of the pump when lifting from below ground tanks/raceways, without incurring any harmful effects. See [FIG 10c](#)



Therefore there are three situations when a fish transfer system could be used on land drainage pump stations. Each case would require a means to divert the fish away from the main lift pumps to the fish transfer pumps.

1. It is required to make an existing non-fish friendly pump station - fish friendly without having to replace the existing pumps.
2. Fish friendly land drainage pumps are too expensive.
3. It is concluded that fish damage could occur whilst passing through a siphon on the discharge of the main lift pumps (axial flow).

Depending on the size and species of fish/eels to be transferred the pump would typically have a 150 mm or 200 mm diameter discharge, and pass flow in the range of 50-100 l/s. The motor power, being in the region of 5.5 Kw to 11.0 Kw.

A fish transfer pump can be mounted in a variety of ways to suit each situation.

INSTALLATION OPTIONS FOR FISH TRANSFER PUMPS

Wet Pit Version

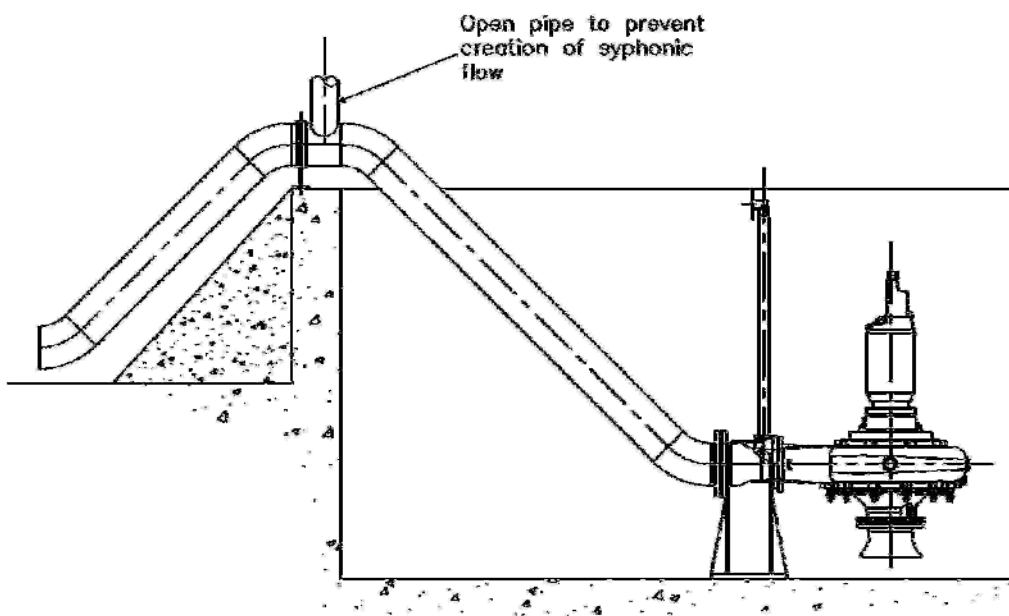


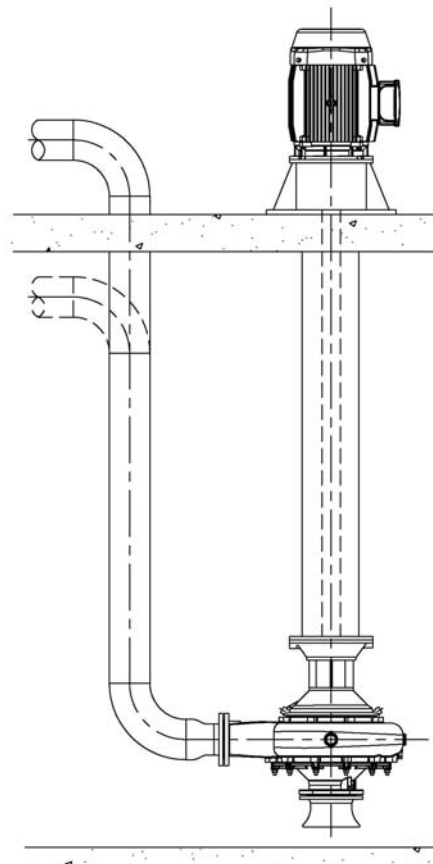
FIG 11a Guide rail mounted with submersible motor.

NOTE: If the water level whilst the pump is in operation is below the top of the submersible motor, we would recommend an immersible motor is fitted. Permitting pump operation whilst the motor is exposed.



Wet Pit Version

FIG 11b Vertically suspended sump type with high efficiency TEFV motor.



Dry Pit Version

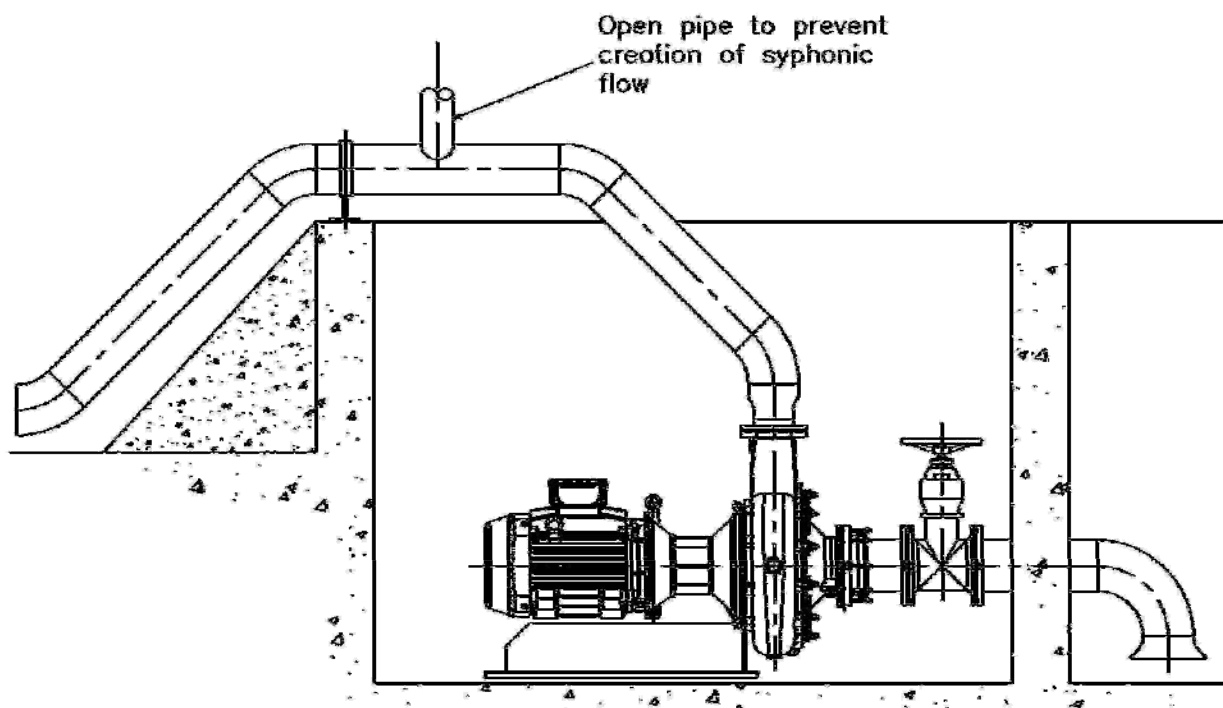


FIG 11c Horizontal end suction pump with high efficiency TEFV motor

Dry Pit Version

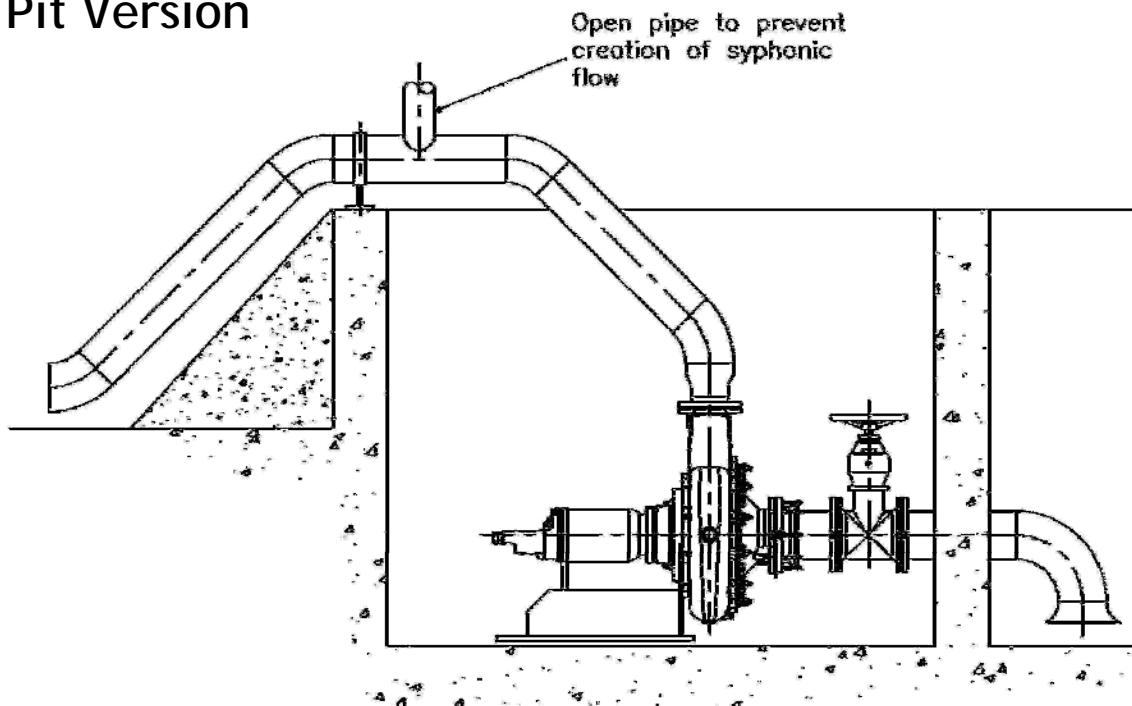


FIG 11d If there is a risk of flooding, a pump with an immersible motor could be fitted which would run continuously whilst flooded

Since the energy consumption is low for a fish transfer system we would propose a simple system having long radius bends and discharge at the same level as the invert of the siphon, but without a siphon and allow gravity flow into the discharge channel.

If an effective and economic system of fish diversion were available this system could be used on any existing land drainage pump station thus making it fish friendly without having to replace the pumps. An attractive option when funds are in short supply.

SUPPLY OF FISH FRIENDLY PUMPING INSTALLATIONS

Hidrostat can design, supply, install and commission either a Fish Friendly pump station or a small fish transfer pump station. For further information or to arrange a visit from one of our engineers to discuss a specific application, please send your enquiry to sales@hidrostat.co.uk.



FISH DIVERSION DEVICES

This paper has not commented on the specific details of fish diversion devices. They seem to be an accepted technology, particularly in the USA and would need further investigation as to cost and effectiveness.

It is the intention of the author that the solution would either 'scare' the fish away from the axial-flow lift pumps or attract them to the area where small fish transfer pumps were installed. It is not the intention to install physical barriers/screens that would quickly become blocked with weed and other debris.

Hidrostal Ltd are available to advise and discuss fish and eel friendly pumping systems. We also offer full supply, design, install and commissioning services for any fish or eel friendly pumping systems.

Comments and suggestions on the subject of this paper would be welcomed and should be sent to:

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