Drainage
FACTSHEET

BRITISH COLUMBIA
Ministry of Agriculture and Food

Order No. 534.100-1
June 1998

FARM DRAINAGE PUMPS

INTRODUCTION

On-farm drainage pumps are usually required for one of two reasons:

- The regional drainage system provided by the local authority may not provide an adequate gravity outlet for the proposed system.
- In certain cases, a small pump outlet may be more economical than installing a lengthy subsurface drainage pipe or deepening or extending an outlet ditch.

The pump station must be designed to pump enough water to meet the drainage requirements against the maximum total head (elevation and friction) expected. The efficient operation of the pump should also be considered.

There are five items that must be considered when designing a drainage pump station:

1. **Pump location**
2. **Pump capacity**
3. **Total dynamic head calculation**
4. **Pump type and power unit**
5. **Water storage to limit pump cycling**

PUMP LOCATION

The main considerations for the location of a pump station are the proximity to the outlet and the location of electric power. If possible, a pump should be located directly adjacent to the outlet. This limits the pumping distance and the size of the pump. However, in some cases, it may be advantageous to locate the pump closer to the electrical power supply. Other considerations are length of collection system, vandalism, year round accessibility and soil stability.

The cost of pumping is related to discharge volume, total dynamic head, pump efficiency and operating time. Consequently, surface runoff from higher ground should be diverted away from the pumped area by surface ditches to a suitable gravity outlet. Diversion ditches or dikes can be used to intercept water from the upland area and bypass the pump by carrying it directly to the outlet. This can greatly reduce the volume of water to be pumped and thereby reduce the installation and operating costs of the pump station.

PUMP CAPACITY

Surface Systems

For surface drainage, the pump capacity is based on the drainage requirement and runoff rate. Factors affecting the drainage requirement include climate, topography, soil, land use and types of crops. It can be estimated by using local knowledge, or through more detailed hydrologic investigations. For small farms (under 50 ha), pumping station capacities can be based on local experience and more detailed investigations are not justified. The pump capacities shown in **Table 2** are based on experience.

Table 1	Pump Capacity for Surface Drainage
Region	**Pump Capacity L/s per Hectare**
Vancouver Island and Gulf Islands	3.0
Lower Fraser Valley	3.0
North Side of Fraser Valley	4.0
Upper Fraser Valley (Agassiz)	4.5
Pemberton	6.0
Kootenays	2.5
Okanagan	2.0
Cariboo	3.0
Peace River	3.5

Subsurface Drains

For subsurface drainage, the pump capacity is based on the drainage rate (drainage coefficient) wanted. If surface inlets are connected to the subsurface drainage system, the additional volume should be added to the capacity. This volume should be increased by 10% when determining pump capacity to allow for variability in the performance of the system.

Table 1 can be used to estimate pumping rates for subsurface drainage systems based on drainage coefficients.

Table 2	Pumping Rates for Different Drainage Coefficients	
Drainage Coefficient mm/day	**L/s per hectare**	**m3/day per hectare**
5	0.579	50
10	1.157	100
15	1.736	150
20	2.315	200
25	2.893	250
30	3.472	300

TOTAL DYNAMIC HEAD

Drainage pumps usually raise water from a lower elevation to a higher elevation. This vertical distance is often called lift or static head. The pump also has to compensate for friction losses in the inlet and outlet pipes as well as the loss of kinetic energy when the water discharges from the outlet. The total dynamic head (or total energy head), H_T, is the sum of these three factors. Hence total dynamic head can be expressed as:

Equation 1:

Where $H_T = H_S + H_F + H_V$

H_T = Total dynamic head, m
H_S = Static Head, m
H_F = Friction Head, m
H_V = Velocity Head, m

Static Head

Static head (H_S) is the vertical distance between the free water surfaces at the suction and discharge sides of the pump, in meters. For a subsurface drainage system, the water level in the sump should not be higher than the invert elevation of the lowest drain outlet. The discharge elevation of the pump depends upon the physical characteristics of the outlet.

Friction Head

Friction head (H_F) represents the friction losses between the entrance and discharge ends of the pump installation. Since most internal friction losses inside a pump are accounted for in the pump specifications, only the friction loss encountered by the inlet and discharge pipes must be accounted for. This head loss can be very significant if, for example, the pump must be located some distance from the final outlet. Pipe friction losses vary depending on the flow velocity, the pipe diameter and the type of pipe. H_F can be obtained from a variety of charts or tables, which are available from the pump or pipe suppliers.

Velocity Head

Velocity head (H_V) is the kinetic energy released when water is discharged at the end of the outlet, hence, it is proportional to flow and cross sectional area of the outlet pipe. Velocity head can be calculated using the following equation:

Equation 2:

$$\text{where } H_V = 82550 \frac{Q^2}{D^4}$$

Q = Pump capacity, L/s
D = Discharge pipe diameter, mm

PUMP TYPE AND POWER UNIT

Most farmland drainage pumping systems require low total dynamic head and high volume. Axial flow or propeller pumps are especially well suited for these parameters. In situations where head requirements are greater than 3 m, a radial or mixed flow pump may be more suitable. When the pump only services a subsurface drainage system, an off the shelf submersible pump will often be suitable. In this case, the pump specifications should match the pumping capacity and total dynamic head. Your local pump supplier can be a good source of information for determining pump type.

Some axial flow pumps are sold without the power unit. Once the pumping capacity and total dynamic head have been determined, the power requirements can be estimated by the following equation:

Equation 3:

$$\text{where } P = \frac{9.8QH_T}{E_P}$$

P = Power requirement, kW
Q = Pump capacity, m^3/s
H_T = Total dynamic head, m
E_p = Total pump efficiency as a decimal fraction

Efficiency

Pumping efficiency generally range from as low as 20% to as high as 75%. A well-designed pump should have a total efficiency of 70% or more. Unfortunately, many commercially available small on-farm drainage pumps have a much lower efficiency.

Power Source

The most convenient power units for pumping are electric motors. Single-phase motors are practical up to about 7.5 kW. Larger motors will normally require three-phase power. Electric motors are usually direct drive. Electric motors are well suited to automatic pumping operations. Automatic operation is usually obtained using float switches controlling a magnetic starter on the pump motor. Internal combustion engines are not recommended except for emergency or auxiliary pumps, or where electrical power cannot be provided at reasonable cost.

WATER STORAGE TO LIMIT PUMP CYCLING

To prevent the motor from starting and stopping too frequently, water storage must be provided between the start and stop pumping elevations. For small pumps, this storage can be built into the pump sump. For larger systems or for manual pump operation, a large open sump or ditch may be required. The volume of required storage depends upon the pumping rate and the maximum acceptable rate of cycling of the pump. For automatic electric pump operation, cycles of operation should be limited to about 10 per hour. Some of the newer pumps on the market have hardier starter mechanisms and can tolerate up to 30 cycles per hour. Always check the pump specifications with your supplier. For manual operation and especially with combustion engine driven pumps, limit cycling to two starts per day (n = 0.08).

Pump Selection and Setup

Once the pumping requirements are calculated, a pump station can be designed. The pump station will depend on the pump type, storage volume requirement and proximity to the outlet. Usually for drainage, axial flow pumps are most effective. The two most common types of axial flow pumps are submersible and propeller

Propeller pumps have overhead motors connected with vertical shafts to the pump propellers. For small capacity systems, small submersible sewage rated pumps are easy to install.

The pump selection should be done in consultation with a pump vendor. The information required is total dynamic head and flow rate required. In turn, the vendor should give you information on power requirement, pump efficiency and maximum number of cycles per hour.

Equation 4:

$$\text{Where} \quad S = \frac{900\,Q}{n}$$

S = Storage volume, m^3
Q = Pump capacity, m^3/s
N = Maximum number of cycles per hr.

Submersible pumps typically require no pump house as the pump sits directly in the sump pit. **Figure 1** shows a typical submersible pump sump. Pre-fabricated concrete rings, corrugated steel or polyethylene are suitable materials for the sump construction. A minimum diameter of 1.1 m is suggested. If corrugated steel or polyethylene is used, a concrete ballast should be added to the floor to prevent uplift. Storage volume should not be gained by extra depth of the manhole beyond 2 m in depth. Extra volume can be provided by increasing the diameter of the sump or by using a vertical pipe as it is shown in **Figure 1**.

Propeller pumps (axial and mixed flow) with overhead vertical shaft connected electrical motors are available as well. These heavy pumps are well suited for higher discharge rates. A pump house is normally required to protect the motor and controls. **Figure 2** shows a typical axial flow pump house. Storage can be provided with a buried sump of suitable dimensions or with an open ditch. Where open ditches are used to collect and transfer water to the pump, a trash rack must be used to prevent entry of floating debris into the sump where damage to the pump might occur.

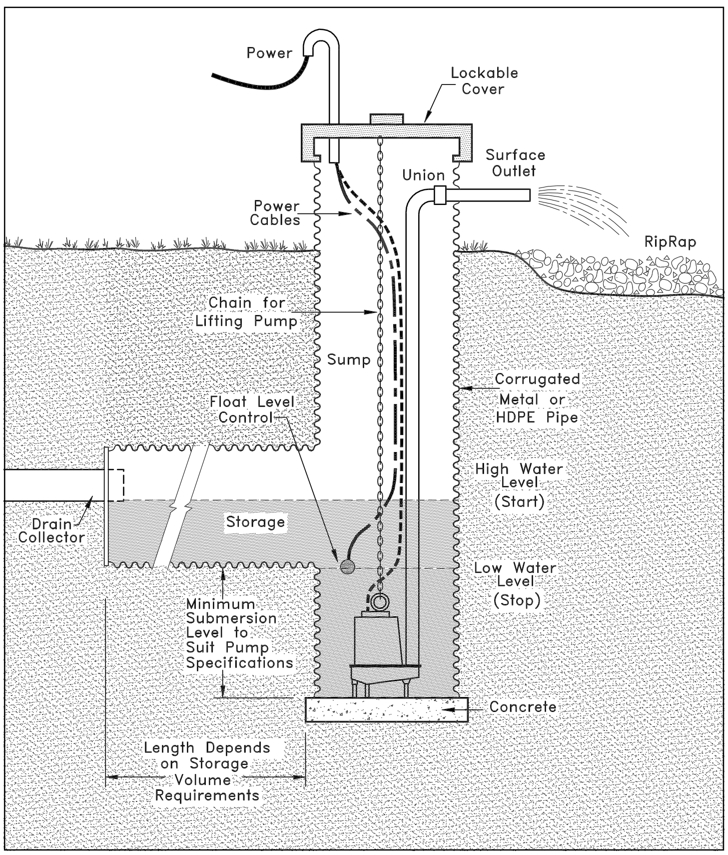

Figure 1 Submersible Drainage Pump and Sump

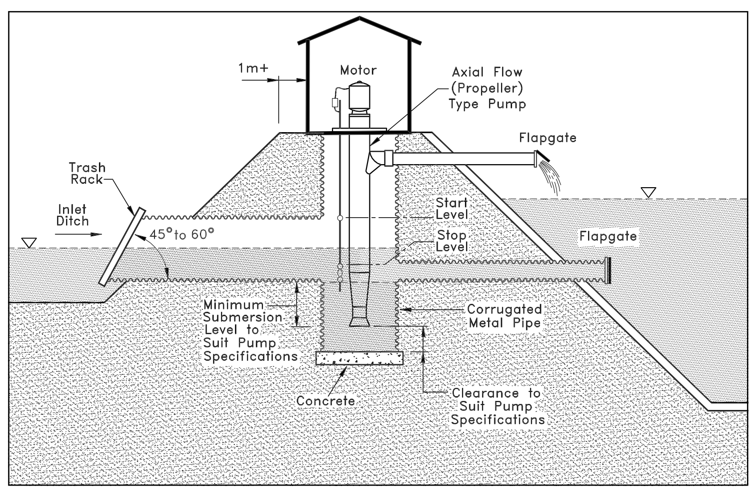

Figure 2 Propeller-type Drainage – Open Ditch Inlet

FOR FURTHER INFORMATION CONTACT
Janine Nyvall, Water Management Engineer
Phone: (604) 556-3113
Email: Janine.Nyvall@gems5.gov.bc.ca

RESOURCE MANAGEMENT BRANCH
Ministry of Agriculture and Food
1767 Angus Campbell Road
Abbotsford, BC CANADA V3G 2M3