

# Use of jet pump in vertical drainage systems

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**Abstract.** Usually, vertical drains are widely used to improve land reclamation and construction of urban planning, transport and road construction, and agriculture. Vertical drainage systems are drainage systems that use pumped wells, open dug wells, or tube wells. There are calculation methods based on pumping curves and calculation methods based on the filtration equation of hydraulic calculation of vertical drainage. In the proposed system, jet apparatus is used in vertical drainage systems. Jet pumps are designed in such a way that they transfer the impulse through the high-speed primary to the secondary flow. Jet devices are widely used in agriculture, mining, oil extraction, and various industries. In addition, they can be used as an independent units or together with pump units.

## 1 Introduction

Usually, vertical drains are widely used to improve land reclamation and construction of urban development, transport and road construction, and other fields. They sharply lower the level of groundwater, regulate the regime of groundwater, take groundwater for irrigation and water supply, and prevent secondary salinization and waterlogging, as well as intended to create water-salt and air temperature regimes of the soil.[9,6]

Underground drainage for water level and soil salinity in agricultural land can be done with horizontal and vertical drainage systems. Vertical drainage systems are drainage systems that use pumped wells, open dug wells, or tube wells.[9]

The main function of vertical drainage wells is melioration. They do not differ from irrigation wells regarding construction technology and construction. They are not deeper than irrigation wells (40-70 m.). Depending on the natural and economic conditions, they serve an area of 5-120 hectares. In many regions, vertical drainage wells serve the purpose of land irrigation and the melioration of agricultural crops [4,5].

In the proposed system, jet apparatus is used in vertical drainage systems. Jet pumps are designed in such a way that they transfer the impulse through the high-speed primary to the secondary flow.

Jet devices are widely used in agriculture, mining, oil extraction, and various industries. In addition, they can be used as an independent units or together with pump units. Due to the simplicity of its construction and high reliability, flow devices are an indispensable unit in the operation of reactors in emergencies related to water shutdown and fire fighting.[2,12]

The development of the theory of jet pumps was slow. Gosline and O'Brien (1934) proposed a one-dimensional theory of jet pumps, which represented the processes in jet pumps through governing equations. This theory was refined by Cunningham and River (1957), Vogel (1956), Muller (1964), Reddy and Carr (1968), Sanger (1970), Gruppung, and others, taking into account frictional losses.[12,15,16,17]

Although vertical drains are considered an effective tool for a wide range of applications, dewatering, and water supply, they have high costs, high energy consumption, and other disadvantages. Many scientific researches have been conducted and are continuing to overcome these shortcomings.

## 2 Methodology

One of the key aspects of vertical drainage design is hydraulic analysis, which involves evaluating the hydraulic parameters of the soil and determining the required drainage depth to ensure the required level of groundwater withdrawal.[6,18]

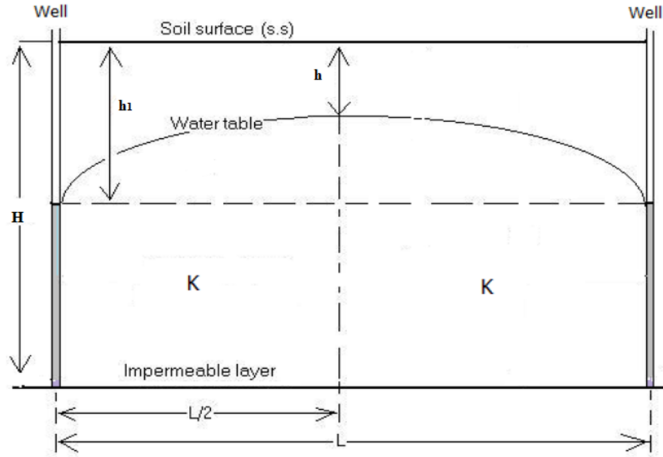
*Methods of hydraulic calculation of vertical drainage:*

There are several hydraulic calculation methods of vertical drainage, each of which has its advantages and disadvantages. The most common calculation methods are based on pump curves and calculation methods based on the filtering equation.[4,6]

The calculation method based on pumping curves is based on the experimental determination of the soil filtration coefficient and the estimation of the rate of decrease of the groundwater level at a certain pumping rate.[4,19]

The calculation method based on the filtration equation is based on the mathematical description of filtering water through the soil. The filtering equation is a differential equation describing the variation of soil saturation stress in time and space. Based on this information, it is possible to determine the required depth of drainage and its hydraulic capacity.[6,20]

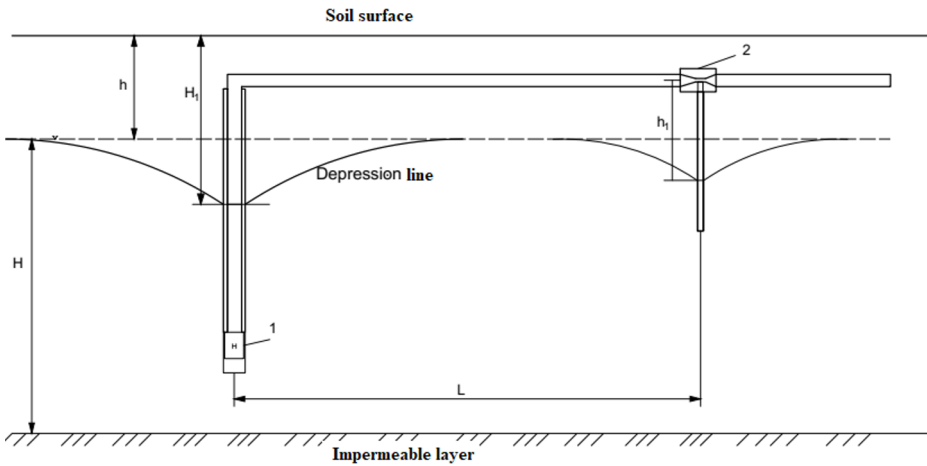
The consumption of water flowing into the well is determined according to the Dupuis equation (1):



**Figure 1.** Vertical drainage well geometric parameters

$$Q = 2\pi \frac{(H - h)(h_1 - h)}{\ln \frac{R}{r}} \tag{1}$$

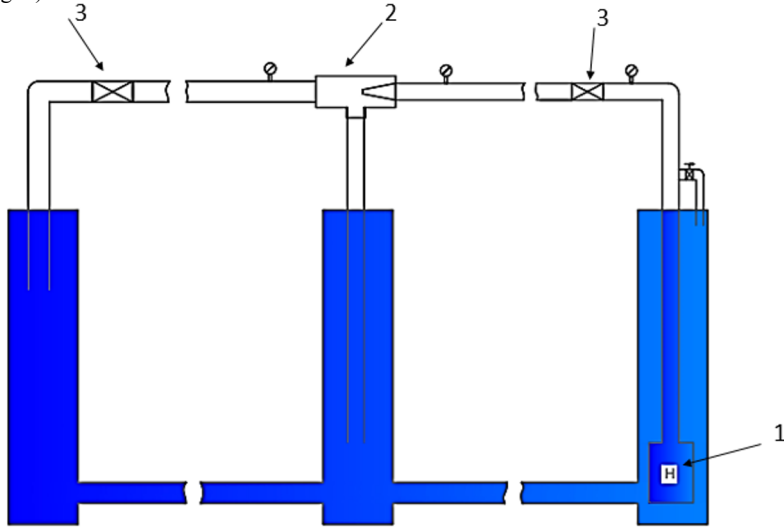
Here: H is depth to waterproof layer; h is depth to the aquifer; h<sub>1</sub> is water depth in the well; K is filtration coefficient of the soil; L is the distance between the wells; R is the radius of influence of the well; r is well radius.



**Figure 2.** Geometric parameters of proposed vertical drainage system

### 3 Results and Discussion

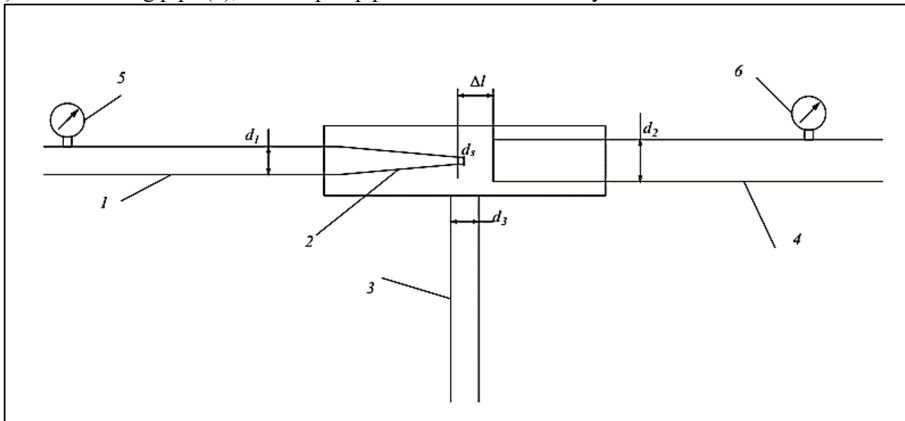
To test the proposed vertical drainage system in the laboratory, the following laboratory device was developed (Fig. 3)



**Figure 3.** Scheme of laboratory device: 1 is pump; 2 is jet device; 3 is water consumption calculation device.

The laboratory device drives water into the pipe through a pump (Fig. 3, 3), and the passing water is determined by a consumption meter. The pressurized water flow passes a certain distance through the jet device, and the suction pipe (3) draws water.

The processes in the jet apparatus were studied by changing the distance  $\Delta l$  between the jet apparatus nozzle (2) and the mixing pipe (4), and the pump pressure in the laboratory structure.



**Fig. 4:** Structural scheme of jet apparatus: 1 is working flow pipe; 2 is nozzle; 3 is suction pipe; 4 is mixing pipeline; 5,6 are manometer indicators.

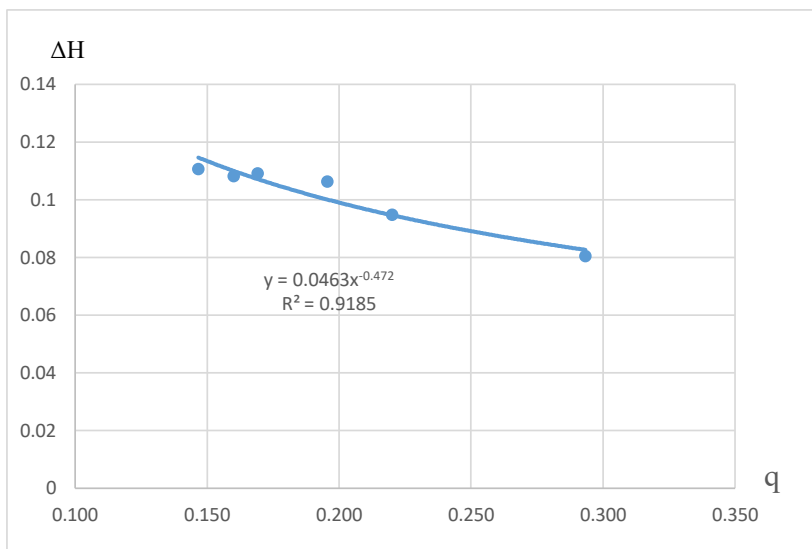


Figure 5. Experiment conducted when  $\Delta l=4$  cm

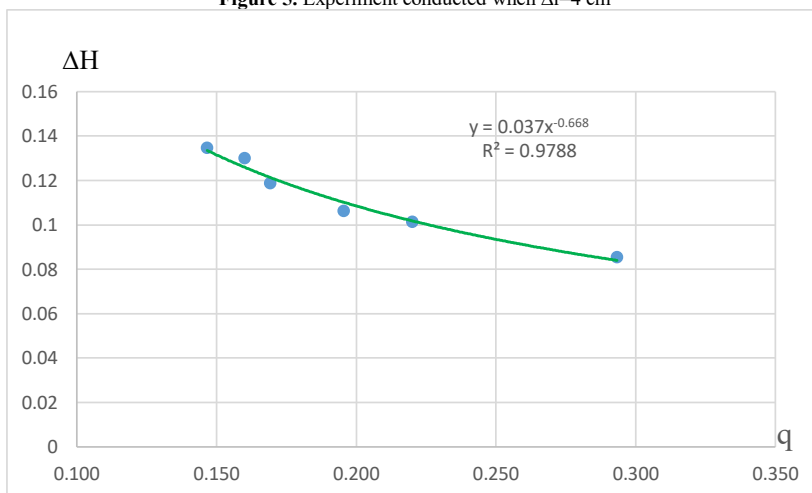


Figure 6. Experiment conducted when  $\Delta l=2$  cm

## 4 Conclusion.

The minimum pressure for the operation of jet pumps in the proposed vertical drainage system is 0.3 atmosphere was determined to organize. Experiments show that as the distance  $\Delta l$  decreases, the consumption coefficient and the efficiency of the reactive device increase. One of the most important parameters for this device is the absorption coefficient. This value is the ratio of the flow rate of the working fluid and the driven substance.

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