A light piston well-flushing technique for clogged relief wells along Yangxin Dyke of Yangtze River in China

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Abstract. Plastic relief wells along Yangxin Dyke of Yangtze River in China have been seriously clogged in recent years. It is necessary to dredge the wells to restore its disaster prevention and mitigation function. However, traditional piston well-flushing technique is suitable to restore steel and iron wells, and it can cause damage to plastic relief wells. A new light piston well-flushing technique is proposed to overcome the limitation of traditional piston well-flushing technique. The proposed light piston has the advantages of simple structure, convenient use and low cost. By the light piston moving down and up quickly the relief well, the nylon brush can clean the side wall and filters of relief well, and the negative pressure can make the deposited materials in the aquifer and inverted filter sucked out. The proposed well-flushing technique is applied to restore the plastic wells along Yangxin Dyke of Yangtze River in China. Its efficiency is illustrated using field pumping test data. It is shown that the drainage capacity and permeability of clogged relief wells can be greatly improved after using the proposed technique. The light piston well-flushing technique can provide an effective way to restore clogged relief wells along Yangtze River levees.

1. Introduction
Relief wells can provide pressure relief and controlled seepage outlets that offer little resistance to flow and, at the same time, prevent sand boils or piping[1][2]. From 1995 to 2001, 164 relief wells were constructed along Yangxin Dyke of Yangtze River in China for controlling seepage and piping along the lower Yangtze River levees[3][4]. The structure of constructed relief wells is shown in Figure 1. The diameter of the wells is 30 cm and the designed well depth is 18.0~30.0m. However, these relief wells have been seriously clogged in recent years. A large amount of debris such as silt and sand were deposited in the wells. The deposits block the filters of relief wells and drainage channel of aquifer, and affect the wells’ seepage control efficiency[5][6], which brings a tremendous threat for the safety of Yangtze River levees. Therefore, it is, necessary to dredge the clogged relief wells to restore its disaster prevention and mitigation function.
Generally, the traditional piston well-flushing technique has been widely used in the maintenance and restoration of relief wells\cite{7}\cite{8}. By moving the piston up and down quickly, instantaneous negative pressure and hydraulic impact are formed at the bottom of relief wells to bring out the deposits\cite{7}\cite{8}. However, the traditional piston well-flushing technique is applicable for the restoration of steel and iron wells. The 164 relief wells along Yangxin Dyke are made of plastic\cite{3}. When the piston moves up and down quickly, the huge instantaneous negative pressure will cause damage to the plastic wall of relief wells and a large number of inverted filter sand outflow. Eventually, the filters (as shown in Figure 1) are destroyed, affecting the performance of relief wells.

This paper explores a new well-flushing technique for mechanically clogged relief wells. Firstly, the light piston well-flushing technique that is applicable for the restoration of plastic wells is proposed, and its dredging mechanism is introduced. Then, the proposed well-flushing technique is applied to restore the plastic relief wells along Yangxin Dyke of Yangtze River in China. Finally, the efficiency of the proposed technique is illustrated using field pumping test data.

2. Light piston well-flushing technique

Figure 2(a) shows the schematic diagram of the light piston. The length of piston is 1.5 m. The light piston mainly consists of four parts: pump pipe, internal plastic pipe, epoxy external pipe and nylon brush. The diameter of pump pipe is 50mm. The inner and external diameter of internal plastic pipe are 50 mm and 100 mm, respectively. The inner and external diameter of epoxy external pipe are 100 mm and 150 mm, respectively. The nylon brush is fixed on the epoxy external pipe. The nylon brush consists of two parts: the long part and the short part. The long part is 270 mm in length and the short part is 255 mm in length.

![Figure 2. Schematic diagram of light piston well-flushing technique](image-url)
Figure 2(b) shows the working schematic of light piston well-flushing technique. The light piston is lowered down the well through a tripod and lifted by the winding engine. When the light piston moves down the relief well, the nylon brush keeps rubbing against the side wall of the well and cleaning the side wall and filters of relief wells (as shown in Figure 1). When the light piston moves up, a great negative pressure forms at the bottom of the piston. Under the negative pressure, the deposited materials in the aquifer and inverted filter are sucked out. Then, the drainage channel of relief wells is dredged and the permeability of aquifer and filters are improved. The light piston is simple in structure and economical in use and maintenance. The light piston is also easy and flexible to operate.

3. Application and efficiency of light piston well-flushing technique

The proposed well-flushing technique for clogged relief well is applied to the 4 plastic relief wells (i.e., 64#–67# wells) along Yangxin Dyke of Yangtze River in China. The diameter of 64#-67# wells is 30 cm and the designed well depth is 30.0 m. The filters and drainage channel of aquifer of these 4 relief wells are silted up with silt and sand seriously.

In order to illustrate the efficiency of light piston well-flushing technique, single-hole steady flow pumping test and non-steady flow water level recovery test are conducted[9–11]. The discharge of unit drawdown is obtained from steady flow pumping test to evaluate the drainage capacity of these four relief wells. The transmissibility coefficient of aquifer is evaluated by the non-steady flow level recovery test to reflect the permeability of aquifer.

The discharge of unit drawdown \( q \) (\( \text{m}^3/\text{h} \)) is calculated as

\[
q = \frac{Q}{s}
\]

in which \( Q \) (\( \text{m}^3/\text{h} \)) represents the correlation coefficient; \( s \) (m) is the drawdown of relief wells.

The transmissibility coefficient \( T \) (\( \text{m}^2/\text{d} \)) of aquifer is obtained as follows:

\[
T = \frac{0.183Q}{[i]}
\]

where \([i]\) is the slope of the straight line section of the curve of residual drawdown and \( \text{lg} t \) data in the recovery stage; \( i \) is the stop time for water level recovery test.

Steady flow pumping test and non-steady flow water level recovery test are conducted to obtain \( q \) and \( T \) of these 4 clogged wells before and after applying the proposed well-flushing technique, respectively. Table 1 shows the results of pumping test for the 4 relief wells. It can be seen that the values of \( q \) of these 4 wells increase obviously after using the proposed light piston well-flushing technique. The \( q \) values are 1.3 to 3.8 times that before dredging. It is indicated that the drainage capacity of relief wells has been improved after the application of the proposed well-flushing technique.

| Relief well number | Before well flushing | After well flushing |
|--------------------|---------------------|--------------------|
|                    | \( q \) (\( \text{m}^3/\text{h} \)) | \( T \) (\( \text{m}^2/\text{d} \)) | \( q \) (\( \text{m}^3/\text{h} \)) | \( T \) (\( \text{m}^2/\text{d} \)) |
| 64#                | 6.22                | 27.65              | 8.51                | 45.79                |
| 65#                | 3.42                | 25.92              | 8.39                | 45.79                |
| 66#                | 1.23                | 13.82              | 4.71                | 44.06                |
| 67#                | 3.53                | 21.60              | 6.20                | 33.70                |

Table 1 also shows the values of \( T \) of these 4 clogged wells. There are great difference between before and after the application of the proposed technique. Before well flushing, \( T \) values range from 13.82 \( \text{m}^2/\text{d} \) to 27.65 \( \text{m}^2/\text{d} \). After dredging the wells by light piston, \( T \) values range from 33.70 \( \text{m}^2/\text{d} \) to 45.79 \( \text{m}^2/\text{d} \). It can be clearly seen that the \( T \) values increase significantly after using the proposed well-flushing technique. It is suggested that the permeability coefficient of aquifer increases. It also indicates that the drainage channel of aquifer has been dredged after using the proposed well-flushing technique.
4. Summary and conclusions
This paper analyzed the clogging mechanism of relief wells along Yangxin Dyke of Yangtze River in China. Because the traditional piston well-flushing technique is applicable for the restoration of steel and iron wells and it can cause damage to plastic relief wells. A new light piston well-flushing technique is proposed to overcome the limitation of traditional piston well-flushing technique.

The proposed light piston consists of four parts: pump pipe, internal plastic pipe, epoxy external pipe and nylon brush. It has the advantages of simple structure, convenient use and low cost. By the light piston moving down and up quickly, the nylon brush can clean the side wall and filters of relief wells and the negative pressure formed at the bottom of the piston can make the deposited materials in the aquifer and inverted filter sucked out. The proposed well-flushing technique is applicable for the restoration of plastic wells.

The proposed light piston well-flushing technique was applied to dredge relief wells along Yangxin Dyke of Yangtze River in China. Its efficiency was illustrated by field pumping test data. It was shown that the drainage capacity and permeability of relief wells can be improved by using the proposed well-flushing technique. The light piston well-flushing technique can effectively clean the deposits in the filters and aquifer of clogged relief wells. The proposed light piston well-flushing technique provides an effective way to restore clogged relief wells along Yangtze River levees.

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