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## Design of Multi-village and Multi-source Drinking Water Joint Transfer and Supply Project--Taking Jin'e District of Hengxi Town in Yinzhou District as an Example

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# Design of Multi-village and Multi-source Drinking Water Joint Transfer and Supply Project--Taking Jin'e District of Hengxi Town in Yinzhou District as an Example

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**Abstract.** Water is the source of life. Improving and consolidating the safety of rural drinking water is of great significance to ensuring the quality of rural drinking water and promoting rural economic development. Taking Jin Epian Drinking Water Safety Promotion Project in Hengxi Town of Yinzhou District as an example, this paper briefly analyses the design of the project, hoping to provide experience support for the development and progress of the project. Jin'e area Drinking Water Safety Promotion Project is located in the upstream of Hengxi Reservoir, Hengxi Town. The drinking water of Jin'e area had poor filtration and disinfection facilities, and the water quality and quantity were difficult to meet the requirements. According to field investigation, considering the uneven spatial and temporal distribution of water resources and the difference of water supply in each village, and considering the current situation of water use in each village, combined with factors such as geographic location of the project, the overall layout of the project needs to be carried out. The main construction contents included centralized water treatment equipment room, clear pool, pumping room and water pipeline laying, with a total investment of 25.6 million yuan. Through the implementation of this project, the water quality and quantity of the existing water supply system and drinking water can be significantly improved, the utilization rate of water resources can be increased.

## 1. Introduction

Drinking water is the basic need for human survival, and the safety of drinking water is directly related to the health of the broad masses of the people [1]. To ensure drinking water safety effectively is the basic requirement of safeguarding the fundamental interests of the vast majority of the people and implementing the scientific concept of development. It is also an important content of realizing the goal of building a well-off society in an all-round way and building a harmonious socialist society. It is an urgent task to put people first into practice [2,3]. At the fourth plenary session of the 13th session of the Zhejiang Provincial Party Committee, it was proposed that the transformation and upgrading of Yinzhou District Government should be impelled by the breakthrough of sewage control, flood control, drainage, water supply conservation and water saving "five-water co-governance"[4,5]. Based on its own actual situation, the Ningbo Yinzhou District Party Committee and District Government, taking "five-water



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co-governance" as an important breakthrough, formulated a three-year plan of action for "five-water co-governance" in Yinzhou District (2014-2016), including agriculture. The village drinking water safety promotion project is not only one of the important contents of water supply protection in the province's "five-water co-governance", but also one of the important projects in the three-year action plan of the district's "five-water co-governance".

## **2. Basic situation of the project**

Jin'e area Drinking Water Safety Promotion Project is located in the upstream of Hengxi Reservoir, Hengxi Town, Yinzhou District. It mainly includes four administrative villages: Da'an Village, Shang Ren Village, Jin'e Village and Daocheng'ao Village. The drinking water of Jin'e area has poor filtration and disinfection facilities, and the water quality and quantity are difficult to meet the requirements. In order to further implement the "Five Water Common Governance" water project and improve drinking water safety, Yinzhou District Water Conservancy Bureau has included the project in the water conservancy construction plan of 2015. After the completion of the project, the problem of drinking water quality safety and water shortage will be solved.

### *2.1. Necessity of Engineering Construction*

#### **1. Improving the existing water supply system and drinking water**

The present water supply system in the water quality construction area is reservoir and pond water supply system, i.e. centralized water supply system with reservoir and mountain pond water as water source, and water storage pond and water supply pipeline. The system is easy to construct and maintain, but it is greatly affected by climate, and it is difficult to guarantee the water quantity and quality in dry season. The aging of drinking water equipment in villages is serious, some of them have been abandoned, and the lack of purification facilities and disinfection equipment is obvious. Even if there are purification facilities, the purified sand layer has not been cleaned and replaced according to the regulations. The present situation of drinking water in villages can not form a complete water supply system. Therefore, from the point of view of improving the existing water supply system and drinking water quality, it is necessary to upgrade the existing water supply system.

#### **2. Guarantee the water demand of residents and improve the utilization rate of water resources**

The villages in the construction area include Da'ao Village, Shang Ren Village, Jin'e Village and Daocheng'ao Village. According to the actual investigation, the water supply of individual villages is insufficient during the peak period of water use. With the continuous development of private enterprises in villages and the construction of new villages in recent years, an unprecedented challenge has been posed to the local people's livelihood water use. Especially in drought years, the problem of water shortage has become more prominent. Some villagers' drinking water must be transported by water trucks from several kilometers away. The present situation of Jin'e area water supply pipelines and reservoirs have been operating for many years, some of which are exposed, and are greatly influenced by human activities, which easily causes waste of water resources. At the same time, there is a lack of water level monitoring measures in the reservoir. When the reservoir is full of water, the incoming water can not be shut down in time, which also causes a lot of waste of water resources. Therefore, in order to improve the water demand of residents and the utilization rate of water resources in drought years, it is also necessary to upgrade the drinking water projects in this area.

### *2.2. Scope of Project Construction and Water Supply Population*

#### **1. Source of Water Supply**

The main source of water supply in Jin'e area is the existing reservoirs and ponds in each village. In the project area, Zhuma Ling Mountain Pond is supplied with Luhua Bridge of Dalan Village alone. The poor water quality of Dali Sishan Pond is not considered.

#### **2. Scope of water supply**

The water supply scope of the project is Jin'e Pian in Hengxi Town, including Da'ao Village (including Luhua Bridge), Shang Ren Village, Jin'e Village (including Shang Pan, Xia Pan, Ling Jia, Tian Long and Zhu Jiafeng), Daocheng'ao Village, a total of four administrative villages.

### 3. Water supply population

The total water supply population of Jin'e area is about 12,050, and the total water supply population of design year is about 12,120. In the design year, the distribution of water supply population in each village is: about 4260 people in Da'ao village, about 2530 people in assuming village, about 2380 people in Jin'e village and about 3040 people in Daocheng'ao village.

## 3. Engineering Construction

### 3.1. Regional Runoff Computation and Analysis

The choice of drinking water source should be satisfied with good water quality, convenient for sanitation and protection; abundant water; economical and convenient. The source of drinking water in Jin'e area can be selected from every village reservoir, Reservoir or Hengxi reservoir. The advantages and disadvantages of the two reservoirs are listed in Table 1-1.

**Table 1.** Comparison of Water Supply Advantages and Disadvantages between Shantang and Hengxi Reservoirs in Villages

Water source area	Advantage	disadvantages
reservoir and pond of every village	1. Effective use of the existing water supply system to save project investment; 2. It has been supplying water to local residents for many years. The water resources are relatively stable and the water quantity basically meets the requirements. 3. The cost of water supply is relatively low.	1. The amount of water used in villages can not be guaranteed in the design dry year. 2. It is scattered in four administrative villages, which are far apart and difficult to centralize management. 3. Water quality is uneven.
Heng Xi reservoir	1. The reservoir has a large capacity and can provide sufficient water throughout the year. 2. Water quality is good, only simple filtration and disinfection are needed. 3. Convenient operation and management.	1. It is far away from each village and the project cost is high. 2. The cost of water supply is high. 3. The existing water supply system can not be used.

According to the above table 1, the pond water source of each village reservoir can effectively utilize the local water resources, with low operation cost, low guarantee rate of water quality and quantity, and high guarantee rate of water quality and quantity of Hengxi reservoir water source, but high operation cost. According to the principle of fully utilizing water resources and the local requirements for later operation and management and water supply cost, the mountain ponds of each village reservoir are selected as the main water source of the project, and the Hengxi reservoir is used as the backup water source to divert water from the Hengxi reservoir when the main water source is insufficient.

The runoff of Hengxi Reservoir is calculated according to the water balance of the basin. Rainfall losses in the project mainly include evaporation, infiltration, plant interception, irrigation loss and residential water use. The water balance equation in the basin is as follows:

$$W_{\text{Input}} = W_{\text{Output}} + W_{\text{Loss}} + \Delta W_{\text{Reservoir}}$$

Among them,  $W_{\text{outflow}}$  is mainly reservoir outflow,  $W_{\text{loss}}$  includes evaporation, infiltration, plant interception, irrigation loss, residential water and so on.  $W_{\text{reservoir}}$  is Hengxi reservoir capacity change. The sum of  $W_{\text{output}}$  and  $\Delta W$  is river basin runoff.

### 3.2. Analysis of regional water resources supply and demand

The project is in the local regional water supply system for water, ponds and reservoirs through simple purification by transporting water distribution network to a centralized water supply system of the user. According to the field survey, the water supply of individual villages is insufficient during the peak period of water use. With the continuous development of private enterprises in villages and the construction of new villages in recent years, the phenomenon of water shortage in construction areas has become obvious, especially in drought years, the problem of water shortage has become more prominent.

#### A .calculation method

In the course of hydrological cycle, the difference between the amount of water entering and the amount of water output for any region and any period must be equal to the amount of variation of its water storage, that is to say, the principle of water balance is satisfied for any region and any period. The following formulas are used for water resources balance analysis in this project area.

$$I-O=\Delta S \quad (1)$$

In the formula: I, O - a region, the total water input and output in a given period of time in the region;  $\Delta S$  - The variation of regional water storage in a period of time, can be positive or negative.

According to the basic requirements of the design of centralized water supply engineering in the Code for Design of Water Supply Engineering for Villages and Towns (SL687-2014), the water consumption for residents can be calculated according to the following formulas:

$$W=P*q/1000 \quad (2)$$

$$P=P_0*(1+\gamma)^n+P_1 \quad (3)$$

Formula:

W—— residential water consumption, m<sup>3</sup>/d;

P—— Number of design water users, people;

$P_0$  —— The current number of permanent residents in the water supply area, including those without local household registration;

$\gamma$ ——The natural growth rate of population in the design period can be determined according to the natural growth rate of local population in recent years.

n—— Five years of Engineering design;

$P_1$ —— The total mechanical growth of population in the design period can be determined by the average growth method according to the population planning of villages and towns and the changes of floating population and household registration migrant population in recent years.

q—— Residents'living water quota, L/person/day.

#### B calculation results

In the design dry year (guarantee rate = 95%), the daily water inflow and output of each village are analyzed and calculated, and the formula (4-1) is used to calculate the water balance. Resident water quota and its analysis parameters are selected according to the relevant provisions of the Code for Design of Water Supply Engineering for Villages and Towns (SL687-2014), and irrigation quota is selected according to the provisions of Zhejiang Water Quota (Trial Implementation) [Zhejiang Water Administration (2004) 46].

The calculation results show that the existing water supply system of Reservoir can not meet the needs of residents in every village in the design dry year (guarantee rate = 95%). At the same time, some reservoirs are damaged seriously and some pipelines are leaking seriously, which further affects the water supply.

Therefore, the current water supply system can not meet the requirement of water supply quantity in the design of low-water year (guarantee rate = 95%) in the "Code for Design of Water Supply

Engineering in Villages and Towns" (SL687-2014), and the water supply quantity in the project area can not be guaranteed.

The raw water in the current regional water supply system is treated by simple filtration and disinfection and then supplied to users through the pipeline network. However, in the field survey, it is found that because of the relatively long construction period and the simplicity of the reservoir, only simple filtration can be carried out in operation, and the filter sand layer has not been regularly replaced; most water supply systems lack disinfection and purification equipment or equipment aging, and the purification effect is poor. The buried depth of the sub-pipeline is shallow, the buried time is longer, and the pollution of the pipeline is more common.

Therefore, the current water supply system does not meet the requirements of the "Code for Design of Water Supply Engineering in Villages and Towns" (SL687-2014) for water quality, and the water quality of water supply in the project area can not be guaranteed.

### 3.3. Engineering Construction

According to the above calculation results, the specific construction contents of the project are water supply quantity and water quality.

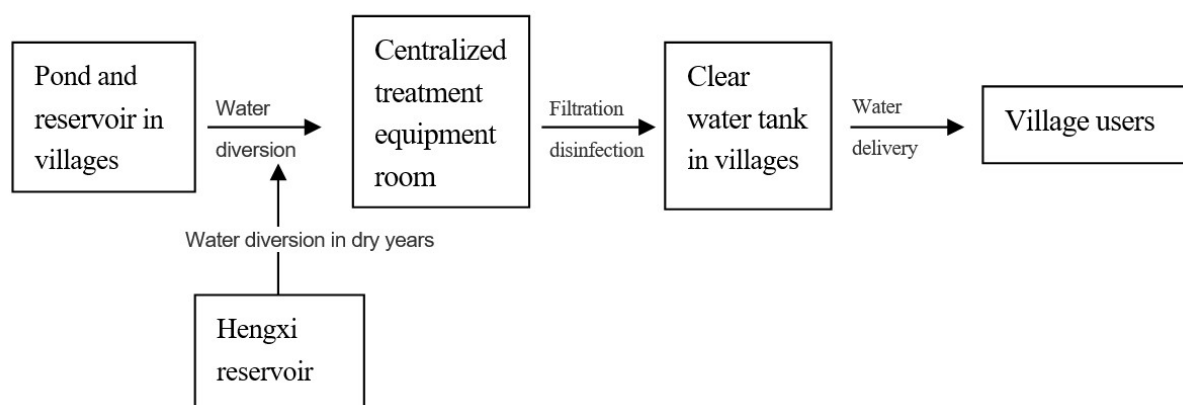
1. Water supply: This project will solve the problem of insufficient drinking water for 12210 people (design level year) in four villages of Da'ao Village, Shang Ren Village, Jin'e Village and Dao Cheng'ao Village in the design low water year (guarantee rate = 95%).

2. Water quality of water supply: The construction standard of centralized water supply station and matching filtration and disinfection facilities should improve water quality of water supply system according to the requirements of "Code for Design of Water Supply Engineering in Villages and Towns" (SL687-2014).

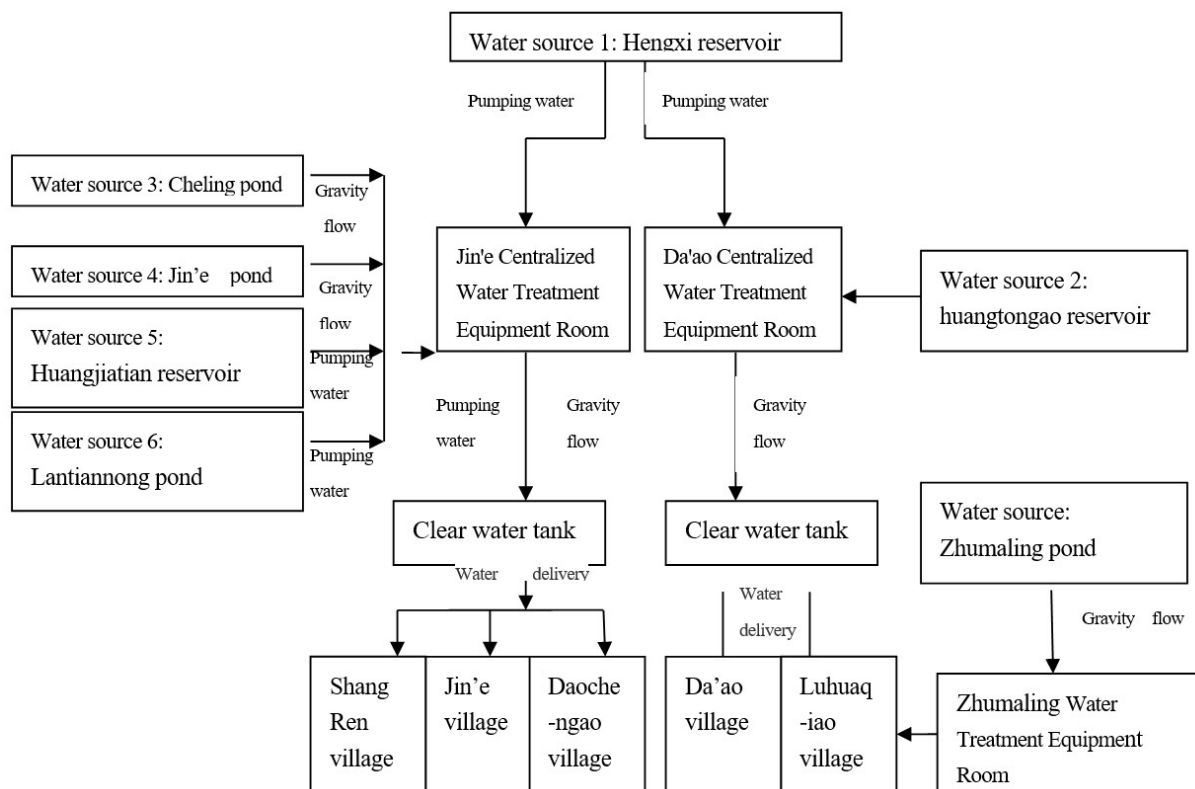
### 3.4. Ideas of Engineering Layout

The project area includes four administrative villages, Da'ao Village, Shang Ren Village, Jin'e Village and Dao Cheng'ao Village. There are eight reservoirs and ponds in the project area. The total area of the river basin is 39.8 km<sup>2</sup>, which all have water supply functions. These reservoirs and ponds have basically been or are being comprehensively renovated to provide water resources for the project area.

According to field investigation and investigation, considering the uneven spatial and temporal distribution of water resources and the difference of water supply in each village, the overall layout of the project is carried out according to the current situation of water use in each village and the geographic location of the project.



**Figure 1.** Design Ideas of Drinking Water Lifting Project in Jin'e Area



**Figure 2.** Flow Chart of Drinking Water Project Arrangement in Jin'e Piece Area

### 3.5. Water purification process design

The project adopts gravity integrated water purification equipment and high purity chlorine dioxide disinfection equipment to purify water. The treated drinking water quality can fully meet the requirements of "Sanitary Standard for Drinking Water" (GB5749-2006). This water purification and disinfection equipment has been built and used in other parts of Ningbo City. It has simple operation technology, safe operation of equipment and good water purification effect.

The process flow of water purification is as follows: the water from the source area is filtered by filters and then enters the outlet pipe. The outlet pipe is disinfected by chlorine dioxide and transported to the clear water pool. After fully mixing in the pool, the water is directly supplied to the users.

### 3.6. Engineering Budget Estimates

The rural drinking water upgrading project needs a large amount of capital investment, which must adopt multi-level and multi-channel fund-raising methods to broaden the funding channels. As the safe drinking water project is beneficial to the people, the government strongly supports it and the masses are highly motivated. In 2014, Yinzhou District's public finance budget revenue was 27.95 billion yuan, Hengxi Town's public finance budget revenue was 290 million yuan, and rural residents' per capita net income was 26,682 yuan. The project funds are raised according to the relevant regulations of the city and district, and the local governments, such as policy processing funds and late operation and management expenses, have the ability to raise funds.

The total investment of this project is 25.6 million yuan, mainly including 8.81 million yuan of construction projects, 7.45 million yuan of mechanical and electrical equipment and installation, 7.06 million yuan of metal structure and installation, etc.

#### 4. Conclusion

Jin E area Drinking Water Safety Upgrading Project in Hengxi Town, Yinzhou District, mainly includes centralized water treatment equipment room, clean water pool, pumping station and pipeline laying. The existing problems of Jin'e tablet drinking water have seriously affected the daily production and life of local villagers. Through field survey and technical analysis, the water source of the project is guaranteed. Reservoirs and mountain ponds are distributed in all villages of Jin'epian. The water resources available in drinking water source area are about 700,000 m<sup>3</sup>. At the same time, Hengxi Reservoir also has about 24 million m<sup>3</sup> of Xingli Reservoir capacity to meet the water demand. At the same time, the technology of filtration and disinfection is guaranteed. The gravity integrated water purification equipment is used in the filtration equipment, and the high purity chlorine dioxide disinfection equipment is used in the water purification. The quality of the treated drinking water can fully meet the requirements of the Hygienic Standard for Drinking Water (GB5749-2006). This water purification and disinfection equipment has been built and used in other parts of Ningbo City. It has simple operation technology, safe operation of equipment and good water purification effect. In addition, the fund of the project is fully guaranteed by the policy of dealing with the fund and the fund raising of the later operation and management.

Therefore, the implementation of Jin'e Chi Drinking Water Safety Promotion Project in Hengxi Town of Yinzhou District is feasible in terms of water source and water purification technology measures, and the implementation of funds is guaranteed. Through the implementation of this project, the existing water supply system and drinking water quality and quantity can be significantly improved, the utilization rate of water resources can be increased, the water demand of farmers can be improved, and the local people's living standards can be guaranteed. It plays an important role.

#### Acknowledgments

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