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ANNEXES

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ANNEX 1

GROUNDWATER SOURCE

ANNEX 1 GROUNDWATER SOURCE

1.1 Groundwater Quantity

The relationship between pumping rate and drawdown was examined from the results of the step-drawdown test at each test well. The drawdown for a 48-hours duration was also measured in the continuous pumping test. Based on the results, the optimal yield of each test well was evaluated as mentioned in Chapter 6 of PART II.

Except at the target communes in Hanoi Province, the necessary amount of water for safe drinking water supply is less than the groundwater potential of each commune from the view point of water balance. In other words, the estimated total groundwater recharge is much greater than the estimated groundwater pumpage for the planned water supply. However, the optimal yield of each test well should be examined considering the aquifer productivity, well structure, and permissible groundwater level for the sustainable groundwater use. Because if the dynamic groundwater level is lower than the permissible groundwater level, the lowering may cause difficulty of pump operation, harmful well interference, land subsidence, and worsening of groundwater quality.

For the priority communes in the Study area except in Hanoi Province, the optimal yield was set based on the well structure such as well depth and screen location(s), and productivity of the target aquifer(s). In this case, the term of "optimal yield" can be defined as a pumping rate for sustainable operation of a designed submersible pump with maintaining a necessary dynamic groundwater level in the well for the pump operation.

Based on the results of the test well drilling and the pumping test, the quantity of groundwater source in the priority commune is evaluated as follows:

1.1.1 Thai Nguyen province

In Thai Nguyen Province, Hoa Thuong and Dong Bam Communes have productive aquifers consisting of limestone. Although the detailed pumping test could not be carried out at the Dong Bam test well, the test wells can yield more than 1,000 m^3/day. The optimal yield of Hoa Thuong test well is estimated as 1,000 m^3/day when a the permissible dynamic groundwater level is set to be 10 m from the ground surface.

In Dong Bam Commune, it is necessary to construct a new production well because the test well was abandoned due to the cave-in of the ground. The optimal yield and permissible groundwater level can be set as the same with the Hoa Thuong test well.

In Thinh Duc Commune, the aquifers are less productive, consisting of thin Quaternary sediments and fractured sandstone and claystone. The optimal yield is only 150 m^3/day even the permissible dynamic groundwater level is set at 20 m in depth. This yield cannot cover the estimated groundwater demand. Therefore, it is necessary to drill more production wells in the commune, however, the hydrogeological conditions in the commune is similar to the drilling site so that the similar small optimal yield is expected from the new production wells. To meet the maximum daily groundwater production of 724 m^3/day, it is necessary to drill four (4) more wells in the commune. For the additional production wells, the well depth and well diameter are proposed to be 100 m and 6 inches, respectively.

The optimal yield of Nam Tien test well is smaller than that of Thinh Duc; it is 100 m^3/day when the permissible groundwater level is set at 10 m from the ground surface. For the Nam Tien test well, the permissible groundwater level cannot set at more deeper depth because the well depth is 21.5 m. According to the existing hydrogeological information, there is a productive aquifer zone in northeast of the commune, but the exact productivity has not been examined. At the test well site, groundwater can be extracted only from thin weathered siltstone and thin Quaternary sediments. If it is assumed that the hydrogeological conditions of the commune is similar to the test well site, 10 more wells are needed to be constructed to meet the estimated maximum daily groundwater production of 1,067 m^3/day. For the additional wells, the well depth and well diameter are proposed to be 21.5 m and 6 inches, respectively.

1.1.2 Hanoi Province

No test wells were drilled in the target communes in Hanoi Province. From the results of existing pumping test data, the transmissivity values of the Second Aquifer in Hanoi Area ranges from 600 to 1,500 m^2/day. The areas having higher transmissivity are located in the western part and southern part of the city. From the data, transmissivity values at Dong Ngac Commune range from 800 to 1,000 m^2/day, whereas transmissivity values of Xuan Dinh ranges from 800 to 1,200 m^2/day.

To meet the maximum daily groundwater productions of 1,337 and 3,058 m^3/day in Dong Ngac and Xuan Dinh Communes, one production well at each commune is needed based on the transmissivity values and the production wells data of the Hanoi Water Supply System. If the transmissivity of production well site is assumed to be 800 m^2/day and the specific capacity is assumed to be 656 m^2/day from the *T*51.22 *Sc* relation by Logan (1964), the computed drawdown is 2.0 m in Dong Ngac well and 4.7 m in Xuan Dinh well. Considering the present piezometric head in the target communes, the dynamic groundwater level of 25 masl (15 m depth from ground surface) can allow the yield to meet the groundwater production. However, the permissible groundwater level of the wells should be determined by considering an optimal groundwater basin management plan of Hanoi Area.

For the new production wells, the well depth and well diameter are 80 m and 6 inches, respectively.

1.1.3 Ninh Binh Province

Although the basement aquifer of the test wells consist of limestone in Ninh Binh Province, optimal yield of test wells ranges from 120 to 1,500 m^3/day.

The test well in Dong Phong has an optimal yield of 1,500 m^3/day when the permissible groundwater level is 10 m from the ground surface. If it is allowed that the permissible level is 15 m, the test well can meet the maximum daily groundwater production of 1,846 m^3/day.

In Quang Son Commune, the permissible groundwater level is needed to be deeper because the static groundwater level itself is located about 10 m from the ground surface. The target aquifer is fractured limestone with caves, however, the optimal yield is only 250 m^3/day because the porous spaces are filled with clayey materials even the permissible level is set at 30 m in depth. To meet the groundwater demand of 1,384 m^3/day, 5 more wells having the same optimal yield are needed in the commune. The additional wells should have 120 m in well depth and 6 inches in well diameter.

The test well in Yen Thang Commune has an optimal yield of only 120 m^3/day with permissible groundwater level of 30 m from the ground surface. Moreover, as mentioned in the next section, the quality of the test well water is saline and unfavorable for drinking water supply. Considering the hydrogeological conditions of the commune, it is difficult to obtain fresh groundwater in the plain area. However, according to the existing well record near the Yen Thang Lake, an yield of 665 m^3/day was pumped from a well tapped at limestone aquifer with drawdown of 1.8 m. If it is assumed that the optimal yield of a new production well tapped at the limestone aquifer is 665 m^3/day, three (3) wells can meet the required maximum daily production of 1,575 m^3/day. The new production wells are proposed to have 120 m in well depth and 6 inches in well diameter.

1.1.4 Thanh Hoa Province

Among the five (5) test wells drilled in the target communes in Thanh Hoa Province, only Van Thang well has less optimal yield of 300 m^3/day, but the rest have a higher optimal yields ranging from 1,400 to 1,800 m^3/day.

The test well in Vinh Thanh has an optimal 1,500 m^3/day with 20 m of permissible groundwater level from the surface. The aquifer is productive fractured limestone. If one more production well is constructed, a total groundwater demand of 2,152 m^3/day for Vinh Loc Town and Vinh Thanh Commune, which can be treated as one water supply zone, can be covered. The additional well is proposed to have 80 m in well depth and 6 inches in well diameter.

The test well of Dinh Tuong Commune has an optimal yield of 1,700 m^3/day with 15 m of permissible groundwater level from the ground surface. The test well can easily meet the maximum daily groundwater demand of 1,182 m^3/day in 2010.

Thieu Hung test well also has a higher optimal yield of 1,400 m^3/day with 15 m of permissible level, extracting groundwater from Quaternary sediments. The test well can supply the maximum daily groundwater demand of 1,224 m^3/day.

The test well in Thieu Do has the highest optimal yield of 1,800 m^3/day in Thanh Hoa Province with 20 m in permissible groundwater level. The test well can meet the groundwater demand of 1,272 m^3/day without any additional wells.

In Van Thang Commune, the test well has small optimal yield of 300 m^3/day. Moreover, the test well water is saline and not suitable for drinking water, that will be mentioned later. Therefore, it is necessary to drill 4 more wells to meet the groundwater demand of 1,209 m^3/day if it is assumed the optimal yield will be the same as the test well. From the hydrogeological points of view, the groundwater quality is poor along the river and will be better towards south and southwest. The new production wells are proposed to have 120 m of well depth with 6 inches well diameter.

1.2 Groundwater Quality

The groundwater quality of the test wells were analyzed except the well in Dong Bam Commune. Among the 14 samples, only 4 samples satisfied the Vietnamese drinking water standard. Based on the results of the results, the quality of groundwater source in the priority target commune is evaluated as follows:

1.2.1 Thai Nguyen Province

Thinh Duc and Nam Tien test wells satisfied the Vietnamese drinking water standard. The groundwater of Hoa Thuong test well is high in iron and manganese. The raw groundwater need to be treated for drinking water supply. It is noted that the iron concentration of 5.15 mg/ℓ in Hoa Thuong water is the highest among the test wells in the F/S target communes. In addition, the shallow groundwater of Thinh Duc and Nam Tien is acidic water so that the well structure of the additional wells should be carefully planned.

1.2.2 Hanoi Province

It is predicted from the existing water quality data that the groundwater of Dong Ngac and Xuan Dinh Communes have higher concentration of iron and manganese. From the data of Ngoc Ha well field of the Hanoi Water Supply System, which is located only 2 km south of Xuan Dinh Commune, the maximum and average iron concentration in the target communes is predicted as 5.0 mg/ℓ and 1.5 mg/ℓ, respectively. Similarly, the maximum and average manganese concentration is predicted as 2.5 mg/ℓ and 1.0 mg/ℓ, respectively.

The concentration of ammonium is also high in the existing production wells in Hanoi area. In the Ngoc Ha well field, the maximum and average ammonium concentration is 3.0 and 0.7 mg/ℓ, respectively. In Ha Dinh well field, the ammonium concentration as high as 20 mg/ℓ is detected from the production wells tapped at the main confined aquifer. The higher ammonium concentration indicates the well water is contaminated from the surface or shallow source of contamination. It also occurs when the well was not properly constructed, particularly when the sealing surrounding the well casing is poor, the contaminated shallow water can easily move to the deeper portion.

1.2.3 Ninh Binh Province

In Ninh Binh Province, only Dong Phong test well water cleared the Vietnamese drinking water standard. The test well water in Quang Son is high in manganese concentration and low in pH. The water in the Yen Thang test well is salty, having more than the standard values in TDS, Fe, Mn, Na, and Cl. The water cannot be used for safe drinking water because of the salinity. However, in the southeastern part of the commune which shows hilly area, the groundwater from limestone has good quality, having 210 to 230 mg/ℓ in TDS.

1.2.4 Thanh Hoa Province

Only test well water in Dinh Tuong Commune cleared the Vietnamese drinking standard. TDS value is high in Thieu Do test well. Iron concentration is high in Vinh Thanh, Thieu Hung, and Van Thang. Manganese is also high in Thieu Hung and Van Thang. Sodium is high in Van Thang. The Van Thang test well water is difficult to treat its high sodium concentration. Therefore, new production wells should be constructed to obtain fresh groundwater from the southeastern part of the commune.

ANNEX 2

WATER SUPPLY SYSTEM OF TARGET COMMUNE AND OPERATION AND MAINTENANCE

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2.1 Water Supply Systems of target commune

The water supply systems of target commune are planned as an independent individual water service system. However, there is no system which can supply water from the geographical features condition by the gravity flow method.

The water supply method is classified into the following two types.

(1) Method to pump pressurizing water supply by setting up distribution reservoir in height (about 15 m) in commune. The pump operation can be stopped according to the seasonal change etc. of demand at nighttime). (Thai Nguyen Province 4 commune)
(2) Pump pressurizing method (An elevated water tank is set up for the stability of the water supply).

Water supply system serving drinking suitable, clean, abundant and cheap water to customer aims at improvement of public health and improvement of life environment. It is necessary to execute each stage of the plan, the design, construction and maintenance properly to achieve this purpose. The operation and maintenance of water supply system is to do the drive control efficiently and safely to have the water quality which suits the water quality standard and hydraulic pressure, and to supply the water which corresponds to demand in the water-supply area for 24 hours as for the water supply facilities.

2.2 Operation and Maintenance

Maintenance is divided roughly into the maintenance control and the operational control. The quality of the maintenance control influences safety and the stability of water service directly.

2.2.1 Maintenance control

The maintenance control is the maintenance of the function of facilities, and is as follows.

- As the accident prevention, an individual function is confirmed and exchanged regular of the check and parts for the breakdown etc.
- Repair of abnormal location, removal of abnormal cause, and recovery of deterioration function, etc.
- Execution of reliability improvement policy etc.

2.2.2 Operational Controls

If neither the operation nor the control do properly even if it is what kind of facilities, the function cannot be demonstrated enough. In general, the control system is constructed considering the range of the control, accuracy, and the technique, etc. enough. There is no change even when this is manually driven or when aiming at the automation. The operational control is to become an efficient operation as a system not to mention normally operating individual facilities or equipment. It is necessary to straighten the system that intimate cooperation with the maintenance section can be kept to improve the operational control.

(1) Water quantity control and hydraulic pressure

The water quantity control is for the volume of water planned at each stage of the water supply system from the water-intake to the water service pipe to be secured, and to control facilities driving to supply the volume of water which corresponds to demand in the water-supply area. On the other hand, the control of hydraulic pressure clarifies the pressure loss consumed in each process and the pressure relation between each system from the well to the water service pipe. And, the control of hydraulic pressure is to drive an efficient safety securing of energy consumption and the adjustments of the end hydraulic pressure or the water level aiming.

It is important to always understand the operating situation and the water supply situation of the water supply facilities whole from the well to the water supply service pipe for the facilities operation and the water transportation which is reasonable and economical. Concretely, various controls like the drive of the pump and adjustment of the valve etc., are done based on the demand forecast based on the volume of water, the hydraulic pressure of a main point in the water supply system or the measurement value of the water level etc.

(2) Water quality control

The water supplied with water supply system is requested to keep always sanitary safe and cleanness. The water quality control which aims at a good quality of water quality control is as follows.

- It is confirmed that the service water has suited the target water quality.
- It is confirmed that the process in the water supply facilities is properly operating.
- The raw water quality in the future is forecast and necessary measures are taken.

As for the request to commune, the water quality control for the confirmation whether facilities are properly operating is requested. There is no necessity for difficultly think about the water quality control. Here to the problem the content of iron and manganese. Because the relation between the density of iron and the color is understood, commune operator has to measure the color, and recorded. Concerning the measurement of bacteria, equipment and the technology are necessary. However, it is understood that the bacillus won't exist if there is residual chlorine. The measurement of residual chlorine is easy. The safety of the water supply is guaranteed by measuring residual chlorine and recording.

2.2.3 Functions of each of facilities

It is necessary to understand the function of each facilities where the system is composed enough to accomplish certain maintenance. The function of main facilities where each commune water supply system is composed is as follows.

(1) Distribution reservoir and Elevated water tank

The distribution reservoir has an adjustment function to a time change of the water-delivery and the reduction function of the influence in abnormal circumstances on the water supply. These functions are important functions in the water supply system. It is necessary to improve the storage function to correspond when it is possible to supply to abnormal circumstances though the effective capacity of the distribution reservoir is assumed for eight hours of the daily maximum water consumption of the plan.

An elevated water tank is the storage facilities of the ground type installed for the adjustment of the water-delivery and the hydraulic pressure of pump pressurizing area adjustment and has the function of the pipeline protection and the muddy water generation prevention.

(2) Treatment facilities

To remove iron and manganese, the biological filters and the chlorine injection equipment are set up. Iron bacteria use is adopted for underground water that the suspension is few. Because maintenance is easy, this method is adopted in a small-scale filtration plant. Constancy within a certain range the filtration rate is requested. When the filtration rate is changed suddenly in the filtration continuation. Iron and the manganese caught in the sand layer flake off, the filtration water might be depraved. It is necessary to avoid sudden change of filtration rate.

Because the influence on the filtration water quality by the sudden change of the filtration rate is different according to each raw water quality, the form of the filter, and the sand layer composition, it is necessary to check the influence for water quality in each treatment facilities.

Water supply system is composed of facilities where the function is different like this. The water supply system produces clean waters of 24 hours constant amount, and storage clean water in the distribution reservoir, and corresponds to the change of the time of demand by moving up and down as the water level of the distribution reservoir.

Because the water supply facilities are often constructed in expectation of the demand increase in the future, the water level of the distribution reservoir in demand's not reaching the plan value moves up and down in the vicinity of the high water stage. It is usual to reduce the filtration rate for a better water quality and to operate the treatment facilities continuously for 24 hours.

But it is necessary to operate for ripening of filtration sand in the plan filtration rate because operator becomes accustomed to the operation. In this case, necessary volume of waters might be able to be produced by the operation only in daytime. In this case, necessary volume of waters might be able to be produced by the operation only in daytime.

These target communes start the water supply project management for the first time. The initial training operation plan is necessary. The operation facilities of night time are made a minimum for about one year as a training period.

2.2.4 Regular Check and Mending

There are every day check, every month check, year's check by operator in the regular check maintenance. Because the check described as follows are more efficient by the consignment, these were summed up partially of the O&M cost.

(1) Maintenance of Well Pump

It is necessary to improve the well pump once every 2 or 3 years, and check or exchange the state of electric motor fixation offspring, the rotation offspring, and the bearing and the seal packing material. Moreover, the repair of loosening of pipe joints and damage is to be consigned.

(2) Water Distribution Pump

Impera, the casing, the sleeve, the decomposition check of the bearing, the correction the exchange of the wear parts, the vault nut, and the coupling rubber bush are consigned and executed once every 5 years.

(3) Water Leakage Mending

It is thought that there are few water leakage accidents in the distribution pipe nets. Majority of the water leakage accidents happen by the water service pipe. When the leakage accident happens between distribution main and meter installed in water service pipe, it is sometimes left for a long time, and this decreases accounted for water. Therefore, water leakage should be repaired by the consignment as soon as such a water leakage is found.

(4) Water Quality Examination

The measurement of the water quality items (water temperature, turbidity, color, and residual chlorine, etc.) assumed to be a daily operation index is work of the operator. However, the measurement of the other water quality standard items is consigned once in quarter.

(5) Power Receiving Equipment

The check is consigned once a year.

(6) Disposal of Sludge

The sludge precipitated in drain basin is to be carried out once a year by consignment.

(7) Clerical Work Expense

The clerical work expense such as traveling expense, the articles of consumption expense, the print bookbinding expense, and vessels is necessary besides mending the above-mentioned facilities. For this, 20% of the charge income was summed up.

2.3 Principles in treatment

2.3.1 Biological Treatment

Iron bacteria use is a method of removing iron and manganese in water by using iron bacteria. This method is used from maintenance easy as a removal measures of iron and manganese in a small-scale filtration plant where underground water, infiltration water and spring water that the water quality change is few, etc. It should be an environment to which iron bacteria can be smoothly grown. Especially, because the raw water quality influences inhabiting of iron bacteria, it is preferable that the change is few.

The principle of the removal of iron and manganese by iron bacteria oxidizes iron and manganese that iron bacteria exist in water and uses a calm character for the surface of the body and inside the body as insoluble iron and a manganese compound. Therefore, it is the treatment process for the raw water to touch with iron bacteria, and to separate iron bacteria and water continuously by the sand filtration after iron and manganese are adsorbed.

Generally, iron bacteria naturally breed to the surface of sand and the surface 7 to 10 days later when keeping leading to the sand filter without ventilating the raw water which pumps up because iron bacteria often exist in underground water which contains a lot of iron. When iron bacteria breed too much and the filtration blockage is caused, the surface of sand is removed or is washed by back washing and the filtration ability is recovered. Even if the majority of iron bacteria are removed, filtration ability recovers at once.

Iron bacteria used are Clonothrix which willingly oxidizes manganese, Leptothrix with ability to oxidize iron and manganese and Siderococcus that the removal of manganese is inferior etc. though iron oxidizes.

Even if this method has some changes of iron and manganese in the raw water, the processing water can stabilize, and remove the ammonia nitrogen of a low density.

2.3.2 Chemical Treatment

If chlorination is performed, free chlorine levels are maintained. If not, manganese remains as manganese ions, which causes no problems if they pass through purification facilities and are discharged from service pipes. But if high-density chlorine continues to be added, manganese oxide is formed gradually in distribution pipes, and it sediments or adheres to pipe walls. This causes a vicious circle, in which manganese oxide, working as a catalyst, rapidly oxidizes manganese-containing water (both treated water and chlorine-added water), creating more manganese sedimentation inside the pipes.

The precipitated manganese oxide then accelerates the oxidation of iron and creates an accumulation of iron hydroxide and manganese, causing problems with black water when the pipe flow accelerates with increasing summer demand. This chain of problems has been successfully solved by the manganese sand/pre-chlorine addition method and the potassium permanganate oxidation sedimentation method, which were intensively studied in the mid 1950's in Japan. Currently, however, Pre-chlorination must also be alternated with another disinfection method due to a fear of pre-chlorination on human health. When the pH values of water containing iron and manganese rise by adding lime and sodium hydroxide, both metals form insoluble iron hydroxide and manganese hydroxide, respectively, which, since they are suspended solids, can be filtered out. In this way, they can be treated by increasing the pH, but this also requires oxidation for re-neutralization and has many problems economy-wise and operation-wise. Therefore, they are usually removed by adding powerful oxidation agents at normal pH to precipitate them from water. The agents used are chlorine, potassium permanganate, ozone, etc.

When chlorine is employed, a catalyst is necessary to oxidize the manganese. If manganese-containing water is being filtered while a small amount of free residual chlorine and potassium permanganate is added, manganese oxide forms a layer on the surface of sand particles, and then works as a catalyst to accelerate the oxidation and precipitation process of manganese by chlorine, making it possible to remove it almost completely. Usually, with chlorine, its reaction with iron is complete in one to two minutes. Oxidation manganese, if a catalyst is not used, is extremely slow and takes up to 10 hours or more. With a catalyst, however, the oxidation process is significantly accelerated as detailed above, and the process is complete in a few minutes.

(1) Iron removal

For iron removal, pre-treatment facilities and filter basins are necessary, in which aeration, chlorination, etc. are employed independently or in combination. Iron is often found at high levels in underground water in the form of ferrous bicarbonate, and in peat regions, colloid form after being chained by humic acid, etc.

Usually, iron is removed in the following manner: organic iron compounds like ferrous iron and colloid iron, which are soluble in raw water, are oxidized by aeration or pre-chlorination. After being precipitated out as insoluble ferric compounds, they are removed by coagulation-sedimentation and filtration, or simply by filtration. In some cases, pH adjustment is employed in combination with the above, contact filtration is employed as the filtration process, or the iron bacteria method is employed independently.

Iron present as ferrous bicarbonate is precipitated as insoluble ferric hydroxide by aeration. This removal process is effective for iron present as ferrous hydroxide, and it also removes free carbon dioxide, hydrogen sulfide, etc.

(2) Manganese removal

For manganese removal, pre-treatment facilities and filter basins are necessary, in which pH value adjustment treatment, chemical oxidation treatment, chemical sedimentation treatment, etc., are employed independently or in combination. Chemical oxidation treatment is performed by pre-chlorination, ozonization or potassium permanganate treatment.

Manganese removal processes include coagulation-sedimentation/filtration processes after chemical treatment by chlorine, ozone or potassium permanganate; contact filtration which uses manganese sand as filter media; iron bacteria treatment etc.

With underground water which contains no suspended solids except for manganese, contact filtration which uses manganese sand is most appropriate since coagulation-sedimentation is not necessary. In this case, filtration is performed immediately after pre-chlorination. In some actual operations, a manganese sand layer of 1,000~2,000 mm and a filtration rate of 500~600 m^3/day are employed.

When manganese is oxidized with chlorine to accelerate the oxidation reaction, chlorination is performed after adjusting pH values. Coagulation-sedimentation and filtration are then carried out. It is confirmed that, in this case, better removal is achieved if the pH values are adjusted slightly to the alkaline side, and the chlorine injection ratio is set to that 0.5 mg/ℓ of chlorine remains after coagulation-sedimentation and filtration.

If manganese removal which uses chlorine as an oxidation agent is continued, the filtration sand gradually turns black, since it becomes coated with manganese oxide, and starts to work in the same way as manganese sand. When this happens, manganese can be removed without pH value adjustment. Moreover, it has been reported that in a purification plant where coagulation-sedimentation and filtration are performed after pre-chlorination, filtration sand transformed itself into manganese sand in a few months, making it possible to remove manganese entirely