Ministry of Agriculture and Rural Development (MARD)
Center for Rural Water Supply and Environmental Sanitation (CERWASS)
The Socialist Republic of Vietnam

BASIC DESIGN STUDY REPORT ON THE PROJECT FOR THE GROUNDWATER DEVELOPMENT IN RURAL PART OF CENTRAL HIGHLANDS PROVINCES IN THE SOCIALIST REPUBLIC OF VIETNAM

MARCH 2006

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO ENGINEERING CONSULTANTS CO., LTD.

PREFACE

In response to a request from the Government of the Socialist Republic of Vietnam, the Government of Japan decided to conduct a basic design study on the Project for the Groundwater Development in Rural Part of Central Highlands Provinces in the Socialist Republic of Vietnam and entrusted the study to the Japan International Cooperation Agency (JICA)

JICA sent to Vietnam a study team from 12th September to 31st October, 2005.

The team held discussions with the officials concerned of the Government of Vietnam, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Vietnam in order to discuss a draft basic design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Socialist Republic of Vietnam for their close cooperation extended to the teams.

March 2006

Seiji Kojima
Vice-President
Japan International Cooperation Agency

March 2006

Letter of Transmittal

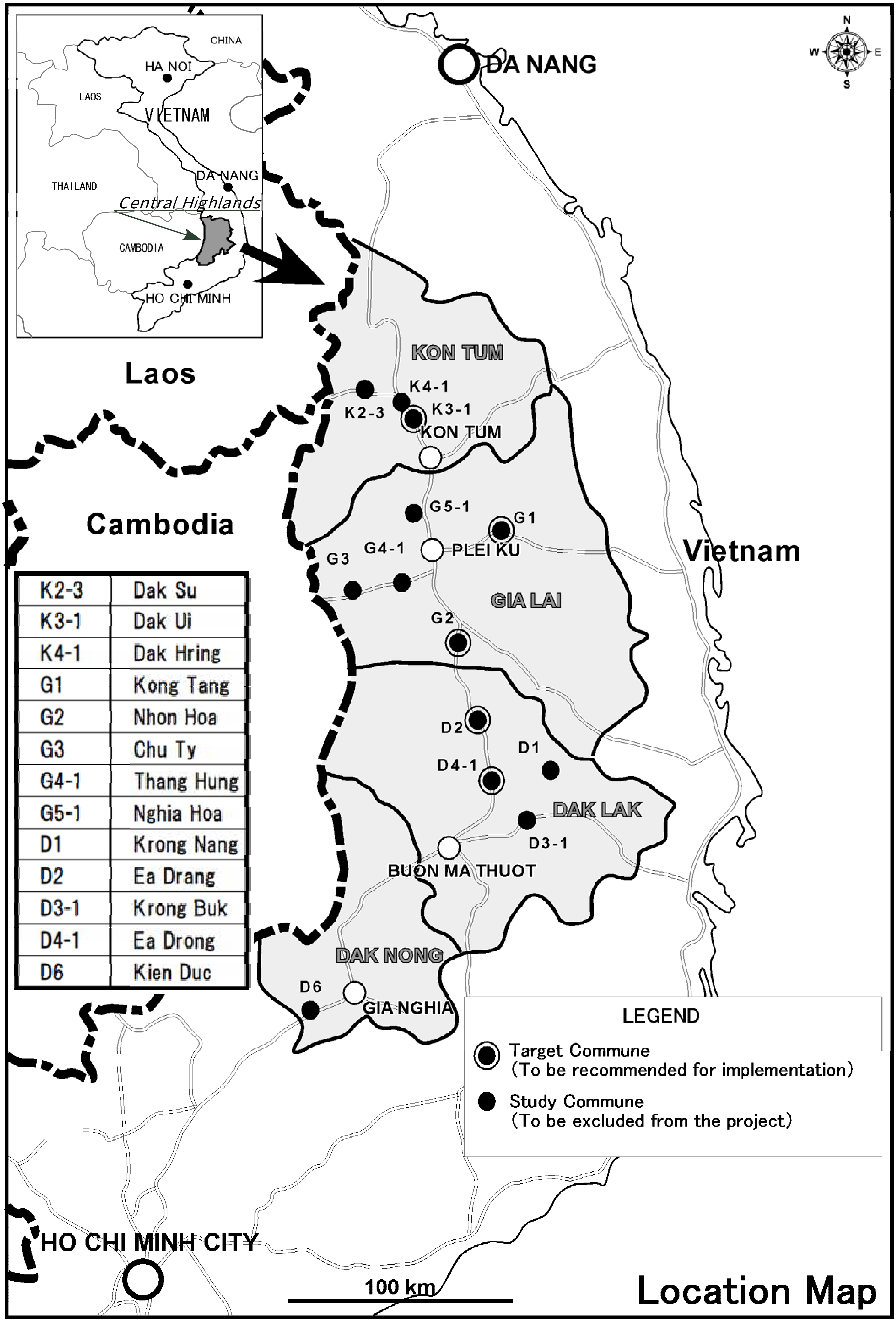
We are pleased to submit to you the basic design study report on the Project for the Groundwater Development in Rural Part of Central Highlands Provinces in the Socialist Republic of Vietnam.

This study was conducted by Tokyo Engineering Consultants CO., LTD., under a contract to JICA, during the period from September, 2005 to March, 2006. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Vietnam and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Kazufumi MOMOSE
Chief Consultant,
Basic design study team on
the Project for the Groundwater
Development in Rural Part of Central
Highlands Provinces in the Socialist
Republic of Vietnam
Tokyo Engineering Consultants Co., Ltd.



K2-3	Dak Su
K3-1	Dak Ui
K4-1	Dak Hring
G1	Kong Tang
G2	Nhon Hoa
G3	Chu Ty
G4-1	Thang Hung
G5-1	Nghia Hoa
D1	Krong Nang
D2	Ea Drang
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Abbreviations

ADB	Asian Development Bank
BD or B/D	Basic Design
BHN	Basic Human Needs
CERWASS	Center for Rural Water Supply and Environmental Sanitation
CPC	Commune People's Committee
DANIDA	Danish International Development Assistance
DARD	Department of Agriculture and Rural Development
DD or D/D	Detailed Design
DPC	District People's Committee
EIRR	Economic Internal Rate of Return
E/N	Exchange of Notes
FD	Financial Department
FIRR	Financial Internal Rate of Return
FR or F/R	Final Report
FS or F/S	Feasibility Study
GDP	Gross Domestic Product
IEC	Information, Education and Communication
JICA	Japan International Cooperation Agency
MARD	Ministry of Agriculture and Rural Development
M/D	Minutes of Discussions
MOC	Ministry of Construction
MOET	Ministry of Education and Training
MOF	Ministry of Finance
MOLISA	Ministry of Labour, Invalid and Social Affair
MOTC	Ministry of Transport and Communication
MP or M/P	Master Plan
MPI	Ministry of Planning and Investment
NRWSS	National Rural Clean Water Supply and Sanitation
ODA	Official Development Assistance
O&M or O/M	Operation and Maintenance
PC	People's Committee
P-CERWASS	Provincial Center for Rural Water Supply and Environmental Sanitation
PMU	Project Management Unit
PPC	Province People's Committee
RWSS	Rural Water Supply and Sanitation
S/W	Scope of Work
UNICEF	United Nations Children's Fund
VND	Vietnamese Dong
WB	World Bank
WATSAN	Water Supply and Sanitation
WMU	Water Management Unit
WSU	Water Supply Unit
d	day
hr	hour
JPY	Japanese Yen
kg	kilogram
kW	kilo Watt
l	liter
mL	milli-liter
min	minute
m	meter
mm	millimeter
m^2	Square meter
m^3	Cubic meter
s	second

Exchange rate 1US$＝110.54 Yen
(as of October 2005) 1VND＝0.00697 Yen

Summary

Summary

In the rural areas of Vietnam where surface water from river, pond, spring, groundwater from dug well, shallow well and rain water are used as sources of daily water for living, it has been difficult to secure the hygienic drinking water due to water source pollution and its drying up in the dry season, etc. This condition threatens health and hygiene of inhabitants and development of agricultural community. The delay of water supply improvement in rural areas has been caused by the suspension of policy formulation and project implementation due to the alteration and change of the organizations and government offices responsible for the rural water supply services. The delay also results from shortage of budget due to weak financial management. Therefore, in August 2000, intending to rectify the situation mentioned above, the Government of Vietnam approved, as the basic policy of the rural water supply and sanitation sector, "National Rural Clean Water Supply and Sanitation Strategy up to Year 2020 (NRWSS)" , which has the development targets as follows:

- By the year 2020, all rural people can at least use 60 liters of safe and clean water per person per day.
- By the year 2010, 85% of rural people can use 60 liters of safe and clean water per person per day.

Towards the achievement of NRWSS targets, the Ministry of Agriculture and Rural Development (MARD) has formulated the Master Plan[*] which clarifies the necessity to construct the water supply facilities in the Central Highlands (including Lam Dong Province) as shown in the table below with the planned amount of 863.1 billion VND (172.6 billion VND/year) from 2006 to 2010. In 2005, however, the three provinces (Kon Tum, Gia Lai and Dak Lak) received only about 35.6 billion VND from the Central Government. In addition, the three provinces received 20.9 billion VND from donors, 6.8 billon VND from provincial governments, and 18.3 billion VND from users. This resulted into a total expenditure of 83 billion VND[**] in three provinces, which is considered to be only half of the estimated cost (172.6 billion VND) required for the Central Highland. Accordingly, more investment is required in order to achieve the planned development targets.

Table 1 Number of Water Supply Projects planed for Central Highlands (2006-2010)

Water Supply Program	Central Highlands	Kon Tum Province	Gia Lai Province	Dak Lak & Dak Nong Provinces	Lam Dong Province
Pipeline Projects	900	99	225	415	161
Small Tube Wells	7,267	796	1,815	3,353	1,303
Dug Wells	14,405	1,578	3,606	6,643	2,578
Spring Preservation	1,249	137	312	576	224
Rain Water Tanks	14,152	1,555	3,545	6,519	2,533
Household Filtration Facilities	10,432	1,141	2,598	4,816	1,877
Amount (Million VND)	863,133	94,867	215,794	398,000	154,877

[*] Decision No. 3600/QD-BNN-KH, approved on September 6, 2000
[**] Kon Tum Province 13.5 billionVND, Gia Lai Province 29.5billion VND, Dak Lak Province 40 billionVND

As part of efforts to achieve the above target, in July 2002, the Government of Vietnam requested the Government of Japan to provide a grant aid for the implementation of “the Project for the Groundwater Development in Rural Part of Central Highlands Provinces in the Socialist Republic of Vietnam” formulated by the technical cooperation of Japan (Development Study). Main contents of the request are the improvement of water supply systems in 13 communes and the supply of power generator, solar power source, well drilling equipment and 4WD vehicles.

Responding to the request, JICA undertook the Basic Design Study of the project and dispatched the Study Team to Vietnam in two phases from 12 September to 31 October in 2005 and from 13 March to 24 March in 2006 for the field surveys and the explanation of the concepts of the basic design, respectively.

Towards the achievement of NRWSS, numerous small-scale water supply systems utilizing dug wells and shallow wells have been undertaken so far in Central Highlands. However, the systems are affected by pollution due to the infiltration of sewage and by water shortage in the dry season. Although the small-scale water supply systems have been operated and maintained by Commune People’s Committee (CPC), the management organization in each CPC has been weak. Furthermore, since the system is numerous, Provincial Center for Rural Water Supply and Environmental Sanitation (P-CERWASS) as the directing agency has not been able to carry out the supervision to CPC sufficiently.

In order to overcome the above-mentioned management problems, the Center for Rural Water Supply and Environmental Sanitation (CERWASS) has promoted the introduction of the central water supply system that is relatively large-scale and utilizes deep groundwater and surface water. The plan of drilling deep wells for the central water supply system is shown in Table 2.

Table 2 Well Drilling Plan in Central Highlands (2006-2010)

Province	Year	2006	2007	2008	2009	2010	Total
Kon Tum	No. of Wells	11	14	14	14	14	67
	Amount (million VND)	1,650	2,100	2,100	2,100	2,100	10,050
Gia Lai	No. of Wells	13	13	10	8	6	50
	Amount (million VND)	2,600	2,600	2,000	1,600	1,200	10,000
Dak Lak	No. of Wells	16	38	39	38	39	170
	Amount (million VND)	1,920	4,560	4,680	4,560	4,680	20.400
Dak Nong	No. of Wells	25	23	20	25	20	113
	Amount (million VND)	3,500	3,220	2,800	3,500	2,380	15,400
Total	No. of Wells	65	88	83	85	79	400
	Amount (million VND)	9,670	12,480	11,580	11,760	10,360	55,850

The large-scale water supply systems will be constructed for 5 communes in 3 provinces out of the requested 13 communes, and at the same time the management organization will be strengthened for the operation and maintenance of the water supply facilities to be constructed since CERWASS has limited experiences of large-scale water supply system.

In the Basic Design Study, it has been analyzed whether the communes' priority decided 3 years ago in the Development Study is still appropriate in 2005, and as a result the number of target communes is determined as 5. The proposed facilities planning in 5 communes is outlined in Table 3.

Table 3 Outline of Proposed Facility Plan in Target Communes

		K3-1 Dak Ui	G1 Kong Tang	G2 Nhon Hoa	D2 Ea Drang	D4-1 Ea Drong
2010 Maximum daily water supply (m3/day)		259	636	1,075	1,572	668
Deep well	Existing well*	1	1	1	-	1
	Proposed well	-	1	6	7	2
Conveyance pipe (km)		0.8(Existing)	2.2	7.9	5.3	4.9
Water treatment plant		Prechlorination, Aeration (Existing), Medium velocity filtration (Existing, Modification) , Chlorination	Prechlorination, pH Control, Rapid Sand filtration, Chlorination	Prechlorination, pH Control, Rapid Sand filtration, Chlorination	Prechlorination, pH Control, Rapid Sand filtration, Chlorination	Prechlorination, Aeration, Sedimentation, Rapid Sand filtration, Chlorination
Distribution reservoir		$90m^3$ (2 basins of $45m^3$ each)	$216m^3$ (2 basins of $108m^3$ each)	$360m^3$ (2 basins of $180m^3$ each)	$540m^3$ (2 basins of $270m^3$ each)	$228m^3$ (2 basins of $114m^3$ each)
Conveying pump		-	2 (Including 1 stand-by)	2 (Including 1 stand-by)	-	-
Elevated tank		-	1 basin of $38.7m^3$	1 basin of $50m^3$	-	-
Distribution pipe (km)		5.0	26.5	38.6	51.8	27.2
No. of service households		624	1,738	2,181	3,874	1,583

*The existing well was that drilled in JICA Development Study and will be utilized for production well in the Project.

Moreover, for the achievement of NRWSS, it is necessary to promote the construction of large-scale water supply system in many communes other than the above 5 communes. To accomplish this, the deep well drilling equipment with a capacity to drill a depth of 200m will be supplied which is the only mean of tapping large volume of deep aquifer water in this case. It is expected that the staff of CERWASS will acquire the technology and skill of large-scale water supply system and well drilling from the OJT through the Japan's assistance (construction of large-scale water supply facilities and the supply of well drilling equipment). Principal features of well drilling equipment are shown in Table 4.

Table 4 Principal Features of Well Drilling Equipment

Equipment		No.	Specifications
1. Well Drilling Equipment			
1-1	Well Drilling Rig	1 Unit	Type & Construction Method: Water well drilling rig, top head drive rotary drilling rig, designed for direct mud circulation and down-the-hole (DTH) drilling. Drilling Depth: upto 200m, Drilling Diameter: 4-3/4”
1-2	High Pressure Air Compressor	1Unit	Output: 30.0m^3/min Rated operating pressure: 2.41MPa
1-3	Miscellaneous Ancillary Equipment	1 Set	-Welder/Generator -Self priming pump Type: 200 liter/min x 20m head -Submersible dewatering pump 200 liter/min x 15m head -Oxygen-acetylene cutting and heating equipment, tool etc.
1-4	Air Lift Equipment	1 Unit	It corresponds to the depth of 200m
2. Supporting Equipment			
2-1	Crane Cargo Truck	1 Unit	6x4 drive, P.T.O. (Power Take Off)driven, cab-back hydraulic crane of 6 tons capacity, 9.0m. Payload capacity : 12,500 kgf, Cargo space length : 6.2m
2-2	Pumping Test Equipment (Submersible pump, Generator, Triangular weir)	1 Set	Submersible pump: Capacity : 240 liter/min x 70m head Submersible pump: Capacity : 576 liter/min x 50m head Generator: 10kVA, AC380V Accessories
2-3	Well Logging Equipment	1 Set	Measurement item: Normal resistively, SP, Natural gamma

The introduction and construction of the requested solar power and the procurement of equipment for the solar power generation system were excluded from the request, which was agreed by both sides. National power supply conditions of Vietnam has been so remarkably improved after the request made in 2002 that power generating system is not necessary any more.

The project cost is estimated at 2.26 billion yen (2.01 billion yen for the Japanese scope of works, and 0.25 billion yen for the Vietnamese scope of works). However, this cost estimate is provisional and would be further examined by the Government of Japan for the approval of the Grant. The implementation period will comprise 4 months for the detailed design and 31 months for the procurement of the equipment and the facility construction.

The improvement of water supply facilities in 5 communes of 3 provinces will contribute to the increase of population served by 44,974 persons and the increase of service ratio by 1.4%. By the supply of the equipment, 60 deep wells will be drilled in 21 communes of the Central Highlands area in 5 years. In 5 Target communes, water supply facilities including deep wells are proposed to be implemented by the Japanese side and in the other 16 communes, by the Vietnamese side. This total number of 21 communes also include Study communes (the 13 communes for which this Study has been carried out). In these 21 communes, the population served will be 200,000 persons and the service ratio will be increased by 6.3%.

It should be noted that several issues need to be addressed for the smooth implementation of the Project as stated below.

- Execution of construction works that has been assigned for the responsibility of Vietnamese side (such as fence construction, provision of access road, land leveling, etc.) during the construction
- Smooth commencement of the water supply services and its proper management to assure the sustainability
- Proper operation and maintenance of water supply facilities after the completion of those facilities
- Execution of strict groundwater monitoring with respect to water quality and water table after the commencement of water supply services
- Confirmation of the owners' intensions on land acquisition before the construction(This matter was confirmed with CPC in the Basic Design)

As stated above, the Project will enhance access to safe drinking water and the project will contribute to the improvement of BHN (Basic Human Needs) for the residents. Accordingly, it is confirmed that the Project is appropriate for the Japanese Grant Aid Scheme. The executing agency for the project is CERWASS under MARD. During the construction stage, the Project Management Unit (PMU) will be established in CERWASS for the management of overall project implementation. For the operation and maintenance of the facilities, the organization will be established in each commune. For the maintenance of the supplied rig and other equipment, the team will be established under the CERWASS.

BASIC DESIGN STUDY ON THE PROJECT
FOR THE GROUNDWATER DEVELOPMENT
IN RURAL PART OF CENTRAL HIGHLANDS PROVINCES
IN THE SOCIALIST REPUBLIC OF VIETNAM

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Chapter 1 Background of the Project

Chapter 1 Background of the Project

In the rural areas of Vietnam where surface water from river, pond, spring, groundwater from dug well, shallow well and rain water are used as sources of daily water for living, it has been difficult to secure the safe drinking water due to water source pollution and its drying up in the dry season. The ratio of the population served by clean water supply remains at 9 % in 2000 in rural areas, which threatens health and hygiene of inhabitants and development of agricultural community. The delay of water supply improvement in rural areas has been caused by the suspension of policy formulation and project implementation due to the alteration and change of the organizations and government offices responsible for the rural water supply services, and shortage of budget.

In 2000, intending to rectify the situation mentioned above, the Government of Vietnam approved, as the basic policy of the rural water supply and sanitation sector, "National Rural Clean Water Supply and Sanitation Strategy up to Year 2020 (NRWSS)". The NRWSS puts emphasis on the border areas, islands, minority tribes and poverty areas, and the Central Highlands are located in one of these areas.

To achieve the NRWSS targets, the Ministry of Agriculture and Rural Development (MARD) which is considered as the responsible agency for the rural water supply, formulated the Master Plan with the target year of 2010 for the Central Highlands. The Master Plan has been inplemented not only with the Vietnamese own fund but also the assistance of UNICEF, DANIDA, World Bank, ADB as well as the other bi-lateral donors, because a huge amount of investment is required in order to achieve the target set out the planned development targets.

In respons to the request of the Government of Vietnam, the Study on Groundwater Development in the Rural Provinces of the Central Highlands (the Development Study) was carried out for the 3 provinces (Kon Tum, Gia Lai and Dak Lak) in the Central Highlands under the technical cooperation of the Government of Japan from January 2001 to August 2002. The Development Study was conducted to formulate a master plan and to carry out a feasibility study, and as a result, 17 water supply systems were proposed to be implemented in these 3 provinces. In addition, the Study confirmed that the positive effects expected by the Project implementation are to contribute the improvement of the service ratio as set for the national target, to demonstrate the Project as a model of water supply system, to play a role of technical cooperation in technical and institutional aspects, and to improve the hygiene conditions of inhabitants. Considering these effects, it is proposed to implement the Project.

Based on the results of the above Development Study, the Government of Vietnam requested the Government of Japan to provide the grant for implementing "the Project for the Groundwater Development in Rural Part of Central Highlands Provinces in the Socialist Republic of Vietnam". The contents of the request are summarized below.

Table 1.1 Contents of the Request

(A)	Facility Construction Construction of water supply facilities for 13 communes of 4 Provinces in the central Vietnam (Kon Tum Province, Gia Lai Province, Dak Lak Province, Dak Nong Province). The solar power generation system is requested in 4 communes.	
(B)	Provision of Equipment	
	Well drilling rig (200m depth type):	1 unit
	Supporting Vehicle (4WD):	4 units
	Water Tank Truck:	1 unit
	Truck with crane:	1 unit
	Materials for well (casing pipe, etc.):	1 unit
	Maintenance equipment for well (air compressor, etc.):	1 unit
	Testing equipment (Well logging equipment, Equipment for water quality analysis, Pumping test equipment):	1 unit
	Solar power generation system (including power generator and water pump):	4 sets

Responding to the request, the Government of Japan send the Basic Design Study Team to Vietnam from September to October in 2005 through JICA (Japan International Cooperation Agency).

In the Basic Design Study, it was confirmed that the communes' priority proposed 3 years ago in the Development Study is still appropriate in 2005, and as a result the number of target communes is determined to be 5 in the 3 provinces. Moreover, for the achievement of NRWSS, the deep well drilling equipment with a capacity to drill a depth of 200m, which is the only mean of tapping large volume of deep aquifer water, was also proposed to be supplied to construct the water supply systems in those communes in the 3 provinces other than the above 5 communes.

Based on the results of the Basic Design, JICA dispatched the Explanation Team of the draft report to Vietnam in March 2006, and agreed on the contents of the Project with MARD and CERWASS (Center for Rural Water Supply and Environmental Sanitation) of the executing agency after a series of discussion with them.

Chapter 2 Contents of the Project

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

2-1-1 Objectives of the Project

The objectives of the project are described below.

- To construct the water supply facilities with the water source of groundwater in 5 communes for hygienic drinking water on sustainable basis
- To provide well drilling rig for promoting construction of water supply facilities in other communes
- To conduct “soft-component” such as capacity building for operation and maintenance of waterworks

In the rural areas of Vietnam where domestic water has been usually taken from surface water sources such as rivers, ponds, springs, shallow groundwater and rain water, it has become difficult to secure stably the hygienic drinking water due to water source pollution and its dry up in the drying season, etc., and hence it is a big obstacle to the health care of inhabitants and social development.

In order to overcome the situation mentioned above, in August 2002, the Government of Vietnam approved, as the basic policy of the sector for rural water supply and sanitation, “National Rural Clean Water Supply and Sanitation Strategy up to Year 2020” (NRWSS) which has the targets as follows:

- By the year 2020, all rural people can use at least 60 liters of safe and clean water per person per day.
- By the year 2010, 85% of rural people can use 60 liters of safe and clean water per person per day.
- By the year 2005, kindergartens, schools, hospitals, markets and public facilities are supplied with safe and clean water.

In order to partly achieve the targets mentioned above, Japan carried out the construction of water supply facilities and the supply of well drilling equipment for the targeted 12 communes in the northern provinces.

Further, NRWSS pointed out 3 areas* where there are problems of water sources. The mountainous Central Highlands is one of them where the study on groundwater development (M/P and F/S) was implemented with cooperation from Japan. In this development study, for the 20 target communes (population of 128,000 persons in 2000) of district-center and semi-district-center towns in 3 provinces (with a total population of 3,060,000 persons in 1999), the availability of groundwater (deep well) with stable water volume and good quality all year round was confirmed and the pumping test was carried out to assess safe yield and then the M/P and F/S were formulated for the confirmed water source.

Table 2.1 shows the water supply plan in Central Highlands to achieve the NRWSS target.

Table 2.1 Outline of Water Scheme in Central Highlands

(unit:nos.)

Water Supply System	Central Highlands	Kon Tum Province	Gia Lai Province	Dak Lak & Dak Nong Provinces	Lam Dong Province
Piped Schemes	900	99	225	415	161
Small Tube Wells	7,267	796	1,815	3,353	1,303
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Spring Protections	1,249	137	312	576	224
Rain Water Tanks and Jars	14,152	1,555	3,545	6,519	2,533
Household Surface Water Treatment Facilities	10,432	1,141	2,598	4,816	1,877
Budget (Million VND)	863,133	94,867	215,794	398,000	154,877

(Source: MARD)

In accordance with the proposal of the development study of the central highlands mentioned above, the objectives of the Project are to construct the water supply facilities for 5 communes of 3 provinces (K3-1 Dak Ui, G1 Kong Tang, G2 Nnoh Hoa, D2 Ea Drang, D4-1 Ea Drong, water supply service population of about 44,974 persons in total) in order to supply hygienic drinking water on sustainable basis and to supply the well drilling equipment in order to promote construction of water supply facilities in other communes.

2-1-2 Outline of the Project

2-1-2-1 Necessity for Improvement of Facilities and Supply of Equipment

Towards the achievement of NRWSS, numerous small-scale water supply systems utilizing dug wells and shallow wells have been constructed so far. However, the water source of the

* As other areas, it is pointed out such as the coastal area and islands where chloride ion concentration is high in water quality and also the lime stone area where groundwater level is deep and surface water is poor.

systems contain the problems of the deterioration of water quality due to the infiltration of sewage and the shortage of water supply volume in the dry season. Moreover, although the small-scale water supply systems have been operated and maintained by households or CPC, the management for the operation and maintenance in each households or CPC has remained insufficient situation. Furthermore, since the number of system is numerous, P-CERWASS as the directing agency has not been able to carry out the supervision to CPC sufficiently.

Accordingly, since CERWASS has very little experience of working with large-scale water supply system, under the Project, the large-scale water supply system will be constructed for 5 communes in 3 provinces and, at the same time, the management organization will be strengthened for the appropriate and efficient operation and maintenance of the water supply facilities to be constructed. Moreover, for the achievement of NRWSS, since it is necessary to promote the construction of large-scale water supply system in many communes in future besides 5 communes also, the deep well drilling equipment with a drilling depth capacity of 200m will be supplied to facilitate tapping of large volume of deep aquifer. It is expected that the staff of CERWASS will acquire the technology and skill of water supply and well drilling through the OJT of the project and, after the completion of the Project, can utilize its skills towards construction and O & M of the water supply systems in other communes. The details of the necessity for facilities improvement and equipment supply are explained in Appendix 15.

The improvement of water supply facilities in 5 communes of 3 provinces will contribute to the increase of population served by 44,974 persons and the increase of service ratio by 1.4%. By the supply of the equipment, 60 deep wells will be drilled in the Central Highlands area for the next 5 years. The total number of communes for well drilling will be 21 consisting of 5 target communes where the water supply facilities are to be improved and other 16 communes. In these 21 communes, the population served will be 200,000 persons and the service ratio will be increased by 6.3%.

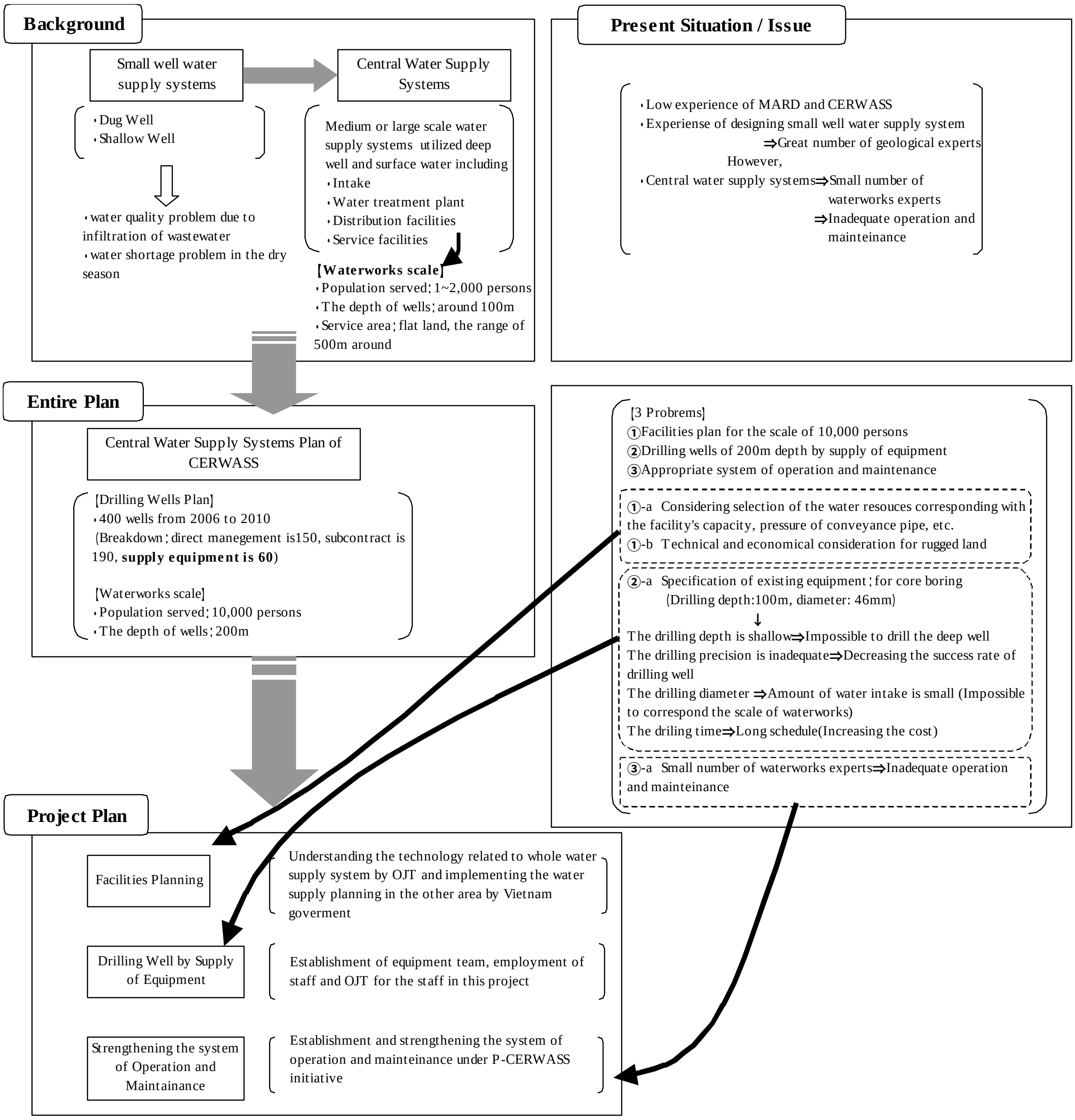

Figure 2.1 Necessity for Improvement of Facilities and Supply of Equipment

2-2 Basic Design of the Requested Japanese Assistance

2-2-1 Design Policy

- To utilize the existing wells (exploratory wells drilled during JICA Development Study and wells drilled and used for the existing water supply systems)
- To utilize the existing water supply facilities such as transmission pipeline, water treatment plant, pump station, distribution pipeline.
- To design the water treatment plant in order to remove iron and manganese properly
- To design the disinfection equipment in order to secure safe drinking water
- To procure materials of transmission pipeline and distribution pipeline as much as possible in Vietnam in accordance with the Vietnamese standards.
- To plan and design such water supply facilities as that the staff of WMU (Water Management Unit) employed from communes are able to operate and maintain by themselves, securing the basic functions of water treatment. It is, therefore, proposed to apply the system of manual operation with monitoring facilities of minimum required items consisting of simple equipment.
- To decide specifications of new well drilling rig so as to be used not only for the Project but also for other projects in the Central Highlands in the future.
- For the house connection, the materials up to water meters (service pipes & ancillaries and water meters) are to be supplied and, the installation is to be done by the users.

2-2-1-1 Natural Conditions and Social Conditions

(1) Natural Conditions

The target area is located in the highland area of the latitude 13°North with the elevation of +350m ~ +750m above the sea level. The climate is the tropical monsoon and the seasons in a year are classified into two, rainy season and dry season. The maximum temperature in the dry season is 33℃～37℃, and during the daytime is strong sunshine. In the rainy season, there are squalls with thunder in the morning and evening, and temperature becomes high during the daytime. Therefore, it is necessary to consider the thunder.

For the design, high temperature, abundant rain, high humidity should be considered. Although Vietnam is not a quake-prone country, the anti-seismic consideration of lower grade is required for the structures.

As for the geological formation in the Central Highlands, the hard unconsolidated layer appears with the depth from five (5) to 20 m, and the exploitable aquifer is located below this layer. It is necessary to drill the borehole as deep as about 200 m to reach the target aquifer. The specifications of the drilling rig to be procured have to be determined so as to meet these conditions

(2) Social Conditions

The study areas are the communes engaged mainly in the primary industry (agricultural production of rice, vegetable, rubber, coffee, pepper, etc.). With respect to the minority ethnic groups and religions, there is no social problem to be considered specially.

In the public projects of Vietnam, the land acquisition is a big task. In case of the private land, it takes especially a long time because of the complication in the procedures for obtaining the agreement and permission of the land acquisition. Therefore, in the selection of lands for the facilities, the public lands should be selected as much as possible.

It is assumed that there are remaining unexploded ordnance that were used during the American War for which the Vietnam side will carry out the detection and inactivation before the commencement of construction activities.

2-2-1-2 Conditions and Issues in Construction and Procurement

(1) Construction/ Procurement Conditions or Special/Local Practices of Business

The construction materials such as sand and crushed stones are available at the site but other materials and well pumps are procured from Hanoi or Hochiminh City. The equipment to be installed such as distribution pumps, flow meters, valves, etc., are procured from Japan or third countries.

For the pipeline installation, when the pipeline crosses the important line facilities such as existing national road, river, canal, river embankment, etc., the crossing works are to be entrusted to the Vietnamese side (Management authority of the facility concerned) because the procedures of obtaining the permissions or authorizations are required.

(2) Use of Local Companies (Construction and Consultant Companies)

There are some state and private construction companies in Gia Lai and Dak Lak Provinces, who are working on the construction of roads, bridges, river works, water supply & sewerage, electric power, communication, buildings, etc. that are of small or medium volume. The large scale construction works are done by the construction companies of Hanoi or Hochiminh City. Although there is concern about the use of local construction companies with experiences of small size or medium size construction works only, they can be used as subcontractors under the supervision of Japanese engineers.

(3) Condition and Issue in Procurement of Well Drilling Rig

There are some problems in terms of the capacity and durability of the old well drilling equipment that are made in China, Russia, etc. Therefore, the Government of Vietnam has requested to procure made-in-Japan products.

2-2-1-3 Simple and Economical Operation and Maintenance

The water supply system to be provided is considered as a new public facility in the target communes. A WMU will be established in each commune to operate and maintain the system under the technical supervision of the respective P-CERWASS. To facilitate the commune-level operation and maintenance, it is essential to apply the simple system requiring the professional skills and labors to a minimum extent in operation and maintenance without any difficulty in obtaining spare parts.

With regard to the well drilling rig, CERWASS will establish the equipment team and conduct the O&M through this team after the project. The drilling equipment should be of similar type as one provided for "Project for the Groundwater Development in Rural Part of Northern Provinces in the Socialist Republic of Vietnam"(referred to as the northern project) so that the technical staff in the equipment team for this project can conduct the O & M without problems with a technical transfer from the staff in the previous project.

Since the budget of CERWSS and the capacity of inhabitants to bear the costs are limited, it is necessary to design the facilities and the equipment so as to reduce the costs of operation and maintenance as much as possible. Especially, it is necessary to consider the reduction of electric power cost that contributes a major part of total costs for the operation and maintenance. Since the drilling equipment is of similar type as one in the northern center, some spare parts and consumable supplies can be shared with each other resulting in O&M cost reduction.

(1) Capacity of Executing Agency for Management of Operation & Maintenance

Except one commune where the pilot projects were carried out under JICA Development Study and one commune where there are existing facilities although they are small scale, it is necessary for other communes to establish new organizations. Therefore, the water management unit (WMU) will be set up mainly by P-CERWASS in each province for the management of waterworks.

Based on the policy of the Government of Vietnam, it is expected that the water supply service shall be managed by the self-supporting financial system with the income source of the water charges collected from the users. The management of 2 communes with the existing facilities will be modified to the similar organizations because the size of facilities will be enlarged by the Project.

In Dak Lak Province, P-CERWASS is proposing to the provincial government that P-CERWASS will manage the operation and maintenance of all large-scale water supply facilities within the province, and it is supposed that the proposal will be accepted in the Province Assembly.

(2) Operation and Maintenance of the Equipment

Japan has supplied the well drilling equipment for exclusive use in the North as the grant aid cooperation. It has drilled 16 wells by the year 2005. From now on, the equipment will be used to drill wells annually in the northern provinces of dry areas and it is planned to improve water supply service ratio in the northern areas. The supplied equipment is operated and maintained by the staff of 9 persons such as an engineer, etc. and they use the equipment fully and effectively.

The equipment supplied by this project is expected to use effectively through the equipment team to be established in the Central Vietnam. The equipment team, consisting of 9 persons similar to the North, will accumulate experiences through on-the-job training of the Project as well as training from the North center.

2-2-1-4 Construction Period

The water supply facilities of the Project are the general facilities with exception of iron and manganese removal facilities and the geological conditions are good. The facilities will be constructed with the general construction materials and construction machinery. Therefore, it will be unnecessary to use any special construction methods or procure anything special.

The construction period is planned for 3 years due to the following reasons:

- The construction sites (5 communes) are separated in 3 provinces.
- The pipelines are long (about 20.0 km of transmission pipeline and about 149.1 km of distribution pipeline).
- The rainy season is long (about 6 months from May to October).
- The rainfall volume (with thunder) is abundant.

The land acquisition is the responsibility of the Vietnamese side. Since it takes a long time for any land acquisition in Vietnam, it is necessary to consider some measures not to cause any delay in the process of land acquisition.

Based on the JICA development study result, the well drilling location and well yield were determined, after carrying out the geophysical investigation additionally. The success rate of a well drilling is assumed to be from 80% to 85%, and modification of the well drilling location may be expected or it may be unable to secure the water requirement in the worst case. Therefore, construction of the water supply facilities should not start before wells are confirmed to yield sufficient amount of water.

Procurement schedule of drilling rig are to be carefully planned because, only after confirmation of well yields and quality, other water supply facilities can be started. Failing of development of appropriate procurement plan will delay whole construction schedule.

The service pipeline work is the responsibility of the users and it will be covered by the counterpart fund from the Central Government. In order to effectively utilize the counterpart fund, the IEC activities to promote the public relations with the inhabitants is recommended to conduct in advance.

2-2-2 Basic Plan (Construction Plan/ Equipment Plan)

2-2-2-1 Target Year of Project

The target year of the Project is 2010 according to the followings:

- The Project is implemented as the grant aid cooperation of Japan. It is aimed for the project to obtain its effects as early as possible in the near future for solving the problems in the present conditions.
- One of the target years of NRWSS is 2010.
- Coincidence with the target year of JICA Development Study
- The final completion of facilities constructed by the Project will be in 2010

2-2-2-2 Service Area and Population Served

The water supply service areas are decided considering degree of densely or sparsely households. The service areas are shown in the DWG NO (1)~(5) of the basic design drawing. The future population of each commune in 2010 is estimated by using the growth rate of population from 2000 to 2005. The total population in 2010 is 52,910 persons. The target of NRWSS, 85%, is adopted for the service ratio. The service population is therefore 44,974 persons.

After 2011, the growth rate is assumed to decrease. However, for the communes where the population growth rate is becoming stable, the same rate until 2010 is assumed to continue.

Table 2.2 Population in Service Area

Province	Commune		Population (Person) 2005	Population Growth Rate (%)		Population (Person)	
				2005-2010 Actual	2010-2020 Adoption	2010	2020
Kon Tum	K3-1	Dak Ui	2,505	5.30	2.03	3,243	3,965
	(K3)	(Total of K3)	(5,704)			(7,386)	(9,038)
Gia Lai	G1	Kong Tang	6,668	3.70	2.30	7,996	10,038
	G2	Nhon Hoa	11,479	0.80	0.80	13,521	16,809
Dak Lak	D2	Ea Drang	19,465	0.30	0.30	19,759	20,360
	D4-1	Ea Drong	7,600	2.00	1.20	8,391	9,454
	(D4)	(Total of D4)	(9,644)			(10,648)	(11,996)
Total	(Except for the total of K3 and D4)		47,717	-	-	52,910	60,626

*1 Population from 2004 to 05 in G2 (Nhon Hoa) are estimated since the population data for these period doesn't exit.

*2 Population of D2 (Ea Drang) in 2020 includes the population of K.9 and B.Le Da as population in service area.

2-2-2-3 Design Water Supply

The service ratio and the per capita water demand in 2010 and 2020 are set as follows:

Table 2.3 Targets of Water Supply Plan

Year	2010	2020
Rate of population served (%)	85	100
Water demand per capita (l/capita /day)	60	60

For the planning of water supply facilities, average daily supply, maximum daily supply, maximum hourly supply are required, and therefore, estimated in accordance with the following definition:

Table 2.4 Definitions of Daily Average Supply, Daily Maximum Supply and Hourly Maximum Supply

Item	Definitions
Daily Average Supply (Q_{av})	$Q_{av} = q \times p \times 1.2$ q: Effective Demand = per capita Water Demand (60LCD) p: Population to be served = Population in service area ×Rate of population served (85% in 2010, 100% in 2020) 10% is added here for non-domestic use like commercial and institutional uses. 10 % is added here for leakage.
Daily Maximum Supply (Q_{max})	$Q_{max} = Q_{av} \times$ Daily maximum coefficient value (1.3) Q_{max} is used to determine: ➢ Number of required wells (depending on safe yield), ➢ Diameter of raw water pipes, ➢ Capacity of water treatment plants ➢ Capacity of elevated water tank and reservoirs
Hourly Maximum Supply (q_{max})	q_{max} = Daily Maximum Supply (Q_{max}) × Time coefficient value(2.0) q_{max} is used to determine diameter of distribution pipes.

According to the definition mentioned above, the daily average supply, daily maximum supply, hourly maximum supply in 2010 and 2020 are estimated, respectively. The result of estimation is as follows:

Table 2.5 Necessary Water Supply Quantity(2010)

Province	Commune		Estimated Population (Person)	Population Served (Person)	Rate of population served (%)	Daily Average Supply (Q_{av}:m^3/d)	Daily Maximum Supply (Q_{max} :m^3/d)	Daily Maximum Hourly Supply (q_{max} :m^3/hr)
Kon Tum	K3-1	Dak Ui	3,243	2,757	85	199	259	22
	(K3)	(Total of K3)	(7,386)		37			
Gia Lai	G1	Kong Tang	7,996	6,797	85	489	636	53
	G2	Nhon Hoa	13,521	11,493	85	827	1,075	90
Dak Lak	D2	Ea Drang	19,759	16,795	85	1,209	1,572	131
	D4-1	Ea Drong	8,391	7,132	85	514	668	56
	(D4)	(Total of D4)	(10,648)		67			
Total (Except for the total of K3 and D4)			52,910	44,974		3,238	4,210	-

Table 2.6 Necessary Water Supply Quantity (2020)

Province	Commune		Estimated Population (Person)	Population Served (Person)	Rate of population served (%)	Daily Average Supply (Q_{av}:m^3/d)	Daily Maximum Supply (Q_{max} :m^3/d)	Daily Maximum Hourly Supply (q_{max} :m^3/hr)
Kon Tum	K3-1	Dak Ui	3,965	3,965	100	285	371	31
	(K3)	(Total of K3)	(9,038)		44			
Gia Lai	G1	Kong Tang	10,038	10,038	100	723	940	78
	G2	Nhon Hoa	16,809	16,809	100	1,210	1,573	131
Dak Lak	D2	Ea Drang	20,360	20,360	100	1,466	1,906	159
	D4-1	Ea Drong	9,454	9,454	100	681	885	74
	(D4)	(Total of D4)	(11,996)		79			
Total (Except for the total of K3 and D4)			60,626	60,626		4,365	5,675	-

2-2-2-4 Water Supply Service Level

The nature in the target communes is not like a village. Therefore, the house connection system is reasonable for every commune.

2-2-2-5 Construction Plan

The outlines of water supply facilities in each commune are mentioned in the Appendix 16.

(1) Facility of Water Source

1) Number of Wells

The water source is selected, as a basic principle, to satisfy the water quality standard of drinking water in Vietnam. If the water quality of the deep well water source does not meet the standard, the water treatment is considered with the conventional technology and conventional method in Vietnam. If water quality does not improve to the standard with use of conventional technology and method, the water source shall be excluded from the development target.

The well drilling plan is formulated based on the results of JICA development study and this basic design study. In the JICA development study, the results are obtained through geophysical prospecting and water-pumping test. The basic study team only supplemented the JICA development study by electrical sounding.

The existing exploratory wells drilled in JICA Development Study are used as the production wells in principle. However, concerning D2 Ea Drang of the exploratory wells in JICA Development Study, the sufficient water volume have not been secured and therefore this well will not be used as the production well.

Considering these factors, in each commune the number of wells are planned and shown in Table below.

Table 2.7 Safe Yield and Number of Planned Wells

Commune	Daily maximum supply in 2010 (m^3/day)	Safe Yield (m^3/day)	Number of wells		
			Existing (JICA to be used)	Planned	Total
K3-1 Dak Ui	259	259	1		1
G1 Kong Tang	636	322	1	1	2
G2 Nhon Hoa	1,075	173	1	6	7
D2 Ea Drang	1,572	225		7	7
D4-1 Ea Drong	668	268	1	2	3
Total	4,210		4	16	20

2) Drilling Site

The well drilling sites are selected in accordance with the following criteria:

a) Selection Criteria for Proposed Area

- In the hydro-geological map prepared by the JICA Development Study, the area of favorable hydro-geological condition where groundwater potential is high is considered.
- Based on the data of existing wells and the result of electrical sounding carried out in the

JICA Development Study, the area where there are most promising ground-layers in the hydro-geological section are identified.

- Based on the supplemental electrical sounding, the areas are identified.
- The area close to the target area for water supply of the Project and the area close to the site of proposed water supply facilities are selected.
- The area where the groundwater level is relatively high and the energy for pumping up water is as small as possible are selected.

In the selected sites mentioned above, the site surveys were carried out together with the staff of CERWASS.

b) Selection Criteria for Drilling Sites

- The site where the construction vehicles for well drilling can be driven into and the land can be secured for the construction works of well drilling.
- The site where the land not only for drilling works but also for construction of ancillary facilities of a well can be secured and the electric power for construction works can be supplied.
- The site where the land acquisition is possible by the Vietnamese side.

3) Well Structure

A schematic well structure of water source is shown in Figure 2.2.

The planned drilling depth of new wells is decided from the existing boring data and the result of electrical sounding carried out in this study (refer to appendix 11). The length of screen is estimated from the existing boring data and the through inflow velocity. The basic structure of each well is shown in Table 2.8

The materials of casing and screen for wells are made of FRP by considering the anti-corrosiveness. Since iron in raw water may become the cause of scale adherence, the screen-opening ratio is calculated as about 20%.

Typical Figure of Well Structure

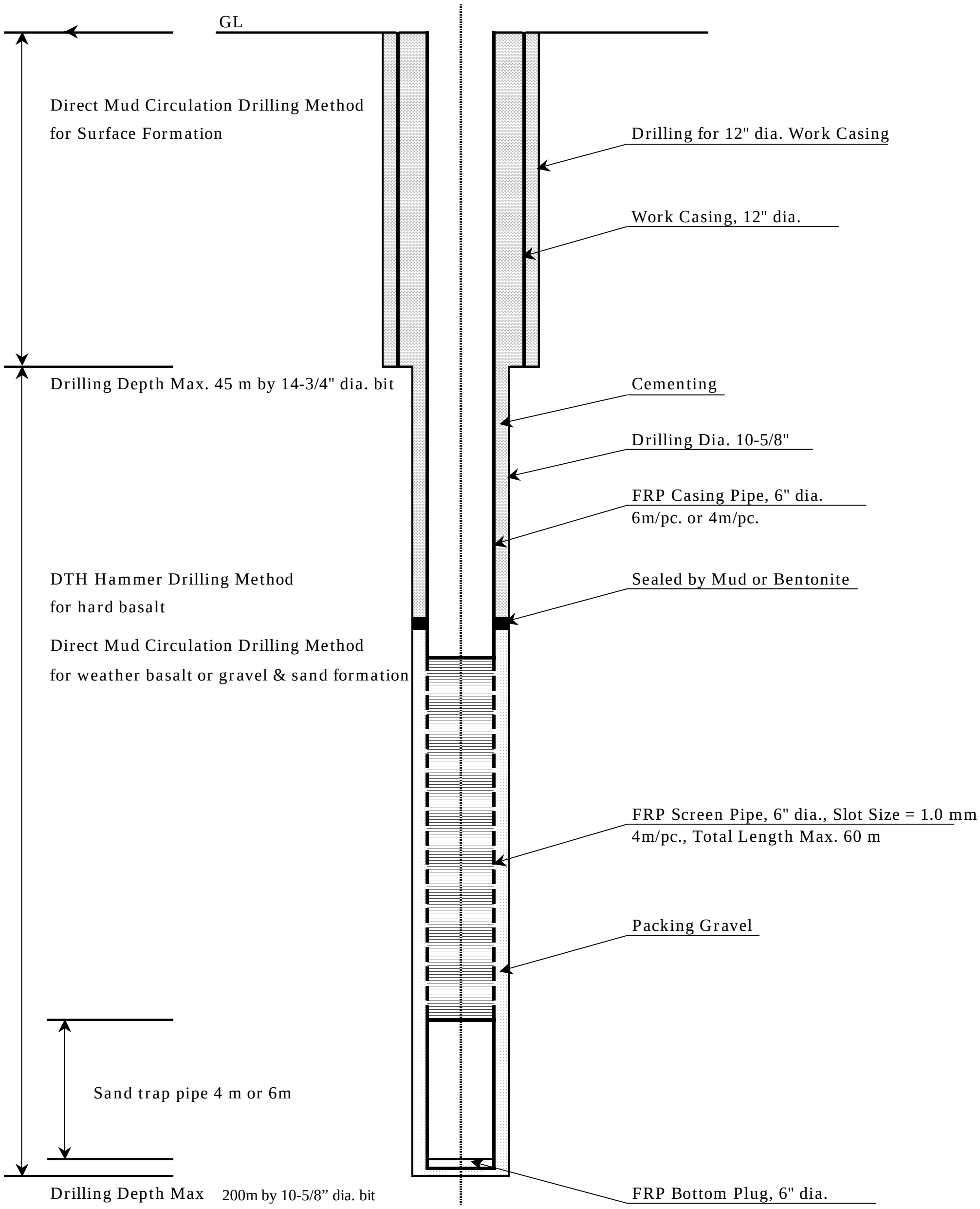

Figure 2.2 Well Structure

Table 2.8 Basic Structure of Each Well

Commune	No.	Maximum Drilling depth (m)				Diameter of casing and screen (mm)	Length of screen (m)	Remarks
		Diameter 300mm	Diameter 240mm	Diameter 110mm	Total			
K3-1 Dak Ui	J1		40	120	160	150	28	
G1 Kong Tang	J1		112	38	150	150	40	
	N1	120		30	150	150	48	
G2 Nhon Hoa	J1		110	60	170	150	34	
	N1	140		30	170	150	40	
	N2	140		30	170	150	40	
	N3	120		30	150	150	40	
	N4	140		30	170	150	40	
	N5	140		30	170	150	40	
	N6	120		30	150	150	40	
D2 Ea Drang	(J1)		120	60	180	150	48	To be Abolished
	N1	120		30	150	150	60	
	N2	120		30	150	150	60	
	N3	120		30	150	150	60	
	N4	120		30	150	150	60	
	N5	120		30	150	150	60	
	N6	120		30	150	150	60	
	N7	120		30	150	150	60	
D4-1 Ea Drong	J1		120	60	180	150	60	
	N1	150		30	180	150	60	
	N2	150		30	180	150	60	

Note: J is existing JICA well, N is new drilling well

4) Specification of Well Pump

Main specifications of the submergible water pump inside the well, like optimum pumping yield, static water level, dynamic water level and depth of pump installation are established as follows:

- Safe yield is decided based on the pumping test in the JICA exploratory wells carried out during the JICA development study. However, since pumping tests were not available in D2 Ea Drang, the supplementary pumping test under this study is used to decide safe yield.
- The static water level and dynamic water level are estimated based on the exploratory results in the JICA Development Study and the data of existing neighbouring wells.
- The depth of pump installation is estimated considering the dynamic water level, seasonal change of water level and some allowances. The specification of well pump is shown in Table 2.9.

Table 2.9 Specification of Well Pump

Commune	No.	Required well yield (m3/d)	Well Designed Water Level (Elevation:m)	Static Water level (Elevation:m)	Dynamic water level (Elevation:m)	Pump Installed Level (Elevation:m)	Pump specification
K3-1 Dak Ui	J1	259	665	663	647	627	0.18m3/min×79m×5.5kw
G1 Kong Tang	J1	322	735	701	679	665	0.23m3/min×73m×5.5kw
	N1	322	736	701	675	666	0.23m3/min×82m×5.5kw
G2 Nhon Hoa	J1	173	408	387	347	338	0.12m3/min×87m×3.7kw
	N1	173	408	387	347	338	0.12m3/min×87m×3.7kw
	N2	173	408	387	347	338	0.12m3/min×88m×3.7kw
	N3	173	380	370	320	310	0.12m3/min×118m×5.5kw
	N4	173	406	385	346	336	0.12m3/min×86m×3.7kw
	N5	173	420	390	350	340	0.12m3/min×85m×3.7kw
	N6	173	383	373	323	313	0.12m3/min×116m×5.5kw
D2 Ea Drang	(J1)	-	625	597	576		-
	N1	225	583	555	523	513	0.16m3/min×141m×7.5kw
	N2	225	566	555	515	496	0.16m3/min×150m×7.5kw
	N3	225	565	555	515	495	0.16m3/min×150m×7.5kw
	N4	225	560	550	505	490	0.16m3/min×161m×7.5kw
	N5	225	554	550	500	484	0.16m3/min×165m×11kw
	N6	225	552	545	497	482	0.16m3/min×167m×11kw
	N7	225	588	560	518	508	0.16m3/min×144m×7.5kw
D4-1 Ea Drong	J1	268	615	593	563	545	0.19m3/min×117m×7.5kw
	N1	268	623	610	565	553	0.19m3/min×112m×7.5kw
	N2	268	600	590	545	530	0.19m3/min×139m×7.5kw

(2) Transmission Facilities

The transmission facilities consist of the transmission pipeline and its ancillary equipments in which the raw water is transmitted by the pressure of intake pump from the well to the water treatment facilities.

1) Route of Transmission Pipeline

The route of the transmission pipeline is planned to be installed in the shortest route along the public roads between the well and the water treatment facilities. In cases when the transmission pipeline and the distribution pipeline are to be installed along same public road, the construction cost saving is considered by installing both of them in the same section of excavation. If the installation inside the rice or other crops fields is inevitable due to the site conditions, the temporary construction method and installation method should be considered in order not to affect the cultivation of rice or other crops as much as possible.

2) Pipe Material and Diameter of Pipe

PVC pipe is adopted because it is possible to procure it in Vietnam and there are advantages such as strength for pressure, anti-corrosion, easy construction and economical advantage that are coincident with the objective of the Project. However, in the locations where it crosses the canal and river and where it is installed on the ground surface, the use of steel pipe will be considered. Concerning the diameter, it is estimated by considering the diameter of economical flow velocity, the lifting capacity of intake pump and the reduction of electric power cost. The summary on dimensions of transmission pipeline is shown in Table 2.10.

Table 2.10 Outline of Transmission Pipe

Commune	Dimension & Specification	
	Diameter (mm)	Length (km)
K3-1 Dak Ui	ϕ100 (Existing)	0.8 (Existing)
G1 Kong Tang	ϕ100～ϕ150	2.2
G2 Nhon Hoa	ϕ80～ϕ250	7.9
D2 Ea Drang	ϕ125～ϕ150	5.3
D4-1 Ea Drong	ϕ100～ϕ125	4.9
Total		20.8

(3) Water Treatment Facilities

1) Item for Treatment

By comparing the drinking water quality standard in Vietnam and the water quality in each commune, the items (parameters) for treatment are shown in Table 2.11.

Table 2.11 Raw Water Quality & Water Quality Standard in Vietnam

Commune	Item			Aeration	Iron Removal	Manganese Removal	pH Control	Chlorination
	Iron (mg/l)	Manganese (mg/l)	pH					
Water quality standard	0.3	0.1	6.5-8.5					
K3-1 Dak Ui	***3.49***	***0.1211***	7.19	○	○	○		○
G1 Kong Tang	***0.82***	0.0130	***5.30***		○		○	○
G2 Nhon Hoa	0.21	***0.1950***	***5.40***			○	○	○
D2 Ea Drang	***0.39***	0.0410	***6.42***		○		○	○
D4-1 Ea Drong	***3.76***	0.0390	7.85	○	○			○

2) Water Treatment Process

a) Existing Facilities

The following facilities are utilized in K3-1, that were constructed under JICA Development Study:

- Aeration facility
- Sand filter (filtration area: $15.7m^2$)
- Distribution reservoir (effective capacity: $5m^3$)

In 2005, the facilities were not in operation due to the problem of water leakage from the distribution pipeline. If the required rehabilitation is implemented, the facilities can be utilized sufficiently. The velocity of the modified slow filtration is rather high, 16.5m/day against 259 m^3/day of the planned maximum daily supply. However, expecting the oxidization effect by the aeration, it is judged that the iron and manganese removal will be possible by iron bacteria.

b) Facilities to be Constructed

The materials of removal are iron and/or manganese. The removal methods are considered to be as follows:

- Rapid sand filter (filtration velocity: 120～150m/day)
- Slow sand filter (filtration velocity: 4～5m/day)
- Medium sand filter (filtration velocity: 10～30m/day)

The slow sand filter and medium sand filter are the biological treatment by the activity of iron bacteria but the stability of its density and pH change is sometimes questioned. On the other hand, the rapid sand filter based on the oxidization by chlorine is more sound and reliable.

Since the rapid sand filter was adopted in "Project for the Groundwater Development in the North of Vietnam" and in Dak Lak Province, the rapid sand filter is adopted from the view point of integration of the operation & maintenance method

The process of removal is summarized as follows:

● Iron

When the ferrous ion is oxidized by chlorine (Sodium hypochlorite) or aeration, it will become the insoluble ferric hydroxide, and will be removed in the rapid sand filter. If the raw water contains relatively high concentration of iron, the aeration facility is added for the purpose of reducing the consumption volume of chlorine.

● Manganese

Raw water after being injected chlorine, enters to the rapid sand filter with the filter media of manganese sand, and thus, the manganese contained in raw water is oxidized by the contact with the surfaces of manganese sands and then removed.

In order to remove iron and manganese at the same time, the combination of the methods mentioned above is adopted. In other words, after injecting chlorine into the raw water, it is led to the rapid sand filter with the filter media using manganese sand.

● pH Control

Water quality standard of Vietnam presents the value from 6.5 to 8.5 for pH. The communes of which pH value observed less than this standard are G1 Kong Tang(5.3), G2 Nhon Hoa(5.4) and D2 Ea Drang(6.42). In these communes, alkaline is required. pH of raw water is adjusted by dose of sodium hydroxide (chlorine). Water in D4-1 Ea Drong contains high iron concentration of 3.76 mg/l, aeration equipment is added to the process so as to keep chlorine consumption at a reasonable rate.

● Others

Not only iron and manganese but also turbidity in the raw water is within the drinking standard limit in the three communes. Therefore, sedimentation process in the three communes is not necessary, but filtration process is required to trap the formed iron and/or manganese micro-floc. As a disinfection chemical, instead of chlorine, sodium hypochlorite is planned, which are adopted in the northern project as well.

The planned water flow in the five communes, including treatment process and distribution systems (explained later) is classified as shown in Figure 2.3.

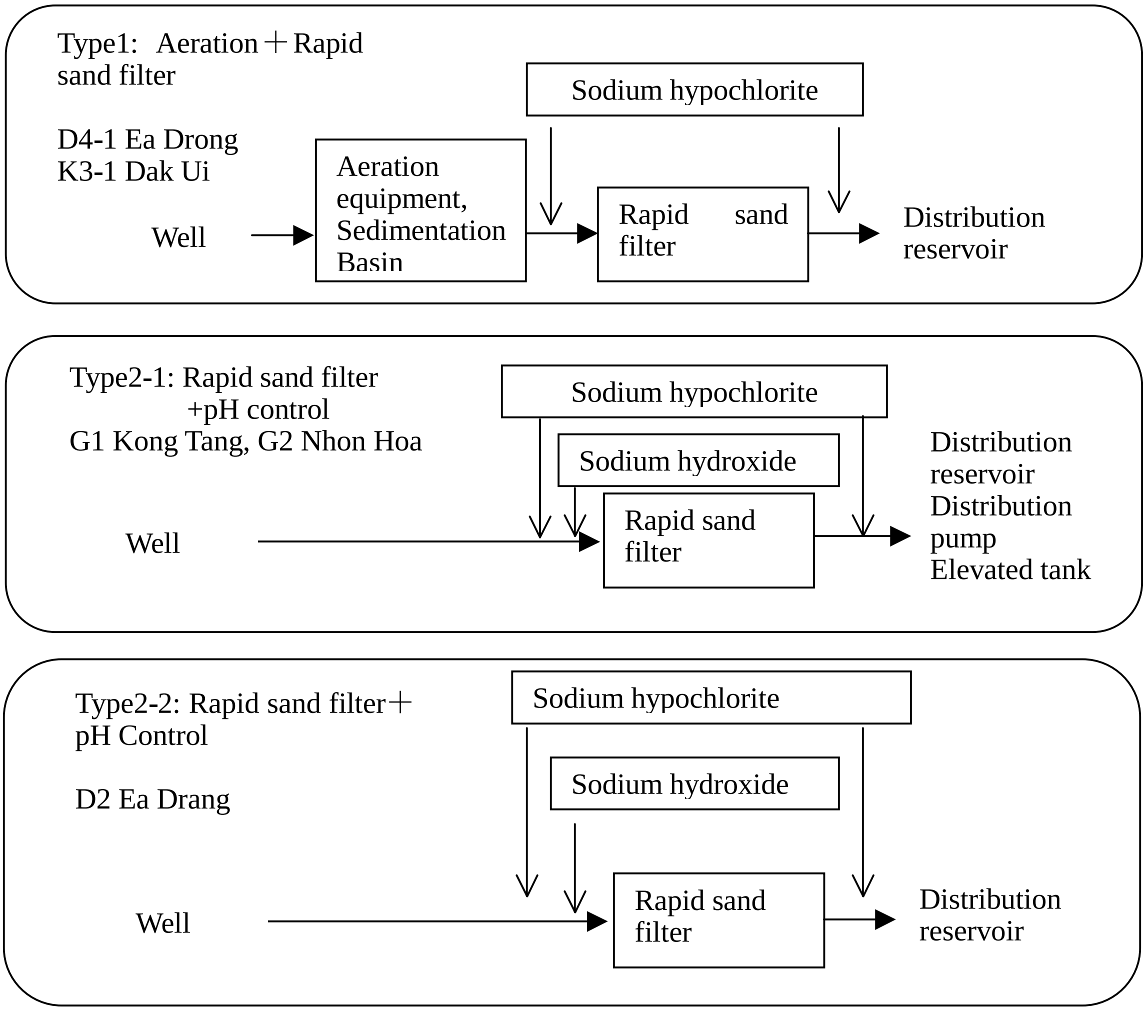

Figure 2.3 Process of Water Treatment Plant

3) Water Treatment Facilities

a) Aeration Facility

In case when the iron concentration is more than 3mg/l, the oxidization by aeration in addition to chlorine injection is planned so as to reduce chlorine consumption. The raw water is sprayed in the air and contacted with the air, and thus, the dissolved iron (ferrous oxide) is oxidized. Subsequently, the iron in the form of micro-flock is removed in the filter. The feature of aeration facility is shown in Table 2.12, and the feature of sedimentation basin is shown in Table 2.13

Table 2.12 Outlines of Aeration Facility

Commune	Dimension & Specification
K3-1 Dak Ui	Capacity: 259m^3/day W1.5m×L1.0m×H3.5m×1(Existing)
D4-1 Ea Drong	Capacity: 668m^3/day W5.2m×L2.6m×H4.0m×2

Table 2.13 Outline of Sedimentation Basin

Commune	Dimension & Specification
K3-1 Dak Ui	W2.8m×L1.0m×1 (Existing)
D4-1 Ea Drong	W5.2m×L2.6m×H4.0m×2

b) Filter Basin

The filter basin is a facility in which the micro-flock, oxidized by aeration and chlorine sodium hypochlorite, and the dissolved manganese are removed. The filtration velocity is 120m/day except for K3-1(16.5m/day). The filter basin is to be washed with treated water from the elevated tank. If the elevated tank does not exist, the filter basin is to be washed with treated water from the distribution reservoir. The outline of filter basin is shown in Table 2.14 and the summary of backwashing equipment of filter basin is shown in Table 2.15.

Table 2.14 Outline of Filter Basin

Commune	Dimension & Specification
K3-1 Dak Ui	W2.8m × L5.6m × 1 basin , A=15.68m^2/basin (Filtration rate; 16.5m/d)
G1 Kong Tang	W1.4m × L1.9m × 2 basin , A=2.66m^2/basin (Filtration rate; 120m/d)
G2 Nhon Hoa	W2.0m×L2.3m×2 basin , A=4.60m^2/basin Manganese sand (Filtration rate; 120m/d)
D2 Ea Drang	W2.9m × L2.3m × 2 basin , A=6.67m^2/basin (Filtration rate; 120m/d)
D4-1 Ea Drong	W1.4m×L2.0m×2 basin , A=2.8m^2/basin (Filtration rate; 120m/d)

Table 2.15 Outline of Backwashing Equipment of Filter Basin

Commune	Dimension & Specification
K3-1 Dak Ui	Non existence
G1 Kong Tang	Surface washing pump 80mm×Q0.4m^3/min×H17m×3.7kw×1 unit Backwashing Washing by treated water from elevated tank
G2 Nhon Hoa	Surface washing pump 80mm×Q0.69m^3/min×H17m×3.7kw×1 unit Backwashing Washing by treated water from elevated tank
D2 Ea Drang	Surface and backwashing pump 200mm×150mm×Q5.0m^3/min×H25m×45kw×2 units (1 unit is stand-by)
D4-1 Ea Drong	Surface and backwashing pump 125mm×100mm×Q2.1m^3/min×H25m×15kw×2 units (1 unit is stand-by)

c) Chemical Feeding Equipment

In the filter basin, the sodium hypochlorite is used for the manganese removal, iron oxidization and disinfection, considering the safety, easiness of procurement and economical advantage. In order to neutralization of the acidic raw water, alkaline is required chemical such as slaked lime and sodium hydroxide. The initial and the running costs for these agents are shown in Table 2.16.

Table 2.16 The Cost Comparison of Slaked lime and Sodium hydroxide

Agents	Initial Cost (Thousand USD)	Running Cost* (VND/m^3)
Slaked lime	14.5	11
Sodium hydroxide	8.1	23

*The required cost for neutralized water of $1m^3$

The running cost for slaked lime is lower than sodium hydroxide. However, if slaked lime is adopted, more number of solution tank, mixer, storage tank with hopper and feeder will have to be installed and lime powder has to be handled carefully to avoid the calcification in the storage. Sodium hydroxide is available in three provinces. Therefore, sodium hydroxide will be used for alkali agent. The chemicals injection ratio is shown in Table 2.17.

Table 2.17 Outline of Chemical Feeding Capacity

Commune	Dimension & Specification	
	Sodium hypochlorite (7%)	Sodium hydroxide (32%)
K3-1 Dak Ui	0.154 kg/hr	-
G1 Kong Tang	1.138 kg/hr	0.829 kg/hr
G2 Nhon Hoa	1.921 kg/hr	1.400 kg/hr
D2 Ea Drang	2.808 kg/hr	2.046 kg/hr
D4-1 Ea Drong	1.192 kg/hr	-

(4) Distribution Facilities

The distribution facilities consist of the distribution reservoir, distribution pump, elevated tank and distribution pipeline. It is preferable to construct the distribution reservoir and the water treatment facilities within the same site. It is the principle that the water distribution is by gravity flow. Therefore, the site was selected in the land with the elevation as high as possible and the possibility to access. In case that the distribution reservoir cannot ensure a sufficient gravitational distribution, the elevated tank with distribution (lifting) pump is added.

1) Distribution Reservoir

The distribution reservoir has the function of adjusting the diurnal demand fluctuation and, at the same time, in case of emergency such as the facilities failure or suspension of intake facilities and water treatment facilities, it has the role of maintaining a certain water volume for a certain period of time. The capacity of distribution reservoir is for about 8 hours of the maximum daily water supply considering the purposes mentioned above. The summary of distribution reservoir is shown in Table 2.18.

Table 2.18 Outline of Distribution Reservoir

Commune	Dimension & Specification
K3-1 Dak Ui	W3.0m×5.0m×H3.0m×2 Capacity: 90m^3/ 2 basins Reinforced concrete
G1 Kong Tang	W4.0m×9.0m×H3.0m×2 Capacity: 216m^3/ 2 basins Reinforced concrete
G2 Nhon Hoa	W4.0m×15.0m×H3.0m×2 Capacity: 360m^3/2 basins Reinforced concrete
D2 Ea Drang	W6.0m×15.0m×H3.0m×2 Capacity: 540m^3/ 2 basins Reinforced concrete
D4-1 Ea Drong	W4.0m×9.5m×H3.0m×2 Capacity: 228m^3/ 2 basins Reinforced concrete

2) Distribution (Lifting) Pump

The distribution pump will be installed in case when the water distribution to all the distribution areas by the gravity flow method is difficult due to the low elevation of distribution reservoir. The distribution pump will lift up the water into the elevated tank.

The capacity of distribution pump is able to distribute the maximum hourly supply planned in the Project. For the planning of the maximum hourly supply, "Facility Standard: National Budget Supporting Projects for Simple Water Supply: Ministry of Health, Labour and Welfare, Japan" is referred to as a similar facility plan because the target area is mainly agricultural communes where the pattern of daily life is almost the same and the water demand becomes greater for a certain time due to the concentration of water consumption during a certain hours of a day. Thus, the time coefficient is considered as 2.0.

A stand-by pump of the same capacity is installed and a pump house is to be constructed, considering the operation, maintenance and inspection. In the pump house, the required electrical equipments are accommodated.

The summary of distribution pump is shown in Table 2.19.

Table 2.19　Outline of Distribution Pump

Commune	Specification
G1 Kong Tang	Nominal Dia.100mm × Q0.88m^3/min × H15.0m × 7.5kw × 2 unit（1 unit is Stand-by）
G2 Nhon Hoa	Nominal Dia.150mm × Q1.49m^3/min × H17.0m × 11.0kw × 2 unit（1 unit is Stand-by）

3) Elevated Tank

The elevated tank has the water level that makes it possible to distribute the treated water to all the areas of water distribution by the gravity flow. After lifting up the treated water by the distribution pump, the elevated tank has the function of storing the lifted water for a while and then distributing the water in accordance with the water demand.

It is possible to make the capacity of elevated tank smaller because the distribution reservoir has the function of adjusting the diurnal fluctuation. Referring to the standard of small scale water supply in “Guidance of Design for Water Supply Facilities: Japan Water Supply Association, Japan”, the capacity of elevated tank is decided as one hour volume of the maximum daily supply. The outline of elevated tank is shown in Table 2.20.

Table 2.20　Outline of Elevated Tank

Commune	Dimension & Specification
G1 Kong Tang	W4.4m×4.4m×H2.0m×1　Capacity: 38.7m3 Reinforced concrete　L.W.L.+752.0m
G2 Nhon Hoa	W5.0m×5.0m×H2.0m×1　Capacity: 50.0m3 Reinforced concrete　L.W.L.+432.0

4) Distribution Pipeline

a) Route of Pipeline

In principle, the distribution pipeline is installed along the public roads from the reservoir or the elevated tank to the water distribution area of the Project. The distribution pipeline has a certain water pressure even at the end of the pipeline and therefore, by connecting it with the water supply service facilities, the water supply service to each household becomes possible.

After the site survey in all the target area of the Project by confirming the conditions of roads, houses, other structures, etc, the route of distribution pipeline is selected by considering the selection of area where the water supply is possible and the realization of route set up. If the installation inside the rice or other crops fields is inevitable due to the site conditions, the temporary construction method and installation method are considered in order not to harm the cultivation of rice or other crops.

b) Pipe Material and Diameter of Pipe

PVC pipe is adopted because it is possible to procure it in Vietnam and there are advantages such as strength for pressure, anti-corrosion, simple construction and economical advantage that are coincident with the objective of the Project. However, in the locations where it crosses the canal and river and where it is installed on the ground surface, the use of steel pipe is considered. Pipe diameter is estimated by the network analysis using Hazen Williams Formula. Assuming the water supply service to the one–storied houses, the minimum water pressure at the distribution pipeline is decided as 0.6kgf/cm^2 in principle.

The summary of distribution pipeline is shown in Table 2.21.

Table 2.21 Outline of Distribution Pipe

Commune	Dimension & Specification	
	Diameter (mm)	Length (km)
K3-1 Dak Ui	φ50～φ100	5.0
G1 Kong Tang	φ50～φ200	26.5
G2 Nhon Hoa	φ40～φ250	38.6
D2 Ea Drang	φ50～φ300	51.8
D4-1 Ea Drong	φ50～φ200	27.2
Total		149.1

(5) Water Supply Service Facilities

The water supply service facilities are the facilities to supply water to each household in the water supply service area and consist of the service pipeline, water meter for household use, etc. The summary of water supply service facilities is shown in Table 2.22.

Table 2.22 Outline of Service Pipe

Commune	Number of households served	Service Pipe (m)	Water Meter for household use (No.)
K3-1 Dak Ui	624	12,480	624
G1 Kong Tang	1,738	34,760	1,738
G2 Nhon Hoa	2,181	43,620	2,181
D2 Ea Drang	3,874	77,480	3,874
D4-1 Ea Drong	1,583	31,660	1,583
Total	10,000	200,000	10,000

2-2-2-6 Equipment Plan

(1) Objects of the Plan

The supplied equipment (Well drilling equipment) will be used for the drilling of 16 wells in the 5 communes where water supply facilities will be constructed under the Project. Through this drilling, technology transfer is carried out, and technical capabilities related to drilling well in Vietnam will be upgraded. It will be further used by CERWASS, after the Project, to drill 44 wells at least in other communes.

(2) Summary of the Equipment

1) Category of Procurement

Equipment will be procured in Japan due to reasons mentioned below.

Equipment	Country of Procurement	Reason
Well Drilling Equipment (truckmounted type)	Japan	This equipment is not produced in Vietnam. Although the equipment made in Russia and China is cheap, this equipment doesn't satisfy the required specification.
Air Compressor (truckmounted type)	Japan	This equipment is not produced in Vietnam. Although it is produced in Europe and United States, Japan made equipment should be used considering soil location and tight delivery schedule.
Crane Cargo Truck	Japan	This equipment is not produced in Vietnam. The truck made in Japan is used in many countries due to easy operation and sophisticated technology.

2) Station of Equipment Team

The well drilling equipment is supplied to the central CERWASS. CERWASS will keep it in Pleiku city in Gia Lai province.

3) Policy to Specification of the Equipment

- Considering the soil conditions in the Central Highlands area, the drilling method is both direct mud circulation and down the hole (DTH).
- Considering the soil conditions in the Central Highlands area, consisting of a hard and soft soils and depth of groundwater aquifer, drilling rig with maximum drilling depth of 200m and diameter of 10-5/8" is required.
- The well drilling equipment and high pressure air compressor should be mounted on the truck considering mobility and easy access to the site of as many as 44 wells at least.
- The cargo truck should be 6×4 drive considering bad road condition in the central highlands.

- The necessity minimum equipment should be planned after careful examination of the existing equipment in CERWASS.
- The diameter of the requested drilling equipment was 450mm. However, since the request of the solar system was withdrawn, the space to accommodate the solar pump inside the well has become unnecessary. Therefore, the drilling diameter is reduced to 300mm to be sufficient with the well diameter and water yield volume for the planned water supply systems in communes.

4) Outline of the Equipment

The planned equipments are well drilling equipment, high pressure air compressor, drilling tools, supporting truck, pumping test equipment and well logging equipment. The outlines of these equipments are explained below.

Table 2.23 Outline of Well Drilling Equipment

Equipment		No.	Specifications
1. Well Drilling Equipment			
1-1	Drilling Rig	1 Unit	Type & Construction Method: Water well drilling rig, top head drive rotary drilling rig, designed for direct mud water circulation and down-the-hole (DTH) drilling. Drilling Depth: up to 200m, Drilling Diameter: 4-3/4”
1-2	High Pressure Air Compressor	1Unit	Free air delivery: 30.0m^3/min Rated operating pressure: 2.41Mpa
1-3	Miscellaneous Ancillary Equipment	1 Set	-Welder/Generator -Self priming pump: 200 liter/min x 20m head -Submersible dewatering pump: 200 liter/min x 15m head -Oxygen-acetylene cutting and heating equipment, tool etc.
1-4	Air Lift Equipment	1 Unit	It corresponds to the depth of 200m
2. Supporting Equipment			
2-1	Crane Cargo Truck	1 Unit	6x4 drive, P.T.O. (Power Take Off) driven, hydraulic operated of 6 tons capacity, Length of boom: 9.5m. Payload capacity: 12,500 kgf, Cargo space length : 6.2m
2-2	Pumping Test Equipment (Submersible pump, Generator, Triangular weir)	1 Set	Submersible pump (a): 240 liter/min x 70m head Submersible pump (b): 576 liter/min x 50m head Generator: 10kVA, AC380V Accessories
2-3	Well Logging Equipment	1 Set	Measurement item: Normal resistively, SP, Natural gamma

5) Contents of Equipment

The contents of equipment are mentioned below.

a) Well Drilling Equipment

The DTH method is adopted for hard rocks, and the mud water circulation method is used for relatively soft geological conditions (surface ground, fully weathered zone, etc.). Maximum drilling depth is decided as 200m and casing diameter as 300mm, judging from the hydro geological conditions in the central highlands, which was analyzed in the JICA Development Study. Considering the mobility, the drilling equipment should be mounted on truck of 6 x 4 type. Since the truck engine is also used for the drilling rig engine, the power take off (P.T.O) should be attached so as to shift the engine power to the rig driving power.

b) High Pressure Air Compressor

High pressure air compressor is used in DTH method. This compressor sends high and large wind pressured air into the inside of drilled holes and enables the drilled soil to move towards surface. Air pressure required is 1.96 MPa (drilling depth: 200m) and adding minimum operation pressure of 0.45 MPa, the total required pressure becomes 2.41 MPa.

Air volume required Q (m^3/min) is calculated by using the following equation:

$$V = \frac{Q}{A}$$

$$A = \frac{\pi(D^2 - d^2)}{4}$$

V: Flow velocity in a loop section (Flow velocity of space of rod and porous wall for carrying drilled soil up from well smoothly). Generally, it is assumed as 1,200～1,500m/min.

A: Section area of in a loop section (m^2)

D: Well diameter = 0.269m (10-5/8")

d: Rod diameter = 0.12m（4-3/4"）

When V is taken as 1,200m/min, Q becomes $1/4 \times \pi \times (0.2191^2 - 0.12^2) \times 1{,}200 = 54.85$ m^3/min. According to the manufacturers' specifications, the maximum output volume is 30m^3/min. Accordingly, the output volume is decided as 30m^3/min. In order to supplement shortage of the required air volume, foaming agent is injected and mixed. And the drilling waste is discharged from well by annular flow water.

c) Drilling Tools

Drilling tools are mentioned below.

① Operating Accessories

Operating accessories are mentioned below.

- Drive head sub (2)
- High pressure rotary hose (1)

- Suction hose for mud pump (1)
- Foot valve with strainer for above suction hose (1)
- Suction hose for injection pump (1)
- Delivery hose for injection pump (1)
- By-pass hose, used for hopper type jet mixer (1)
- Hopper type jet mixer (1)
- High pressure air hose set for air compressor to rig (1 lot)
- Single sheave traveling block (1)
- Hoisting wire rope (1 roll)
- Sand reel wire rope (1 roll)

② Drilling Tools

- Drilling common tools & accessories (Drill pipe, drill collar etc.)
- Down-The-Hole (DTH) drilling tools (DTH hammer, work casing pipe etc.)
- Direct mud circulation drilling tools & accessories (Tri-cone rock roller bit, stabilizer etc.)

③ Casing Tools

- Casing clamps

④ Fishing Tools

- Fishing taper tap, drill pipe clamps, hydraulic jack etc.

⑤ Air Lift Equipment

- Air compressor: （Stationary type, High pressure type 1.18MPa, Free air delivery 10.0m^3/min）
- Water pipe
- Air pipe
- Others (water pipe clamp, water pipe elevator, etc.)

⑥ Miscellaneous Ancillary Equipment

- Welder/generator and accessories（Current range : 30 to 300A, Generating capacity : 10 kVA, AC380V）
- Electric tools (Electric disc grinder, Electric drill etc.)
- Others (Chain pipe tong, Pipe wrench, Wire rope, Hand tools, etc.)

d) Crane Cargo Truck

The crane cargo truck is used to transport the long and heavy drilling tools required for the drilling of deep wells. The main equipments and materials are drill pipe, drill collar, DHT hammer bit, work casing, air pipe, water pipe, grout pump, grout mixer, etc. Since the drill collar is the longest material of 6.0m, the truck should be of long body chassis with the cargo base length of 6.2m. The crane capacity should be 6.0 ton with PTO drive.

e) Pumping Test Equipment

① Submersible Pump

Submersible pump is utilized for pumping test. The pump of two types (high head/ small discharge, low head/ large discharge) is used according to the well capacity.

- Submersible pump A（240 L/min, H=70m, 5.5kW with accessories）
- Submersible pump B (576 L/min, H=50m, 7.5kW with accessories)

② Generator

Generator is utilized as power source. Normal power of motor generator engine for operating submersible pump (7.5kW) is 37kVA.

③ Water Measuring Equipment.

- Triangular weir
- Water level indicator

f) Well Logging Equipment

① Logging Basic Unit

Logging basic unit with display and printer is utilized as data collection for assessing the location of aquifer. Normal resistively, SP and Natural Gamma will be measured. Well logging equipment consists of data logger, accessories and computer.

② Accessories

- Prove for Normal resistively, SP, Natural Gamma
- Winch (310m 4-core cable)
- Others (sheave, surface electrode stick, battery pack etc.)

③ Computer with Printer

- Computer with printer
- Software

2-2-3 Basic Design Drawings

DWG No.	Title of Drawing
1	K3-1 Dak Ui General Plan
2	G1 Kong Tang General Plan
3	G2 Nhon Hoa General Plan
4	D2 Ea Drang General Plan
5	D4-1 Ea Drong General Plan
6	K3-1 Dak Ui Flow Sheet
7	G1 Kong Tang Flow Sheet
8	G2 Nhon Hoa Flow Sheet
9	D2 Ea Drang Flow Sheet
10	D4-1 Ea Drong Flow Sheet
11	K3-1 Dak Ui Layout of WTP
12	G1 Kong Tang Layout of WTP
13	G2 Nhon Hoa Layout of WTP
14	D2 Ea Drang Layout of WTP
15	D4-1 Ea Drong Layout of WTP
16	Pump House & Well Pump House (1/2) (G1 Kong Tang, G2 Nhon Hoa, D2 Ea Drang, D4-1 Ea Drong)
17	Pump House & Well Pump House (2/2) (G1 Kong Tang, G2 Nhon Hoa, D2 Ea Drang, D4-1 Ea Drong)
18	Purification facilities (TYPE-1: Filter)1/2(G1 Kong Tang)
19	Purification facilities (TYPE-1: Filter)2/2(G1 Kong Tang)
20	Purification facilities (TYPE-2: Filter)1/2(G2 Nhon Hoa, D2 Ea Drang)
21	Purification facilities (TYPE-2: Filter)2/2(G2 Nhon Hoa, D2 Ea Drang)
22	Purification facilities (Aeration room, Sedimentation basin, Filter)1/2(D4-1 Ea Drong)
23	Purification facilities (Aeration room, Sedimentation basin, Filter)2/2(D4-1 Ea Drong)
24	Reservoir (TYPE-1) (K3-1 Dak Ui)
25	Reservoir (TYPE-2) (G1 Kong Tang, G2 Nhon Hoa, D4-1 Ea Drong)
26	Reservoir (TYPE-3) (D2 Ea Drang)
27	Elevated Tank(G1 Kong Tang, G2 Nhon Hoa)
28	Wastewater Tank (All Communes)
29	Administration Office & Pump House of Wastewater Tank (1/2) (All Communes)
30	Administration Office & Drain Pump of Wastewater Tank (2/2) (All Communes)
31	Plan of Pipeline (K3-1 Dak Ui)
32	Plan of Pipeline (G1 Kong Tang)
33	Plan of Pipeline (G2 Nhon Hoa)
34	Plan of Pipeline (D2 Ea Drang)
35	Plan of Pipeline (D4-1 Ea Drong)

K3-1 Dak Ui
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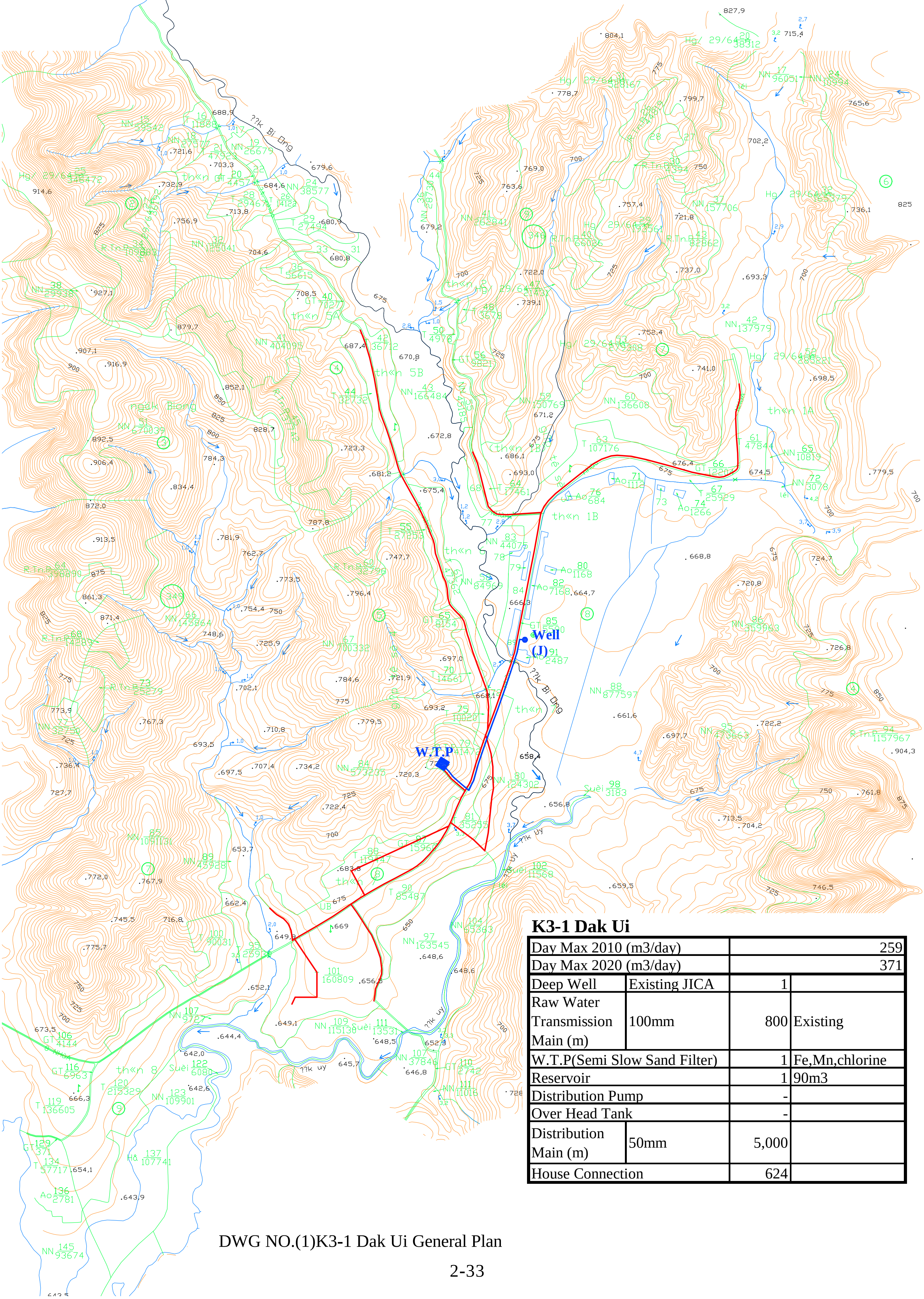

K3-1 Dak Ui

Day Max 2010 (m3/day)		259	
Day Max 2020 (m3/day)		371	
Deep Well	Existing JICA	1	
Raw Water Transmission Main (m)	100mm	800	Existing
W.T.P(Semi Slow Sand Filter)		1	Fe,Mn,chlorine
Reservoir		1	90m3
Distribution Pump		-	
Over Head Tank		-	
Distribution Main (m)	50mm	5,000	
House Connection		624	

DWG NO.(1)K3-1 Dak Ui General Plan

G1 Kong Tang
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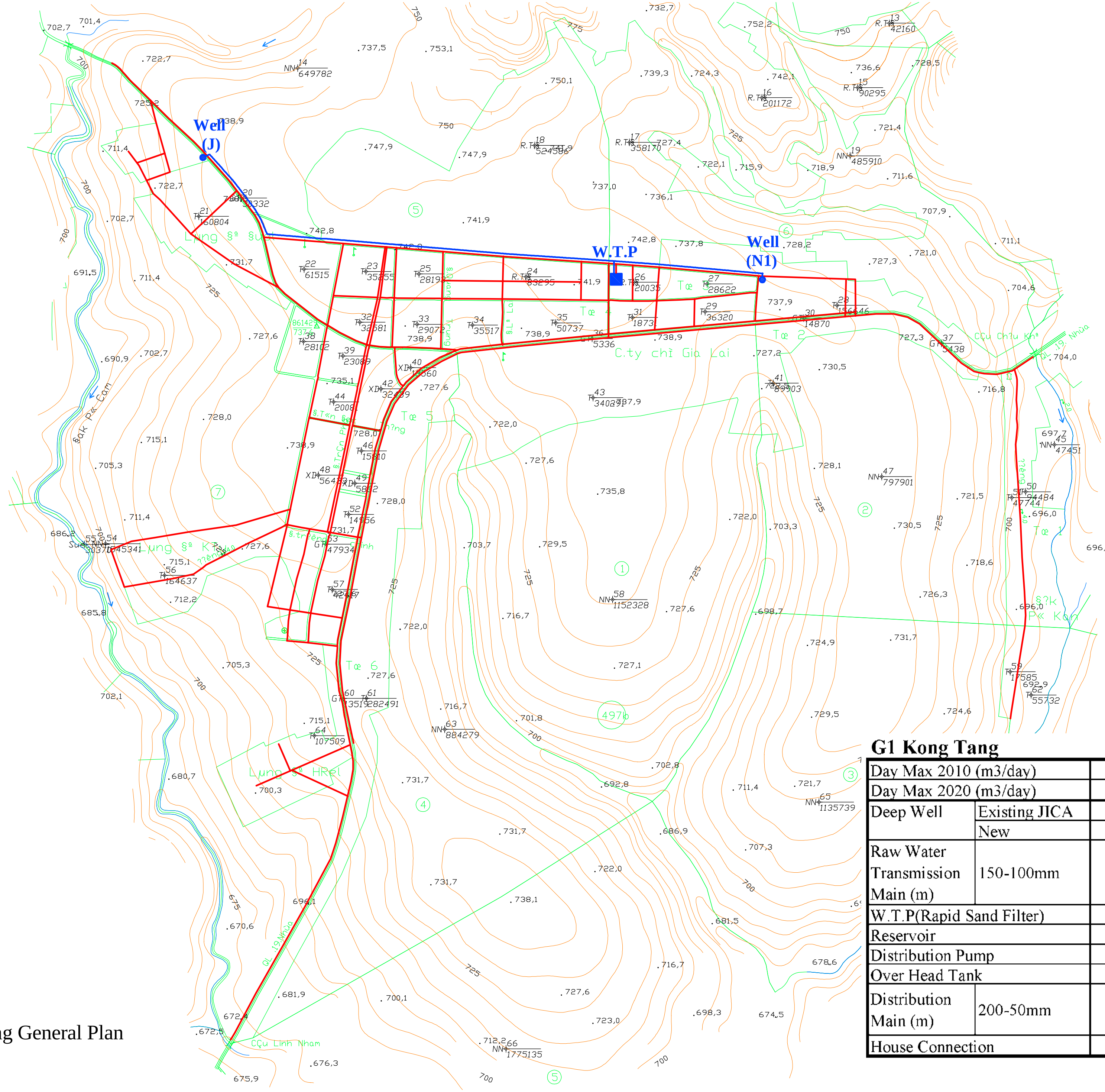

G1 Kong Tang

Day Max 2010 (m3/day)		636	
Day Max 2020 (m3/day)		940	
Deep Well	Existing JICA	1	
	New	1	
Raw Water Transmission Main (m)	150-100mm	2,200	
W.T.P(Rapid Sand Filter)		1	Fe,chlorine.pH
Reservoir		1	216m3
Distribution Pump		1	
Over Head Tank		1	38.7m3
Distribution Main (m)	200-50mm	26,500	
House Connection		1,738	

DWG NO.(2)G1 Kong Tang General Plan

G2 Nhon Hoa
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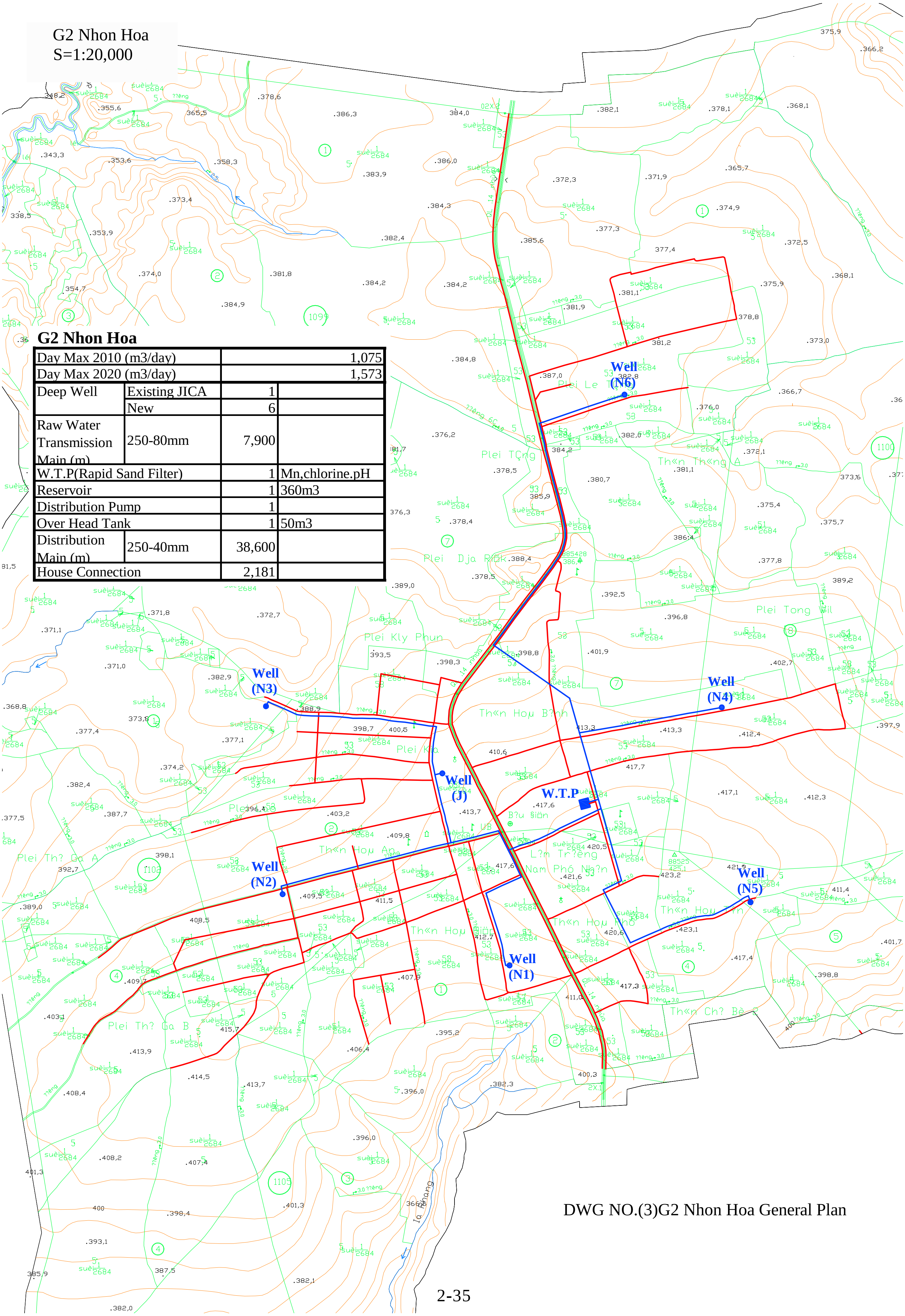
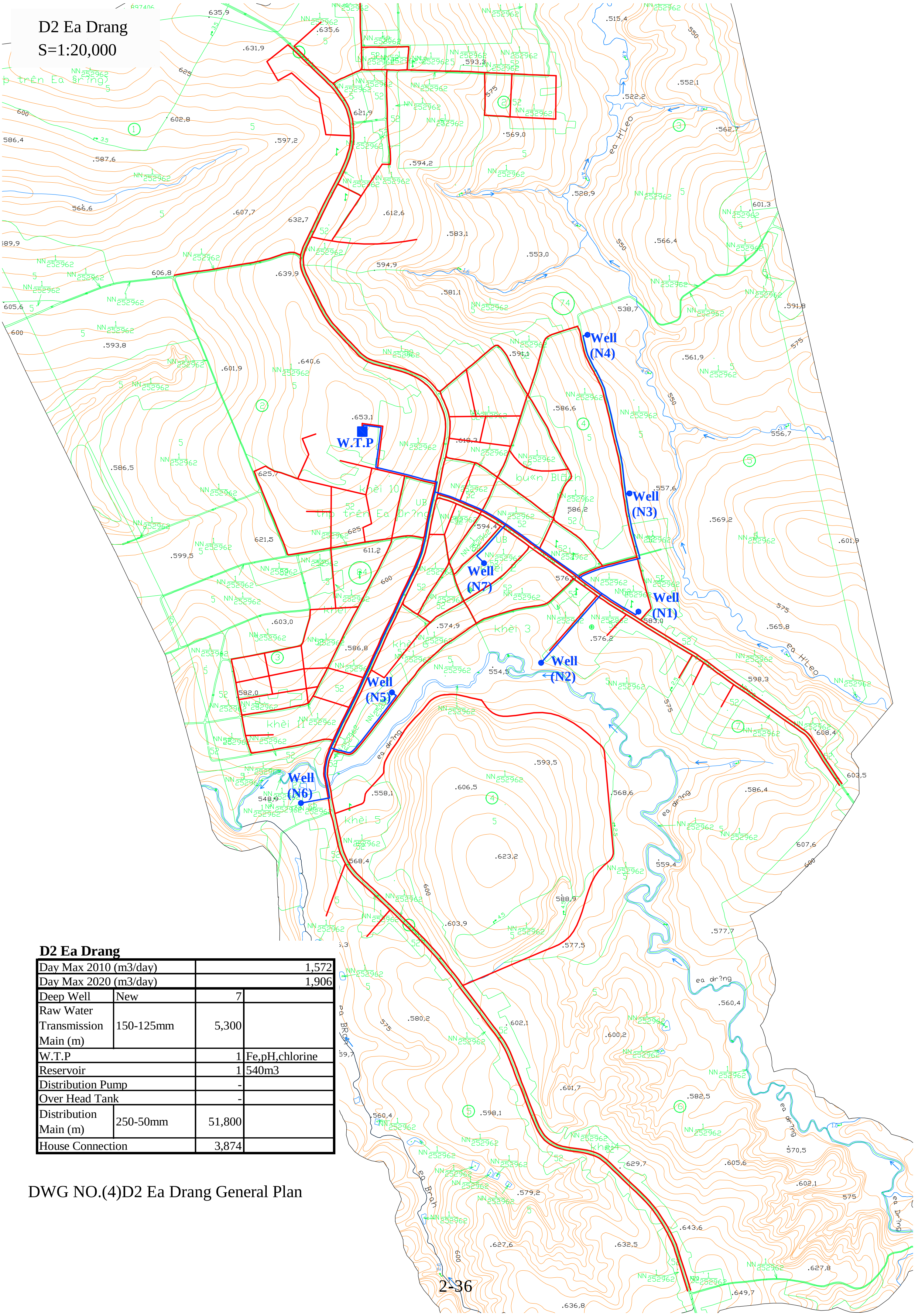


G2 Nhon Hoa

Day Max 2010 (m3/day)		1,075	
Day Max 2020 (m3/day)		1,573	
Deep Well	Existing JICA	1	
	New	6	
Raw Water Transmission Main (m)	250-80mm	7,900	
W.T.P(Rapid Sand Filter)		1	Mn,chlorine.pH
Reservoir		1	360m3
Distribution Pump		1	
Over Head Tank		1	50m3
Distribution Main (m)	250-40mm	38,600	
House Connection		2,181	

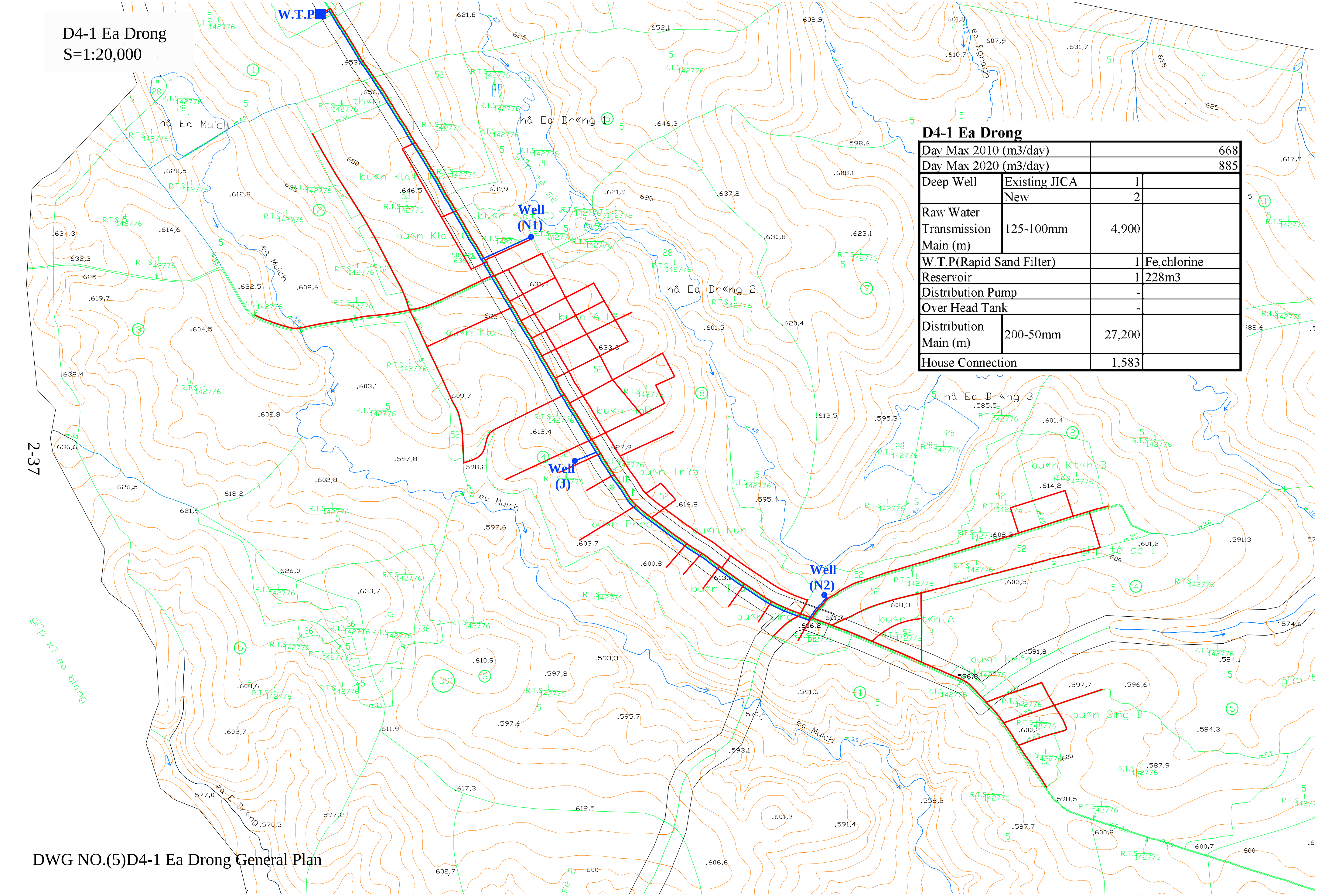
DWG NO.(3)G2 Nhon Hoa General Plan



D2 Ea Drang

Day Max 2010 (m3/day)		1,572	
Day Max 2020 (m3/day)		1,906	
Deep Well	New	7	
Raw Water Transmission Main (m)	150-125mm	5,300	
W.T.P		1	Fe,pH,chlorine
Reservoir		1	540m3
Distribution Pump		-	
Over Head Tank		-	
Distribution Main (m)	250-50mm	51,800	
House Connection		3,874	

DWG NO.(4)D2 Ea Drang General Plan



D4-1 Ea Drong

Day Max 2010 (m3/day)		668	
Day Max 2020 (m3/day)		885	
Deep Well	Existing JICA	1	
	New	2	
Raw Water Transmission Main (m)	125-100mm	4,900	
W.T.P(Rapid Sand Filter)		1	Fe,chlorine
Reservoir		1	228m3
Distribution Pump		-	
Over Head Tank		-	
Distribution Main (m)	200-50mm	27,200	
House Connection		1,583	

DWG NO.(5)D4-1 Ea Drong General Plan