

(5) Evaluation

It is presumed from the regional geologic structures, the limestone having high groundwater potential occurs in the southwestern part of the commune, having NW-SE direction. It is estimated that basement rock in the central to the northeastern parts of the commune would consist of shale or claystone, having low groundwater potential.

This discharge of the test well shows that limestone aquifer in Vinh Thanh Commune has very high productivity and prospective for water supply. The groundwater quality in Vinh Thanh test well is also good and can be used for water supply with treatment of iron concentration. However, for future additional production wells, the areas near the Ma River should not be selected because the shallow groundwater quality is poor. It can be said that prospective well sites for future groundwater development should also located in the southwestern to southern parts of the commune.

1.4.2 Vinh Loc Town

(1) Hydrogeology

Vinh Loc Town is almost surrounded by Vinh Thanh Commune. Therefore, the hydrogeological conditions are similar to that of Vinh Thanh Commune.

There are two aquifers as shown below:

- Quaternary deposits distributed and exposed on the surface of flat terrain. They are composed of clay, silty clay mixed with sand and gravel. Quaternary deposits has low groundwater potential.
- Lower Triassic carbonate rocks is underlying of Quaternary deposits. They consist of limestone with moderate fracture grade. Lower Triassic limestone with high fracture level has high groundwater potential and prospective for water supply.

In the basement rock, however, very hard and massive shale to claystone are found at the southeastern part of the commune, forming a small hill. The exact distribution of this basement rock is not known, but it is presumed that the shale and claystone may be distributed under the commune from the geotectonic point of view.

(2) Groundwater level

Groundwater level of 6 existing dug wells were measured in October 1998. Groundwater levels of 4 tube wells could not be measured due to the well structures.

The measured 6 wells show the depth to groundwater level ranges between 0.43 and 2.65 m. Shallow groundwater levels within 2.0m from the ground surface were detected at 5 wells.

(3) Groundwater quantity

According to the result of the test well (JICA-11) drilled in Vinh Thanh Commune, the limestone aquifer can yield much groundwater with good quality except iron. However, the groundwater productivity of the basement rock in the Vinh Loc Town is not confirmed. If the basement rock is composed of shale or claystone, it is predicted that the groundwater potential will be comparatively smaller than that of limestone.

(4) Groundwater quality

1) Existing wells (see Figures 1.22 to 1.24)

The groundwater quality survey was carried out at 5 hand dug wells and 5 tube wells in the town. The depth of tube wells varies from 14.5 to 28 m (VL-5). The results of the field measurement are as follows:

pH from 5.60 to 7.36

EC from 5.6 to 82.3 mS/m

ORP from 295 to 531 mV

DO from 3.6 to 5.5 mg/l

The EC values are more higher with approaching to the Ma River. The lowest EC value of 5.60 mS/m was found from the northern part of the town. However, pH values in the northeastern part of the town are low and cannot meet the Vietnamese standard value. The water in hand dug wells of VL-2, VL-3 and VL-4 has coliform about 100 pcs./ml, however, the rest of the wells have coliform from 0 to about 23 pcs./ml.

The results of laboratory chemical analysis of groundwater samples from existing hand-dug wells show that the iron and manganese concentrations are higher than the standard:

VL-1 (Mn51.784 mg/l, Fe50.840 mg/l), VL-2 (Fe50.645 mg/l), VL-3 (Fe50.755 mg/l), VL-4 (Fe50.560 mg/l), VL-5 (Fe50.560 mg/l), VL-6 (Fe51.820 mg/l), VL-8 and VL-9 (Fe50.700 mg/l), VL-10 (Fe50.560 mg/l)

Three hand-dug wells have lower pH values than the standard value:

VL-1 (pH56.24), VL-7 (pH56.10), VL-10 (pH55.95)

The Stiff diagrams of the shallow groundwater show that the groundwater is mostly Ca-HCO₃ type. The size of stiff diagrams is large in the area along the Ma River.

2) Test well

The result of chemical analysis of groundwater from the test well (JICA-11) in Vinh Thanh Commune shows that only iron (ΣFe) exceeds the Vietnamese and WHO standard for drinking water.

$\Sigma\text{Fe} 51.82 \text{ mg/l}$ (the Vietnamese standard; $\Sigma\text{Fe} 50.5 \text{ mg/l}$, the WHO standard $\Sigma\text{Fe} 50.3 \text{ mg/l}$)

For using the test well water for water supply, it is necessary to treat the water to reduce the iron concentration.

(5) Evaluation

Although no test wells were drilled in the town, it is presumed that if a deep tube well encountered fractured limestone, the well can yield much groundwater. However, from the geologic point of view, such limestone may not exist in the town. In case the basement rock is composed of hard shale claystone, it is difficult to obtain groundwater.

The quality of deep groundwater will have high concentration of iron and manganese. Compared with the quality of shallow groundwater in Vinh Thanh Commune, the quality of Vinh Loc Town is worse in the view point of Fe concentration. Because most of investigated shallow wells have higher Fe concentration above the standard value.

The EC values show better because there is some distance between the town and the Ma River.

Further, the area of Vinh Loc Town is limited so that suitable well sites may be difficult to find. It is recommended, therefore, the water supply system and its source should be designed together with Vinh Thanh Commune.

1.4.3 Dinh Tuong Commune

(1) Hydrogeology

The topography of the site is rather flat. There are two following aquifers in the commune:

- Quaternary unconsolidated deposits distributed in the flat terrain, consisting of yellowish gray to bluish gray silty sand and bluish gray silty sand with mica flakes with plant remains ($Q_{iv}^{1-2} tb$). These are underlain by gray to brownish gray silty clay and sandy clay. The lower part consists of bluish gray clayey fine sand and gravel.
- Lower Triassic terrigenous sediment (T_{1cn}) composed of sandstone and conglomerate intercalated with strongly altered bluish gray to dark gray claystone. The rocks are strongly fractured and distributed from 86.8 to 92.1 m, strongly altered claystone, containing bluish gray and blackish gray silica at the test well site.

(2) Groundwater level

Groundwater level of 7 existing dug wells were measured in October 1998. The measured 7 wells show the depth to the groundwater level ranges between 1.56 and 6.05 m. Shallow groundwater levels within 4.0 m from the ground surface were detected at 6 wells.

The static groundwater level of the test well (JICA-10) was 4.90 m below the ground surface in April 1999.

(3) Groundwater quantity

In Dinh Tuong Commune, the test well (JICA-10) has a well depth of 91.2 m. The screens were installed at depths from 23.2 to 39.2 m in Quaternary gravel layers and from 47.2 to 63.2 m in sandstone aquifer.

The result of step-drawdown pumping test shows that the yields and drawdowns in the 4 steps are as follows:

$Q_1 5300 \text{ l/min,}$	$s_1 51.26 \text{ m}$
$Q_2 5600 \text{ l/min,}$	$s_2 53.02 \text{ m}$
$Q_3 5900 \text{ l/min,}$	$s_3 54.92 \text{ m}$
$Q_4 51,200 \text{ l/min,}$	$s_4 57.07 \text{ m.}$

The discharge of test well is 1,200 l/min in correspondence with the final drawdown of 7.07 m by the continuous pumping test.

The optimal yield of the test well was evaluated as 1,700 m³/day with the permissible

groundwater level of 15 m from the ground surface.

(4) Groundwater quality

1) Existing wells (see Figures 1.25 to 1.27)

The groundwater quality investigation was carried out at 7 hand dug wells and 3 tube wells in the commune. The results of the field investigation are as follows:

pH from 6.43 to 7.11

EC from 22.7 to 128.1 mS/m

ORP from 29 to 432 mV

DO from 2.9 to 5.6 mg/l

The color of water changes from slight yellow to very brown. The EC values are high in the northwestern and northeastern parts of the commune, showing more than 90 mS/m. The values in the central to the southern part are lower than 50 mS/m. The pH values show that the shallow groundwater in the western part of the commune is slightly acidic, whereas the water in the central to the eastern parts is slightly alkaline.

The results of laboratory chemical analysis of groundwater samples from existing hand-dug wells show that the iron and manganese concentrations are higher than the standard. All the 10 investigated wells have higher Fe concentrations over the Vietnamese standard. Among 10 investigated wells in the commune, the following 6 hand dug wells have higher iron concentrations more than 1.0 mg/l:

DT-4 ($\Sigma\text{Fe}51.540 \text{ mg/l}$), DT-5 ($\Sigma\text{Fe}52.300 \text{ mg/l}$), DT-6 ($\Sigma\text{Fe}51.120 \text{ mg/l}$), DT-7 ($\Sigma\text{Fe}51.120 \text{ mg/l}$), DT-9 ($\Sigma\text{Fe}51.510 \text{ mg/l}$), DT-10 ($\Sigma\text{Fe}53.350 \text{ mg/l}$)

Manganese concentrations are also higher in 2 dug wells than the standard value:

DT-3 (Mg50.698 mg/l), DT-8 (Mg53.217)

The TDS value in DT-5 well has as high as 1,271 mg/l, exceeding the standard value. One dug well has lower pH value than the standard; DT-8 (pH56.45).

The Stiff diagrams show that the groundwater in the northern part of the commune is (Na1K)-Cl type, whereas the groundwater in the central part is Ca-HCO₃ type.

2) Test well

The result of chemical analysis of groundwater from the test well (JICA-10) shows that the groundwater quality in Dinh Tuong is good for water supply.

(5) Evaluation

The test well has two (2) screen layers. Considering the hydrogeologic conditions of the well, it is evaluated that the Quaternary gravel aquifer is very productive. The basement sandstone aquifer also yields some amount of water, but the yield is smaller than the Quaternary aquifer. Therefore, it is evaluated for the commune that the target aquifer is the gravel layer in the lower part of the Quaternary sediments.

The groundwater quality of the Quaternary aquifer is good, but it should be noted that the shallow groundwater has poor quality on Fe, Mn, and TDS concentrations. Therefore, the quality of the test well should regularly be monitored when it is used as a production for the water supply.

1.4.4 Thieu Hung Commune

(1) Hydrogeology

In Thieu Hung Commune there are two aquifers.

- Quaternary unconsolidated aquifer (Q), which is widely exposed on the surface, is represented by recent alluvial deposits. They are composed of silty clay in the upper part, fine and medium sand underlain by coarse sand and gravel in the lower part. The thickness of Quaternary deposits is 40 to 80 m. The Quaternary aquifer has high groundwater potential.
- Triassic terrigenous aquifer (T) is represented by solid sandstone. The Triassic sandstone aquifer has low groundwater potential that can not be used for water supply.

(2) Groundwater level

Groundwater level of 9 existing dug wells were measured in October 1998. The measured 9 wells show the depth to the groundwater level ranges between 1.70 and 5.06 m. Shallow groundwater level within 2.0 m was detected only from one dug well. The rest have groundwater levels between 3.74 to 5.06 m from the ground surface.

The static groundwater level of the test well (JICA-9) was 4.00 m below the ground surface in February 1999.

(3) Groundwater quantity

In Thieu Hung Commune, the test well (JICA-9) has a well depth of 52 m. The screens were installed at depths from 32 to 48 m in the Quaternary gravel aquifer.

The result of pumping test shows that the yields and drawdowns in the 4 steps are as follows:

Q ₁ 5245 ℓ/min,	s ₁ 52.4 m
Q ₂ 5490 ℓ/min,	s ₂ 54.55 m
Q ₃ 5735 ℓ/min,	s ₃ 57.12 m
Q ₄ 5980 ℓ/min,	s ₄ 510.01 m

The discharge of test well is 980 ℓ/min in correspondence with the final drawdown of 10.02 m by the continuous pumping test.

The optimal yield of the test well is evaluated as 1,400 m³/day with the permissible dynamic groundwater level of 15 m below the ground surface.

(4) Groundwater quality

1) Existing wells (see Figures 1.28 to 1.30)

In the commune, groundwater of 9 hand dug wells and one tube well was investigated. The characteristics of shallow groundwater quality by the field survey are as follows:

pH from 6.16 to 7.04
EC from 37.6 to 167.2 mS/m
ORP from 27 to 189 mV
DO from 4.3 to 6.4 mg/ℓ

The water has different color such as slightly turbid, brown, slightly brown and slightly yellow. The EC values are high in the eastern half of the commune, having more than 100 mS/m. The pH values are low in the central part of the commune, showing below 6.5. The quantity of coliform is high, ranging from about 200 to 400~500 pcs./ml.

The results of chemical analysis of groundwater show that pH values of some hand dug wells are lower than the standard value. The wells having low pH values are:

TH-4 (pH56.46), TH-5 (pH56.49), TH-6 (pH56.49), TH-8 (pH56.49)

Among the 9 samples, iron concentrations are above the standard value in 9 wells, ranging from 0.610 mg/l (TH-3) to 9.520 mg/l (TH5). Manganese concentrations are higher than the standard value at TH-5 (Mn50.112 mg/l) and TH-9 (Mn50.234 mg/l). A higher TDS value more than the standard was detected from TH-10 (TDS51,711 mg/l).

The Stiff diagrams show that the groundwater is (Na1K)-Cl type to Ca-HCO₃ type. It is noted that SO₄ concentration is high in the eastern part of the commune.

2) Test well

The result of chemical analysis of groundwater from test well (JICA-9) shows that the concentrations of iron and manganese are higher than the Vietnamese standard for drinking water:

Σ Fe51.420 mg/l (Vietnamese standard Σ Fe50.5 mg/l)

Mn50.480 mg/l (Vietnamese and WHO standard Mn50.100 mg/l)

For water supply, the treatment for iron and manganese reduction will be necessary.

(5) Evaluation

The aquifer in the lower part of the Quaternary sediments has high groundwater productivity. In the commune, it can be said that the Quaternary aquifer can yield enough amount for the water supply. The groundwater quality of the Lower Quaternary aquifer is better than that of the shallow aquifer. The TDS value is lower than the standard value. However, the deep groundwater also has high concentrations of iron and manganese. Therefore, it is necessary to monitor the groundwater quality before and after the treatment. It is also recommended that the well structure for future wells requires proper sealing to prevent contamination from the shallow groundwater. For future groundwater development, the well site should be selected from the western part of the commune from the viewpoint of groundwater quality.

1.4.5 Thieu Do Commune

(1) Hydrogeology

The topography of Thieu Do commune is rather flat. The commune is located at the south of the Chu River.

In Thieu Do Commune there are two aquifers as follows:

- Quaternary aquifer is represented by recent alluvial deposits. They are composed of clay with sand in the upper part and gravel in the lower part. The thickness ranges from several meters to 20.0 m. The Quaternary gravel aquifer has high groundwater potential.
- Triassic carbonate aquifer

Carbonate deposits are composed of limestone. The limestone has good groundwater potential.

(2) Groundwater level

Groundwater levels of 8 existing wells were measured in October 1998. The measured 8 wells show that the depth to the groundwater level ranges between 0.44 and 3.88 m. Shallow groundwater levels within 1.0 m were detected at 3 wells.

The static groundwater level of the test well (JICA-14) was 2.85 m below the ground surface in March 1999.

(3) Groundwater quantity

In Thieu Do Commune, the test well has the well depth of 68 m. The screens were installed at depths from 18 to 50 m in the Quaternary aquifer and from 58 to 64 m in the limestone aquifer.

The result of the step-drawdown pumping test shows that the yields and drawdowns in the 4 steps are as follows:

Q ₁ 5330 l/min,	s ₁ 52.08 m
Q ₂ 5660 l/min,	s ₂ 54.21 m
Q ₃ 5990 l/min,	s ₃ 57.01 m
Q ₄ 1,320 l/min,	s ₄ 13.67 m

The discharge of test well is 1,320 l/min in correspondence with the final drawdown of 14.19 m by the continuous pumping test.

The optimal yield of the test well is evaluated as 1,800 m³/day with the permissible dynamic groundwater level of 20 m below the ground surface. This is the highest optimal yield among the test wells drilled by the study.

(4) Groundwater quality

1) Existing wells (see Figures 1.28 to 1.30)

In the commune, 8 hand-dug wells and 2 tube wells were investigated. The characteristics of the field quality measurement are as follows:

pH from 6.71 to 7.55

EC from 34.7 to 162.5 mS/m

ORP from 46 to 296 mV

DO from 4.7 to 6.5 mg/l

The color of water changes from clear, slightly yellow to slightly turbid. The EC values are high along the Chu River and the central part of the commune, showing more than 100 mS/m. The pH values along the Chu River is about 7.0; the values are high in the southern part and low in the western part of the commune. The water has many coliforms, ranging from 100 to 300 pcs./ml.

The results of chemical analysis show that the water of all the investigated wells has higher concentration of iron than the standard value. The wells having higher iron concentrations more than 0.1 mg/l are:

TD-5 ($\Sigma\text{Fe}51.540$ mg/l), TD-6 ($\Sigma\text{Fe}52.940$ mg/l), TD-7 ($\Sigma\text{Fe}51.120$ mg/l), TD-8 ($\Sigma\text{Fe}52.800$ mg/l), TD-9 ($\Sigma\text{Fe}51.205$ mg/l), TD-10 ($\Sigma\text{Fe}51.540$ mg/l).

The water of 5 hand dug wells have high TDS values exceeding the standard:

TD-2 (TDS51,597 mg/l), TD-3 (TDS51,637 mg/l), TD-4 (TDS51,411 mg/l), TD-5 (TDS51,550 mg/l), TD-9 (TDS51,206 mg/l).

One well has higher manganese concentration more than the standard: TD-4 (Mn50.292 mg/l).

The Stiff diagrams show that shallow groundwater near the Chu River is (Na1K)-HCO₃ type. The diagrams in the south of the communes show Ca-SO₄ type.

2) Test well

The result of chemical analysis of the test well (JICA-14) shows that the test well groundwater in Thieu Do Commune has a high TDS value (TDS51,096 mg/l) more

than the Vietnamese TDS standard (The Vietnamese standard 51,000 mg/ℓ). The rest of the chemical parameters show below the standard value.

(5) Evaluation

From the view point of quantity, the aquifers of Thieu Do Commune are excellent. The Quaternary aquifer and the limestone aquifer can yield enough groundwater for the water supply. However, the quality is not good, because the test well water has a higher TDS value than the standard value. It is noted that the concentrations of iron and manganese were low in the test well, however, it is necessary to carry out regular quality check after starting the pumping operation of the test well.

1.4.6 Van Thang Commune

(1) Hydrogeology

In Van Thang Commune, there are two aquifers:

- Quaternary unconsolidated aquifer, which is represented by alluvial deposits, is widely exposed on the surface. The thickness is several meters to 20 m. They consist of clay and sandy clay.
- Middle Triassic terrigenous aquifer (T_{2a} dt). They are composed of sandstone. Middle Triassic terrigenous aquifer with fractured sandstone has high groundwater productivity. The outcrops of the weathered shale was found at the foot of a small hill in the southern part of the commune.

(2) Groundwater level

Groundwater levels of 9 existing dug wells were measured in October 1998. The measured 9 wells show that the depth to the groundwater level ranges between 0.26 and 1.06 m. The groundwater levels of shallow groundwater are characterized by very shallow in the commune.

The static groundwater level of the test well (JICA-8) was 5.70 m in February 1999.

(3) Groundwater quantity

The test well (JICA-8) in Van Thang Commune has a well depth of 150 m. The screens were installed at depths from 99 to 119 m in sandstone aquifer.

The result of the step-drawdown pumping test shows that the yields and drawdowns in the 4 steps are as follows:

Q ₁ 5120 ℓ/min,	s ₁ 59.83 m
Q ₂ 5240 ℓ/min,	s ₂ 520.98 m
Q ₃ 5360 ℓ/min,	s ₃ 541.60 m
Q ₄ 5480 ℓ/min,	s ₄ 556.53 m

The discharge of the test well is 480 ℓ/min in correspondence with the final drawdown of 63.58 m by the continuous pumping test.

The optimal yield of the test well was evaluated as 300 m³/day with the permissible dynamic groundwater level of 30 m.

(4) Groundwater quality

1) Existing wells (see Figures 1.31 to 1.33)

In this commune, 9 hand dug wells and 1 tube well were investigated. The depth of tube well is 26.0 m. The depth of hand dug wells ranges from 2.8 m (VT-5) to 4.8 m (VT-10). The groundwater quality by the field measurement is as follows:

pH from 5.79 to 7.23

EC from 10.3 to 141.6 mS/m

ORP from 233 to 385 mV

DO from 4.7 to 7.2 mg/ℓ

The water has different color such as slightly turbid, slight yellow, slightly turbid and milky. The EC values are high in the northern part of the commune along the Muc River. In the central to the southern part of the commune, the EC values are lower than 30 mS/m. The pH values are high in the north and low in the southern part in the commune. The lowest pH value less than 6.0 was found at the foot of a small hill in the southern part of the commune. The quantity of coliforms changes from 100 to 300-400 pcs./ml.

The results of chemical analysis of water show that the 9 water samples out of 10 have higher iron concentrations than the standard value, ranging from 0.7 to 3.64 mg/ℓ (VT-6). The water of VT-7 dug well has high TDS of 1,433 mg/ℓ, which is above the standard value. The well is located close to the Muc River. The lowest pH value was found at VT-9 (pH56.10). The SO₄ and Na concentrations at VT-8 exceed the standard values.

The Stiff diagrams show that the groundwater near the Muc River is (Na1K)-Cl type.

2) Test well

The result of chemical analysis shows that the concentrations of manganese, iron, chloride and sodium exceeds the Vietnamese and/or the WHO standard for drinking water:

Σ Fe 50.950 mg/l (Vietnamese standard Σ Fe 50.500 mg/l)

Mn 50.270 mg/l (Vietnamese and WHO standard Mn 50.100 mg/l).

Cl 5412.80 mg/l (Vietnamese: Cl 500.00 mg/l, WHO: Cl 250.00 mg/l)

Na 5317.00 mg/l (Vietnamese and WHO standard Na 200.00 mg/l)

(5) Evaluation

It is noted that the quality of deep groundwater from the test well was worse than that of shallow groundwater. The test well water is saline and it cannot be used for the source of the drinking water supply. It is necessary to drill several production wells in the commune to provide safe drinking water. The locations of new production wells should be selected from the central to the southern parts of the commune, apart from the Muc River. The yield of each well may not be so big, about 300 m³/day based on the result of the test well.

1.4.7 Nong Cong Town

(1) Hydrogeology

The hydrogeological conditions of Nong Cong Town are similar to the hydrogeological conditions of Van Thang Commune. There are two aquifers:

- Quaternary unconsolidated aquifer is represented by alluvial deposits and widespread exposed on the surface. The thickness is of several meters to 20 m. They consist of clay and sandy clay. Groundwater potential in the Quaternary deposits is low.
- Middle Triassic terrigenous aquifer (T_{2a dt}) is composed of sandstone. The aquifer has medium potential of yielding groundwater based on the test well drilling in Van Thang Commune.

(2) Groundwater level

Groundwater level of 4 existing dug wells were measured in October 1998. The measured 4 wells show that the depth to groundwater level ranges between 0.28 and

0.44 m.

(3) Groundwater quantity

No test well was drilled in the commune. According to the result of the test well in Van Thang Commune, about 300 m³/day can be pumped from a well drilled at the fractured sandstone aquifer.

(4) Groundwater quality

1) Existing wells (see Figures 1.31 to 1.33)

The groundwater quality of 6 tube wells and 4 hand dug wells were measured in this town. The depths of the tube wells range from 24 m (NC-5) to 34 m (NC-8). The depth of hand-dug wells ranges from 3.15 to 5.27 m. The characteristics of groundwater quality in the existing wells are as follows:

pH from 6.30 to 7.73

EC from 58.0 to 416.0 mS/m

ORP from 309 to 391 mV

DO from 5.5 to 7.5 mg/l

The EC values are very high in the commune, particularly along the Muc River. The distribution of pH values is complex, but it can be seen that the southern part of the town is slightly high, showing slight alkaline water. Coliform quantity in water changes from about from 100 to 300~400 pcs./ml.

The results of chemical analysis show that the water of following tube wells and hand dug wells have higher TDS values than the standard:

NC-2 (TDS53,142 mg/l), NC-3 (TDS53,156 mg/l), NC-5 (TDS51,564 mg/l), NC-6 (TDS56,424 mg/l), NC-7 (TDS51,369 mg/l), NC-8 (TDS51,104 mg/l)

The groundwater from the following two wells has iron concentrations higher than the standard:

NC-5 (Σ Fe57.140 mg/l), NC-8 (Σ Fe51.235 mg/l)

Manganese concentrations are also high in the following wells:

NC-2 (Mn52.353 mg/l), NC-3 (Mn53.155 mg/l), NC-5 (Mn50.408 mg/l), NC-6

(Mn50.619 mg/l), NC-7 (Mn50.976 mg/l), and NC-9 (Mn50.762 mg/l)

Na and Cl concentrations are also very high in 4 existing wells, showing higher than the standard values. A SO₄ concentration at NC-10 well exceeds the standard value.

The Stiff diagrams show that the groundwater in the existing wells is Na-Cl type.

2) Test well

Although no test well was drilled in the town, the quality of deep groundwater may be worse than that of shallow groundwater.

(5) Evaluation

The groundwater quality in Nong Cong Town is poor, not good for drinking water supply. Particularly in the area along the Muc River, the groundwater is saline, which is influenced by the tidal river water.

For safe drinking water supply from the groundwater, it is difficult to find a suitable location near the Muc River where most of houses are situated. The possibility is only remains in the southwestern part of the town to obtain good groundwater. But it is presumed that the quantity of groundwater is not so much based on the result of the test well drilling in Van Thang Commune. But, it would also happen that the deep groundwater quality is poorer than that of shallow groundwater like the Van Thang test well.

It is recommended that if the town needs a safe groundwater source, the source should be found from the outside of the town. From the hydrogeological viewpoints, the southern to southwestern areas from the town are the candidate places for drilling production wells. It is also a optional idea that safe groundwater source in Van Thang Commune will cover Nong Cong Town, sharing the source and the water supply system with the commune.

1.5 Ha Tinh Province

1.5.1 Yen Ho Commune

(1) Hydrogeology

The Quaternary aquifer (Q) is the main aquifer in Yen Ho Commune. According to the

test well drilling in Duc Yen and Trung Le Communes, the gravel layers in the lower part of the Quaternary sediments from a aquifer.

Neogene sediments consisting mainly of weakly consolidated claystone has very low groundwater potential. Base on the results of geophysical prospecting and test well drilling, the Neogene sediments is composed of such fine sediments and occur at least 150 m from the ground surface.

Therefore, it can be said that the target aquifer is only the Quaternary aquifer in the area within a depth of 150 m from the surface.

(2) Groundwater level

Groundwater levels of 10 existing dug wells were measured in October 1998. The measured 10 wells show that the depth to the groundwater level ranges between 0.58 and 2.94 m. Shallow groundwater levels within 1.0 m from ground surface were detected at two (2) wells.

(3) Groundwater quantity

Detailed information is not available on the groundwater quantity in the commune, however, it is estimated from the test wells in Duc Yen and Trung Le Commune that the Quaternary aquifer can yield 10 to 250 m³/day per well.

(4) Groundwater quality

1) Existing wells (see Figures 1.34 to 1.36)

There are 11 investigated hand dug wells in Yen Ho Commune. The pH values vary from 4.18 to 6.81. The hand dug well YH-3 has a very low pH value of 4.18. Other characteristics are:

EC from 28.9 to 146.0 mS/m

ORP from 253 to 415 mV

DO from 3.3 to 7.0 mg/l

Water of all hand dug wells have brown, green or yellowish brown in color. There is one public well where water is used by 60 houses; the color of water is green. All hand dug wells were polluted by coliform, from about 100 to 400~500 pcs./ml. In dry season, many hand dug wells are dried up (YH-1, YH-2, YH-3, YH-4, YH-7, YH-8).

The EC values are high in the northern to the eastern parts of the commune, having

more than 100 mS/m. The pH values show the shallow groundwater is acidic, particularly in the northwestern part of the commune where the pH values are below 6.0. The values in the eastern part also show between 5.5 to 6.0.

The results of chemical analysis show that the groundwater of all the investigated hand dug wells have higher concentration of total iron (ΣFe). The iron concentration is about two to five times higher than the Vietnamese standard of iron concentration. There are following hand dug wells having higher concentration of iron more than 1.0 mg/l:

YH-1 ($\Sigma\text{Fe}53.024$ mg/l), YH-2 ($\Sigma\text{Fe}53.080$ mg/l), YH-4 ($\Sigma\text{Fe}55.095$ mg/l), YH-5 ($\Sigma\text{Fe}52.912$ mg/l), YH-10 ($\Sigma\text{Fe}51.045$ mg/l), and YH-11 ($\Sigma\text{Fe}52.010$ mg/l)

The pH values of the hand dug wells are very low compared with the Vietnamese standard of pH values for drinking water. The wells having lower pH values are:

YH-1 (pH56.4), YH-3 (pH54.9), YH-4 (pH56.3), YH-9 (pH56.02), and YH-11 (pH56.06)

Groundwater from some hand dug wells have higher TDS values than the standard value. Those wells are:

YH-3 (TDS51,030 mg/l), YH-8 (TDS51,091 mg/l), YH-9 (TDS51,123 mg/l), and YH-10 (TDS51,473 mg/l)

Higher manganese values above the standard value are also found from 8 wells, ranging from 0.186 mg/l (YH-5) to 2.894 mg/l (YH-2).

The Stiff diagrams show that the shallow groundwater is Na-Cl type and Mg-SO₄ type.

2) Test well

There is no test well in the commune, however, it is presumed that the quality of the Quaternary aquifer in depths from 20 to 50 m below ground surface will be saline and containing much iron and manganese

(5) Evaluation

The groundwater potential of the Neogene sediments are very low, that cannot be used as a source aquifer for the drinking water supply from the quantity and quality points of view. The Quaternary aquifer may be medium productive, however, the quality is not

meet the drinking water standard.

Therefore, it is concluded that the groundwater resource in the commune is not suitable to provide safe drinking water. It is recommended that other water sources such as surface water or rainwater should be used for safe water supply.

In addition, the possibility to find fresh groundwater source from more deeper layers is not known. But there is no indication of the occurrence of such deep fresh groundwater from various kind of field surveys carried out by the study.

1.5.2 Duc Yen Commune

(1) Hydrogeology

The Quaternary aquifer (Q) is the main aquifer in Duc Yen Commune. According to the test well drilling in the commune and Trung Le Commune, the gravel layers in the lower part of the Quaternary sediments form a aquifer.

The Quaternary sediments are composed of Pleistocene including Nghi Xuan formation ($apQ_{I-II} nx$) and Yen My formation ($am Q_{III} ym$) and Holocene sub-division (composed of Middle Holocene sub-division $am Q_{IV}^2$ and upper Holocene sub-division $a Q_{IV}^3$).

The upper Holocene sub-division ($a Q_{IV}^3$) is represented by recent alluvial deposits occurring along rivers and stream in the area. It is composed of sand, clayey sand, muddy clay mixed with some small gravel of gray, dark gray colors. The thickness is 2 to 8 m.

The Middle Holocene sub-division ($am Q_{IV}^2$) is widely distributed on the surface in the Duc Yen Commune of alluvial-marine genesis, consisting of clay, silty clay, sandy clay of gray color. In the lower part it is composed of fine to medium sand of gray and blackish gray color with the thickness of 2 to 10 m. Yen My formation ($am Q_{III} ym$) underlying of Middle Holocene sub-division ($am Q_{IV}^2$) and covering the Nghi Xuan formation ($ap Q_{I-II} nx$). Yen My formation is of alluvial and marine genesis, composed of clay, sandy clay, sand, gravel, pebble of motley yellowing brown, White gray color, compacted. The thickness is 5-30m.

Nghi Xuan formation ($ap Q_{I-II} nx$) was encountered in the test well with proluvial and alluvial genesis, consisting of clay, quartz, and polymictic sand, pebble and gravel. The pebble and gravel are 1 to 2 cm in size, in some places 3 to 4 cm in size, medium

rounded and sorted. The groundwater capacity is medium. The thickness is 5 to 30 m. Nghi Xuan formation is distributed in the depth from 27.4 m to 36.7m.

Neogene system occur in the deeper part of Duc Tho Town below the Quaternary cover (the Nghi Xuan formation). It was encountered in all the test wells in Duc Tho District.

Lithologically it is composed of claystone, siltstone, in some places it is intercalated, the rocks reddish brown, yellowish brown, purple brown, gray, black gray in color, with medium bedded to thick bedded structures. The upper part is strongly weathered, rather friable. The groundwater potential is very low. The thickness is 150 to 120 m.

In test well, the thickness of the Middle Holocene sub-division (am Q_{IV}^2) is 8.10 m. The thickness of the Yen Myx formation (am Q_{III}^{ym}) is 19.3 m. The Thickness of Nghi Xuan formation (ap Q_{I-II}^{nx}) is 9.3m. The thickness of Neogene system is 67.3 m.

Groundwater in Quaternary sediment in Duc Tho District in general and in Duc Yen Commune in particular is brackish or saline, can not use for drinking water.

Neogene deposits in Duc Yen Commune has very low productivity, and groundwater quality is not good.

Neogene sediments consisting mainly of weakly consolidated claystone has very low groundwater potential. Base on the results of geophysical prospecting and test well drilling, the Neogene sediments is composed of such fine sediments and occur at least 150 m from the ground surface.

Therefore, it can be said that the target aquifer is only the Quaternary aquifer in the area within a depth of 150 m from the surface.

(2) Groundwater level

Groundwater levels of 8 existing dug wells were measured in October 1998. The measured 8 wells show that the depth to the groundwater level ranges between 0.64 and 3.11 m. Shallow groundwater levels within 2.0 m from ground surface were detected at 5 wells.

The static groundwater level of the test well was 2.90 m below the ground surface in March 1999.

(3) Groundwater quantity

In Duc Yen commune, the test well (JICA-12) has the well depth of 104 m. The screens were installed at depths from 20 to 28 m in the Quaternary sediments and from 84 to 100 m in the Neogene clay.

The result of step-drawdown pumping test shows that the yields and drawdowns in the 4 steps are as follows:

Q ₁ 575 ℓ/min,	s ₁ 51.36 m
Q ₂ 5150 ℓ/min,	s ₂ 53.24 m
Q ₃ 5225 ℓ/min,	s ₃ 56.11 m
Q ₄ 5300 ℓ/min,	s ₄ 59.27 m

The discharge of the test well is 300 ℓ/min in correspondence with the drawdown of 14.43 m by the continuous pumping test.

The optimal yield is evaluated as 250 m³/day with the permissible dynamic groundwater level of 10 m below the ground surface.

(4) Groundwater quality

1) Existing wells (see Figures 1.37 to 1.39)

In Duc Yen Commune, 10 hand-dug wells were investigated. Water of all 10 wells was polluted by coliform. Quantity of coliform varies from about 100 to 400~500 pcs./ml. Especially the water of hand dug well of DY-1, DY-2, DY-3, DY-6, DY-7, DY-8 were strongly polluted by coliform. The results of the field measurement are as follows:

pH from 6.29 to 7.34

EC from 27.2 to 178.5 mS/m

ORP from -102 to 169 mV

DO from 3.2 to 5.5 mg/ℓ

The EC values are high in the central to eastern parts of the commune, showing more than 100 mS/m. The pH values are less than 7.0 along the river, but it increases with the distance from the river.

Compared with the Vietnamese and WHO standards, the results of chemical analysis show that the shallow groundwater has higher values in TDS, manganese and iron. The water of the following hand-dug wells has higher iron concentration and TDS than the

standard values:

DY-1 (Fe50.563 mg/l), DY-2 (Fe50.700 mg/l), DY-3 (Fe50.755 mg/l), DY-6 (Fe54.815 mg/l), DY-10 (Fe51.380 mg/l)
DY-9 (TDS51,804 mg/l), DY-8 (TDS51,316 mg/l)

Manganese concentrations are high in DY-4 (Mn50.570 mg/l), DY-6 (Mn52.035 mg/l), DY-7 (Mn50.480 mg/l), and DY-8 (Mn50.504 mg/l).

The Stiff diagrams show that the shallow groundwater is Na-Cl type or Na-SO₄ type.

2) Test well

The result of chemical analysis of groundwater from the test well (JICA-12) in Duc Yen Commune shows that, the TDS, Mn, Fe, Cl and Na exceeds the Vietnamese and WHO standard for drinking water:

TDS51,815 mg/l, Fe50.82 mg/l, Mn52.05 mg/l, Cl51,126 mg/l, and Na5588.40 mg/l

(5) Evaluation

The groundwater potential of the Neogene sediments are very low, that cannot be used as a source aquifer for the drinking water supply from the quantity and quality points of view. Especially the groundwater in the commune is strongly saline water. The Quaternary aquifer may be medium productive, however, the quality is not meet the drinking water standard.

Therefore, it is concluded that the groundwater resource in the commune is not suitable to provide safe drinking water. It is recommended that other water sources such as surface water or rainwater should be used for safe water supply.

In addition, the possibility to find fresh groundwater source from more deeper layers is not known. But there is no indication of the occurrence of such deep fresh groundwater from various kind of field surveys carried out by the study.

1.5.3 Bui Xa Commune

(1) Hydrogeology

The Quaternary aquifer (Q) is the main aquifer in Bui Xa Commune. According to the test well drilling in Duc Yen and Trung Le Communes, the gravel layers in the lower

part of the Quaternary sediments from a aquifer.

Neogene sediments consisting mainly of weakly consolidated claystone has very low groundwater potential. Base on the results of geophysical prospecting and test well drilling, the Neogene sediments is composed of such fine sediments and occur at least 150 m from the ground surface.

Therefore, it can be said that the target aquifer is only the Quaternary aquifer in the area within a depth of 150 m from the surface.

(2) Groundwater level

Groundwater levels of 10 existing wells were measured in October 1998. The measured 10 wells show the depth to the groundwater level ranges between 1.24 and 4.91 m. Shallow groundwater levels within 2.0m from ground surface were detected at the 5 wells.

(3) Groundwater quantity

Detailed information is not available on the groundwater quantity in the commune, however, it is estimated from the test wells in Duc Yen and Trung Le Commune that the Quaternary aquifer can yield 10 to 250 m³/day per well.

(4) Groundwater quality

1) Existing wells (see Figures 1.37 to 1.39)

There are 10 hand dug wells which were investigated in Bui Xa Commune. The sanitary conditions of groundwater are not good. Water of all 10 hand dug wells are polluted by coliforms. Quantity of coliforms varies from 84 to 400 pcs./ml.

The groundwater levels in the hand dug wells vary by season. In dry season, many wells are dried up (BX-1, BX-6, BX-9). People of the commune use the water of hand dug wells only for washing. They use river water and rain water for drinking and cooking.

The characteristics of the groundwater quality are:

pH from 6.38 to 7.45

EC from 45.3 to 239.0 mS/m

ORP from 214 to 195 mV

DO from 3.7 to 6.5 mg/l

Water of all the wells has color from slight brown to very yellowish brown. The EC values are ranging from 45 to 100 mS/m in the central part of the commune, however, higher EC values more than 100 mS/m were found in the western part and northeastern part of the commune.

The results of chemical analysis of groundwater from the 10 hand dug wells show that there are 6 hand dug wells having TDS over the standard value (31,000 mg/l) among the 10 hand dug wells. The wells having higher values of TDS are:

BX-1 (TDS51,382 mg/l), BX-2 (TDS51,174 mg/l), BX-3 (TDS51,832 mg/l), BX-4 (TDS53,040 mg/l), BX-9 (TDS53,200 mg/l), and BX-10 (TDS52,812 mg/l)

There is one hand dug well having SO_4^{2-} over the standard value (BX-10: SO_4^{2-} 5558.89 mg/l). Six (6) dug wells have iron concentration over the standard value, the maximum is recorded at BX-6 (Fe51.260 mg/l). And one hand dug well (BX-10) has Mn and Na concentrations more than the standard values. (Mn50.192 mg/l, Na5234.40 mg/l).

2) Test well

There is no test well in the commune, however, it is presumed that the quality of the Quaternary aquifer in depths from 20 to 50 m below ground surface will be saline and containing much iron and manganese.

(5) Evaluation

The groundwater potential of the Neogene sediments are very low, that cannot be used as a source aquifer for the drinking water supply from the quantity and quality points of view. The Quaternary aquifer may be medium productive, however, the quality is not meet the drinking water standard.

The TDS values of shallow groundwater show that the water quality in the central part of the commune is better than other areas in the commune, however, it is presumed that quality of the deep groundwater will be saline in the whole commune.

Therefore, it is concluded that the groundwater resource in the commune is not suitable to provide safe drinking water. It is recommended that other water sources such as surface water or rainwater should be used for safe water supply.

In addition, the possibility to find fresh groundwater source from more deeper layers is

not known. But there is no indication of the occurrence of such deep fresh groundwater from various kind of field surveys carried out by the study.

1.5.4 Trung Le Commune

(1) Hydrogeology

The hydrogeological conditions of Trung Le Commune are similar to hydrogeological conditions of Duc Yen Commune.

There are two aquifer in Trung Le Commune:

- Quaternary porous aquifer exposed on the surface is represented by recent alluvial (river and marine) deposits. The thickness is 68.0 m. The groundwater in the Quaternary deposits is brackish or saline and can not be used for drinking water.
- Neogene deposits in test well has the thickness 38.6 m. The results of pumping test from the test well JICA 13 (from the Neogene deposits) and test well JICA-15 (from the Quaternary deposits) shows that the groundwater in both aquifer is very limited can not use for water supply.

(2) Groundwater level

Groundwater levels of 8 existing dug wells were measured in October 1998. The measured 8 wells show the depth to the groundwater level ranges between 0.98 and 3.36 m. Shallow groundwater levels within 2.0 m from the ground surface were detected at 5 wells.

The static groundwater level of the JICA-13 test well was 2.80 m below the ground surface in April 1999, whereas the level of JICA-15 well was 2.48 m in April 1999.

(3) Groundwater quantity

In Trung Le Commune, there are two tests well (JICA 13 and JICA15).

The JICA-13 has the well depth of 100 m. The screens were installed at depths from 58 to 82 m in Neogene clay and a part of the Quaternary gravel layer. The result of step-drawdown pumping test at the JICA-13 well shows that the yields and drawdowns in 2 steps are as follows.

$Q_1 59 \text{ l/min,}$ $s_1 52.56 \text{ m.}$

Q₂518 ℓ/min, s₂514.6 m

The discharge of JICA-13 well was 18 l/min in accordance with the final drawdown of 22.76 m by the continuous pumping test.

The JICA-15 well has the well depth of 70 m. The screens were installed at depths from 16 to 36 m in the Quaternary gravel layer.

The result of step-drawdown pumping test in the JICA-15 well shows that the yield and drawdowns in the 4 steps are as follows:

Q ₁ 545 ℓ/min,	s ₁ 50.85 m
Q ₂ 590 ℓ/min,	s ₂ 51.80 m
Q ₃ 5135 ℓ/min,	s ₃ 53.09 m
Q ₄ 5180 ℓ/min,	s ₄ 56.93 m.

The discharge of JICA-15 well is 180 ℓ/min in correspondence with the final drawdown of 6.75 m by the continuous pumping test.

The optimal yield of the JICA-13 well was evaluated as 10 m³/day with the permissible dynamic groundwater level of 10 m below the ground surface. The optimal yield of the JICA-15 well was evaluated as 250 m³/day with the permissible dynamic groundwater level of 15 m below the ground surface.

(4) Groundwater quality

1) Existing wells (see Figures 1.37 to 1.39)

In Trung Le Commune, 8 hand dug wells and 2 tube wells were investigated. The depths of 2 tube wells are 24 and 34 m.

The characteristics of the groundwater quality are as follows:

pH from 5.17 to 7.72
EC from 20.3 to 213.0 mS/m
ORP from 102 to 159 mV
DO from 3.5 to 6.2 mg/l

The EC values in the commune are generally high, showing more than 100 mS/m. Only sporadically lower EC values are found at the western part and eastern part of the

commune. The pH values are high in the northern part and low in the southern part of the commune. The groundwater of all hand-dug wells and tube wells are polluted by coliforms. Quantity of coliforms varies from about 100 to 400 pcs./ml. Color of water greatly differs from slightly turbid, dark grey, slightly brown to yellowish brown.

The results of chemical analysis show that the groundwater in the existing wells has higher values of TDS, Mn, SO₄, Fe, and Na than the Vietnamese standards. The wells having higher values of TDS are as follows:

TL-1 (Fe51.568 mg/l), TL-2 (Fe51.12 mg/l), TL-3 (Fe50.728 mg/l), TL-4 (Σ Fe51.540 mg/l), TL-8 (Fe50.84 mg/l), and TL-10 (Fe50.56 mg/l)

Sulfate (SO₄²⁻) concentration in groundwater of TL-5 hand dug well is 534.60 mg/l, which is higher than the maximum standard value of 400 mg/l. TDS values of groundwater in some hand-dug wells are higher than 1,000 mg/l, which is the standard value of WHO and Vietnamese rural criteria. The hand dug wells having higher TDS values are the following:

TL-1 (TDS51,977 mg/l), TL-3 (TDS52,647 mg/l), TL-5 (TDS51,331 mg/l), TL-7 (TDS51,452 mg/l), TL-9 (TDS51,602 mg/l), and TL-10 (TDS52,390 mg/l).

Five (5) hand-dug wells have higher Mn concentrations than the standard value; they range from 0.218 to 1.003 mg/l.

The Stiff diagrams show that the shallow groundwater is Na-Cl type or Mg-SO₄ type.

2) Test well

The result of chemical analysis of groundwater of JICA-13 well shows that the TDS, Mn, Fe, Cl, and Na values exceed the Vietnamese drinking water standards:

TDS55,296 mg/l, Fe572.64 mg/l, Mn57.31 mg/l, Na5906.80 mg/l, and Cl51,775.2 mg/l

The JICA-15 has TDS52,149 mg/l, Cl5609.8 mg/l, and Na5391.23 mg/l. These values are exceeding the Vietnamese drinking water standard.

(5) Evaluation

The groundwater potential of the Neogene sediments are very low, that cannot be used

as a source aquifer for the drinking water supply from the quantity and quality points of view. Especially the groundwater in the commune is strongly saline water. The Quaternary aquifer may be medium productive, however, the quality is not meet the drinking water standard.

Therefore, it is concluded that the groundwater resource in the commune is not suitable to provide safe drinking water. It is recommended that other water sources such as surface water or rainwater should be used for safe water supply.

In addition, the possibility to find fresh groundwater source from more deeper layers is not known. But there is no indication of the occurrence of such deep fresh groundwater from various kind of field surveys carried out by the study.

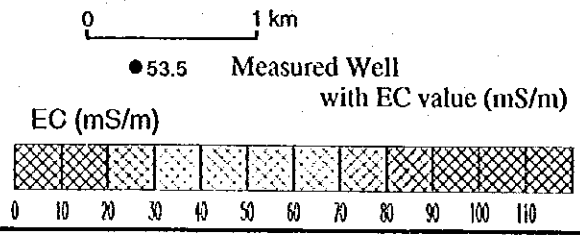
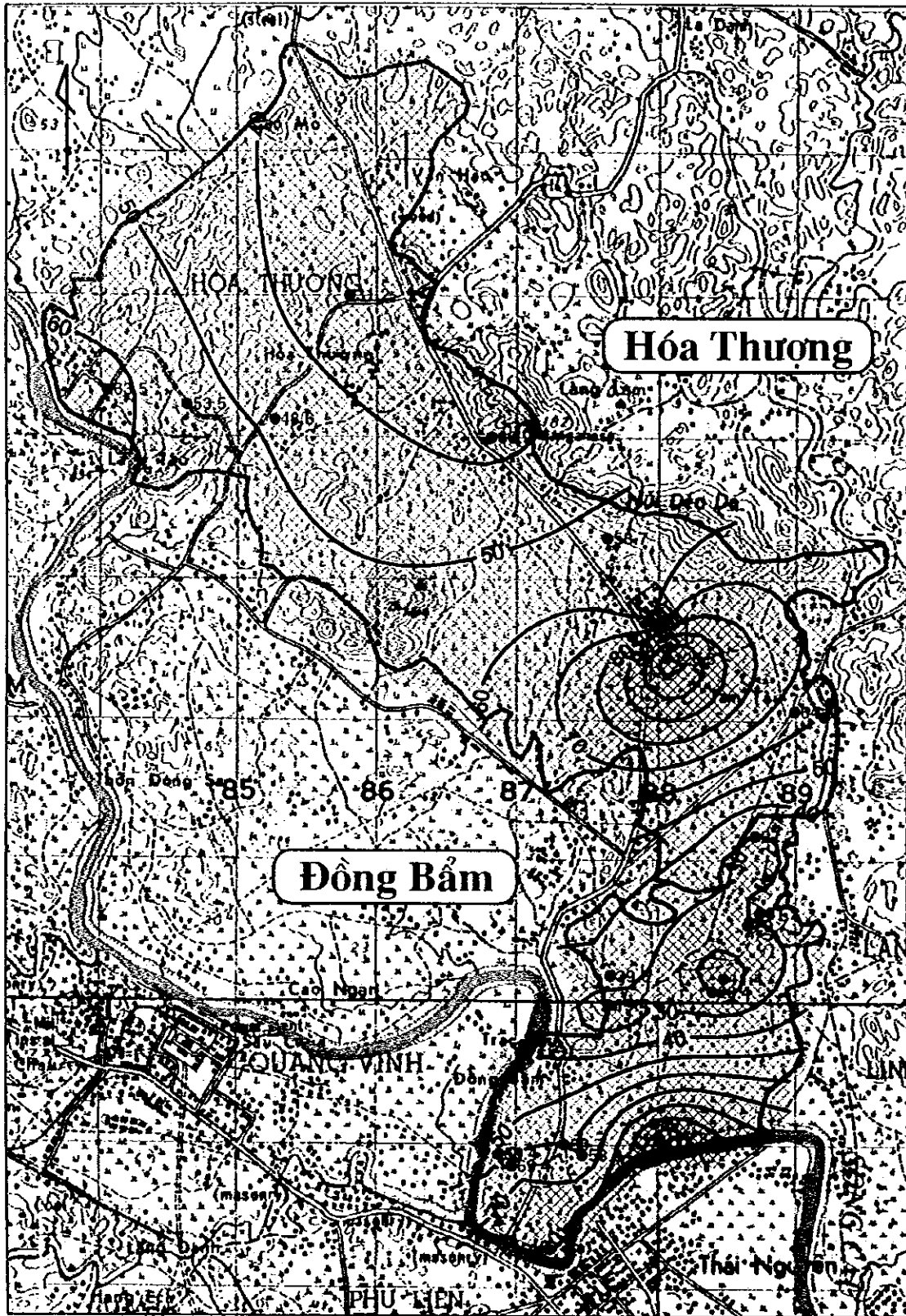
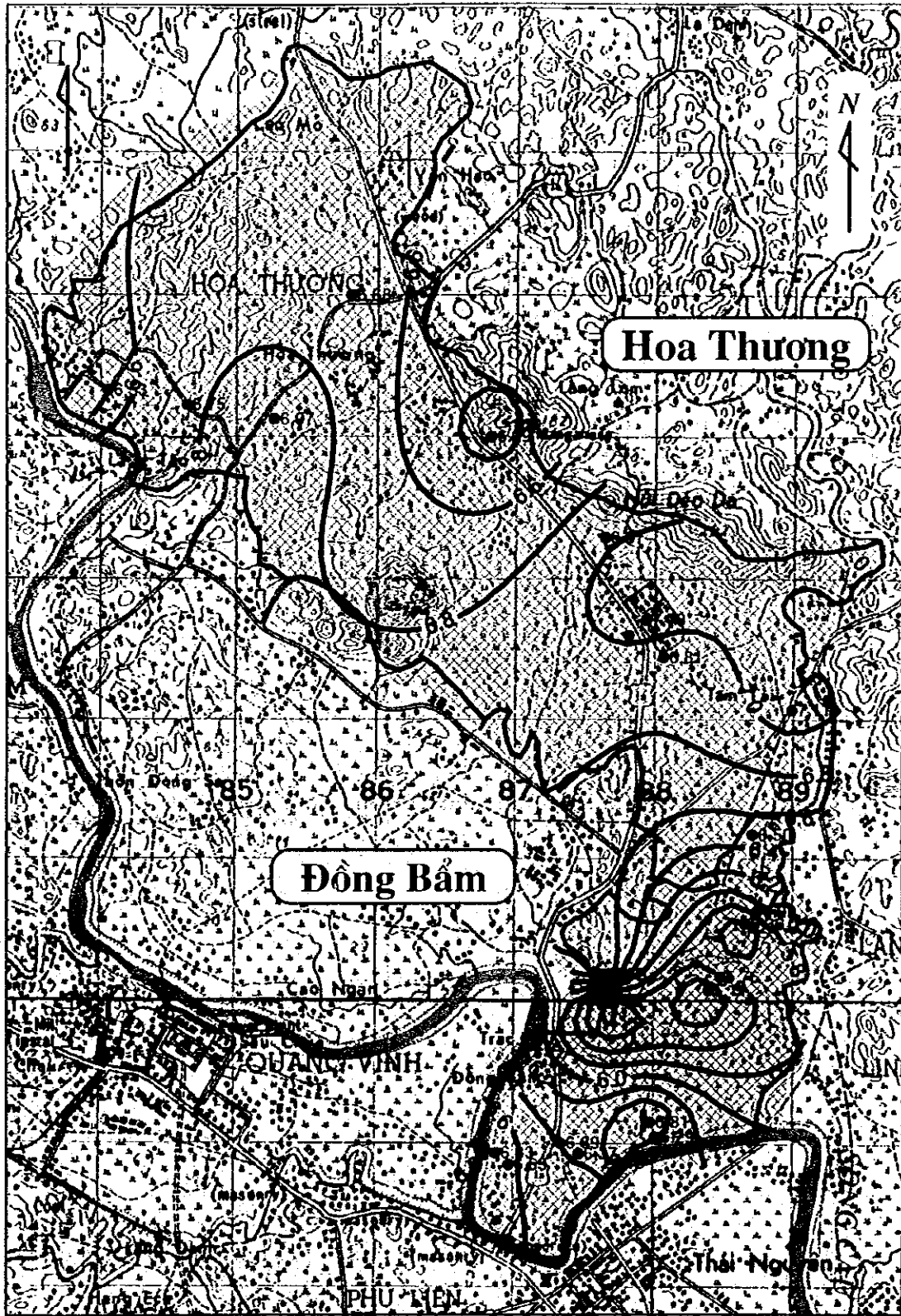


Figure 1.1 Distribution of EC Values in Hoa Thuong and Dong Bam Communes, Thai Nguyen Province

THE STUDY ON GROUNDWATER DEVELOPMENT IN THE RURAL PROVINCES OF NORTHERN PART IN THE SOCIALIST REPUBLIC OF VIETNAM

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



0 1 km

● 7.00 Measured Well with pH value



4.0 4.4 4.8 5.2 5.6 6.0 6.4 6.8 7.0

Figure 1.2

Distribution of pH Values in
Hóa Thượng and Đông Bám Communes,
Thái Nguyên Province

THE STUDY ON GROUNDWATER DEVELOPMENT IN
THE RURAL PROVINCES OF NORTHERN PART IN
THE SOCIALIST REPUBLIC OF VIETNAM

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

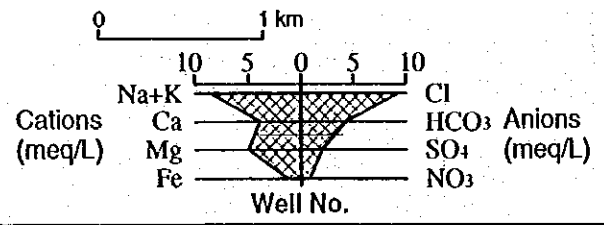
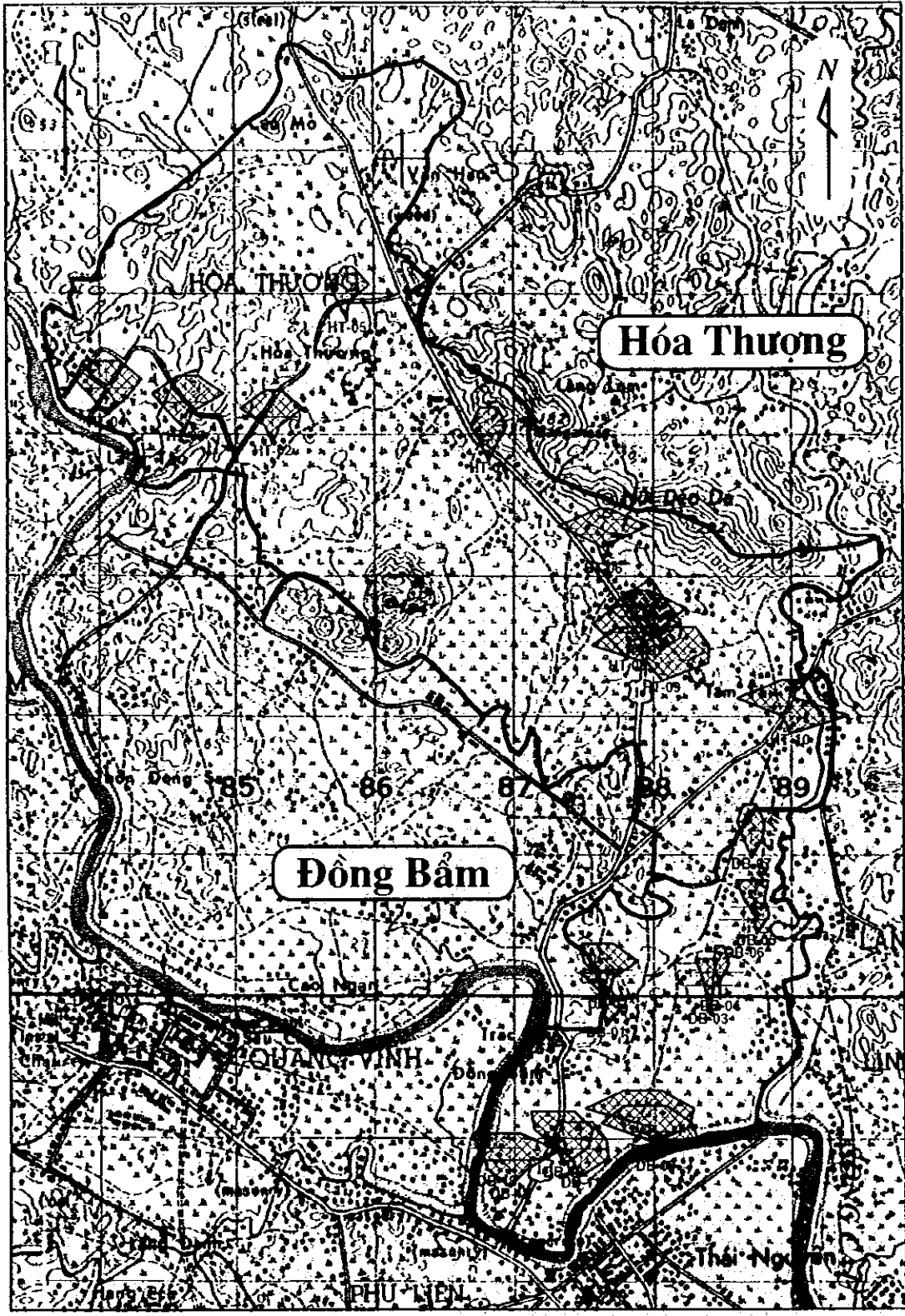
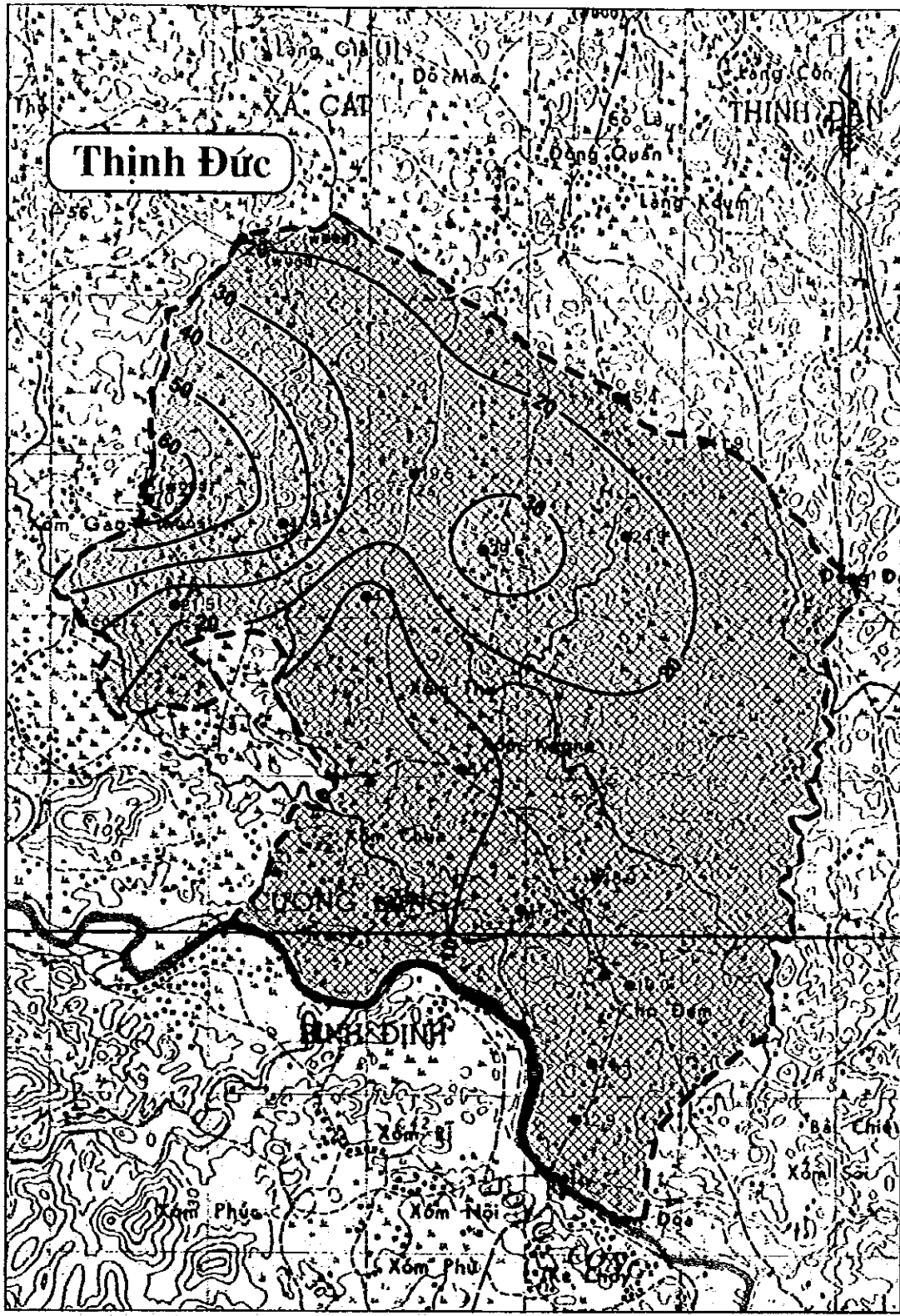


Figure 1.3 Stiff Diagram of
Hóa Thượng and Đông Bám Communes,
Thái Nguyên Province

THE STUDY ON GROUNDWATER DEVELOPMENT IN
THE RURAL PROVINCES OF NORTHERN PART IN
THE SOCIALIST REPUBLIC OF VIETNAM

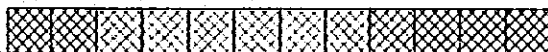
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



0 1 km

● 53.5 Measured well with EC value (mS/m)

EC (mS/m)



0 10 20 30 40 50 60 70 80 90 100 110

Figure 1.4

Distribution of EC Values in Thinh Duc Commune, Thai Nguyen Province

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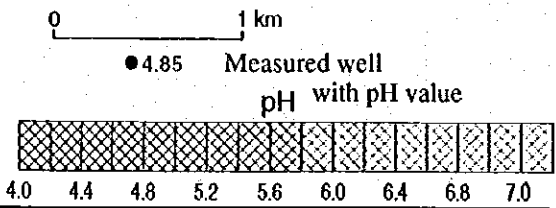


Figure 1.5 Distribution of pH Values in Thỉnh Đức Commune, Thái Nguyên Province

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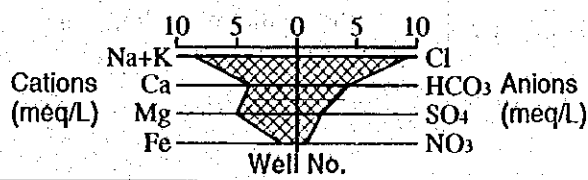
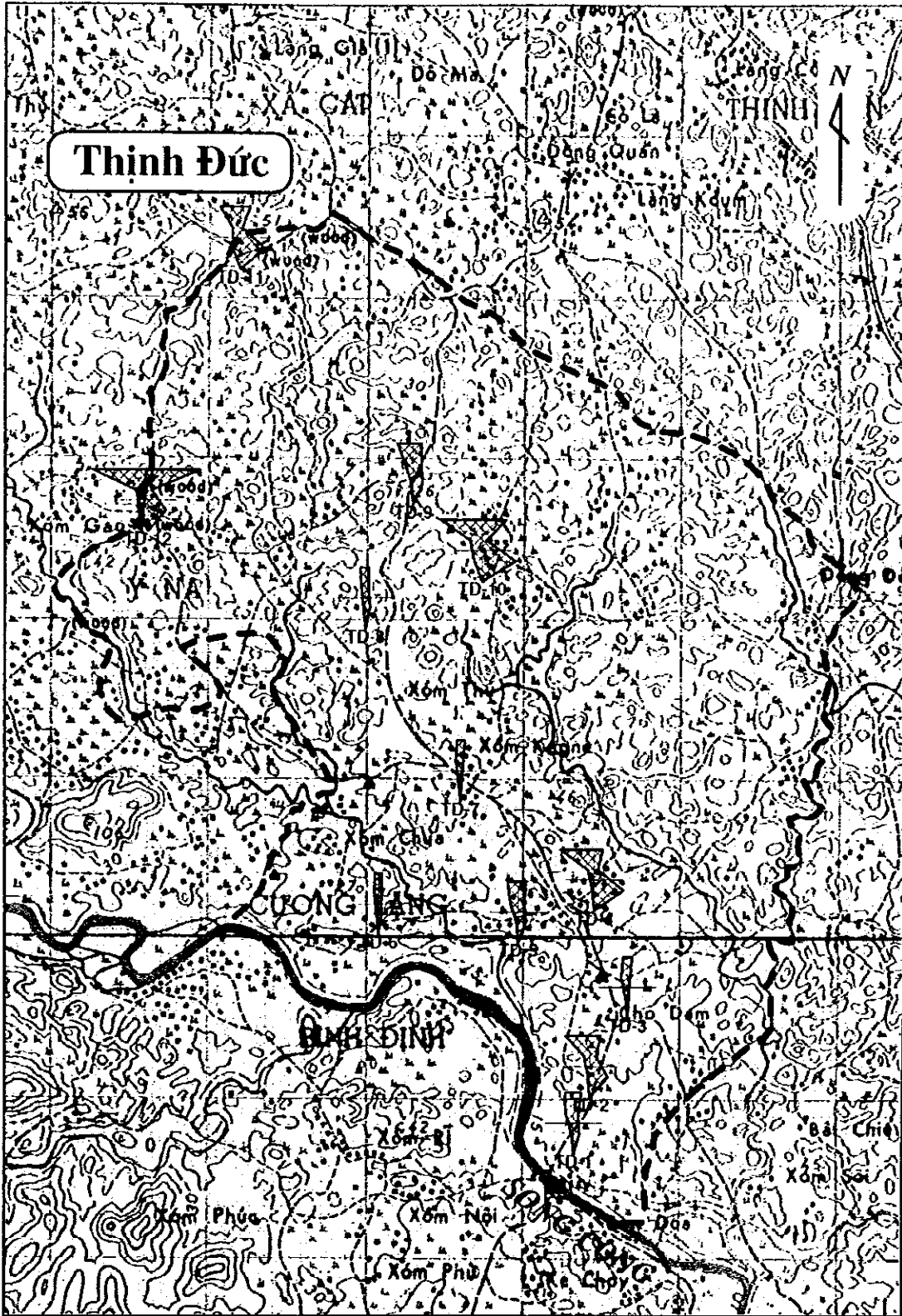


Figure 1.6 Stiff Diagram of Thỉnh Đức Commune, Thái Nguyên Province

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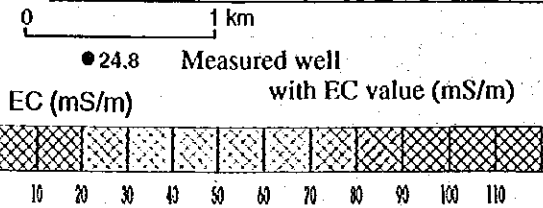
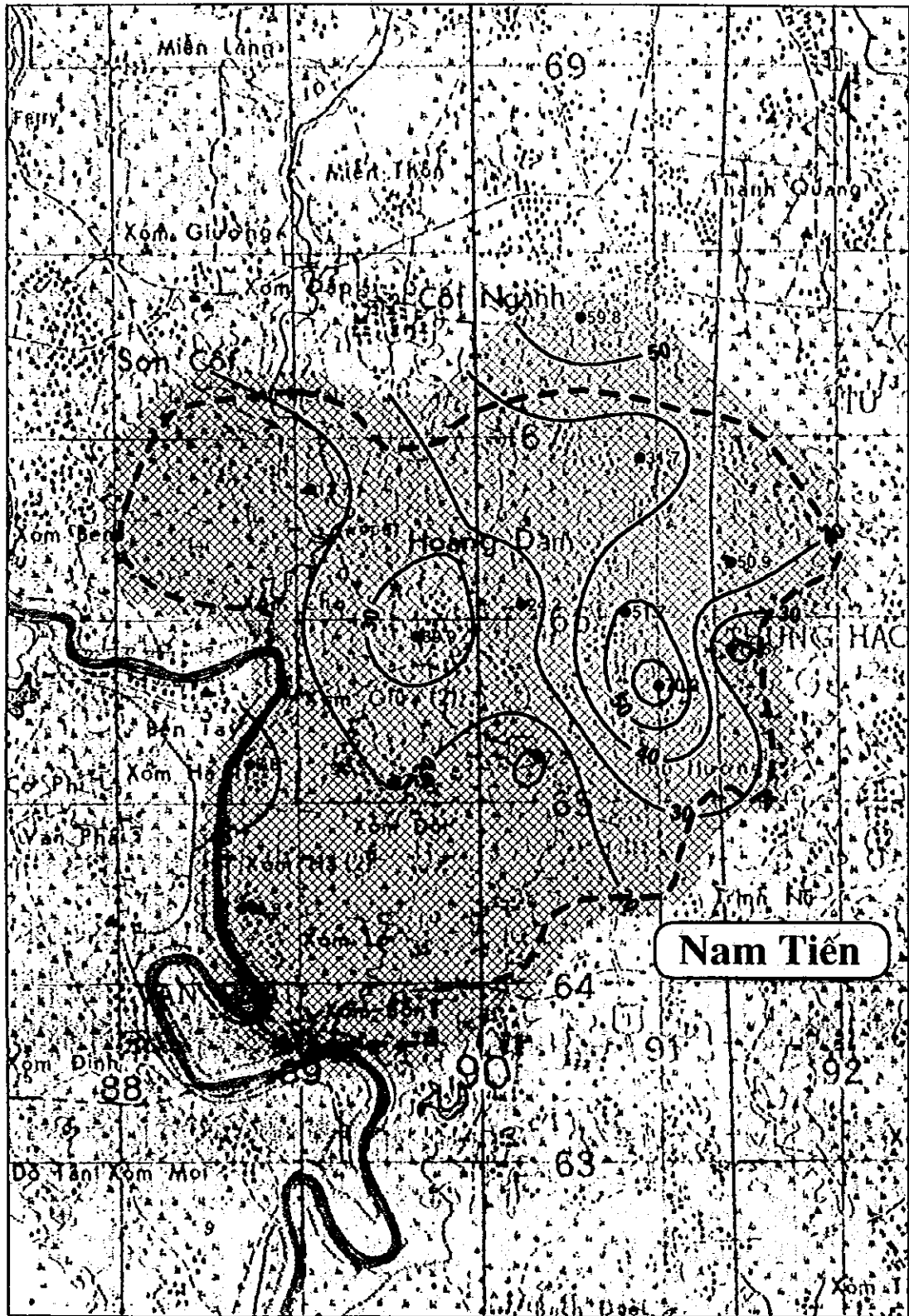
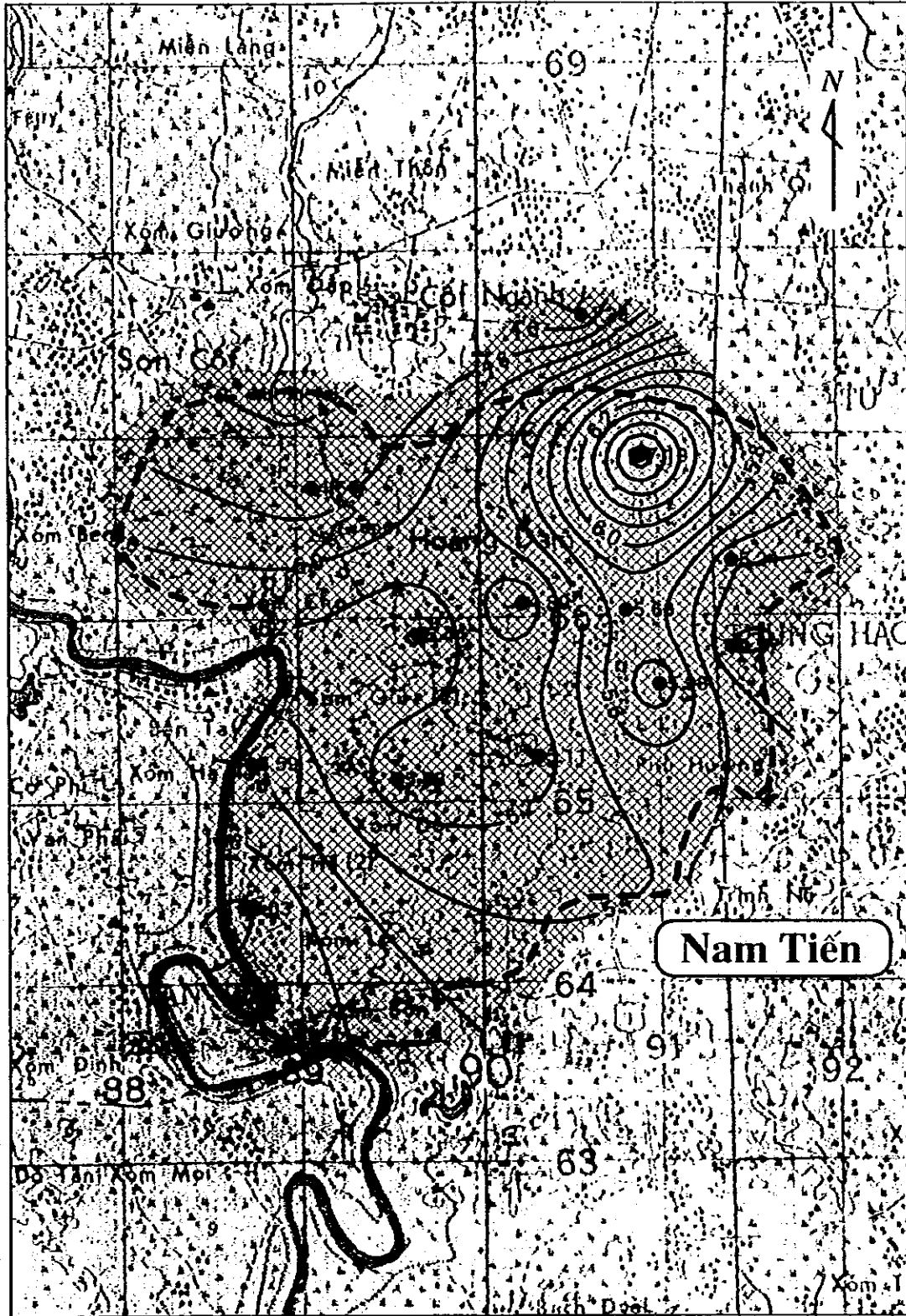


Figure 1.7 Distribution of EC Values in Nam Tiến Commune, Thái Nguyên Province

THE STUDY ON GROUNDWATER DEVELOPMENT IN THE RURAL PROVINCES OF NORTHERN PART IN THE SOCIALIST REPUBLIC OF VIETNAM

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



0 1 km

● 5.08 Measured well
pH with pH value



Figure 1.8

Distribution of pH Values in
Nam Tiên Commune, Thái Nguyên Province

THE STUDY ON GROUNDWATER DEVELOPMENT IN
THE RURAL PROVINCES OF NORTHERN PART IN
THE SOCIALIST REPUBLIC OF VIETNAM

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

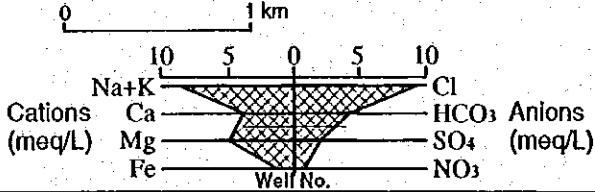
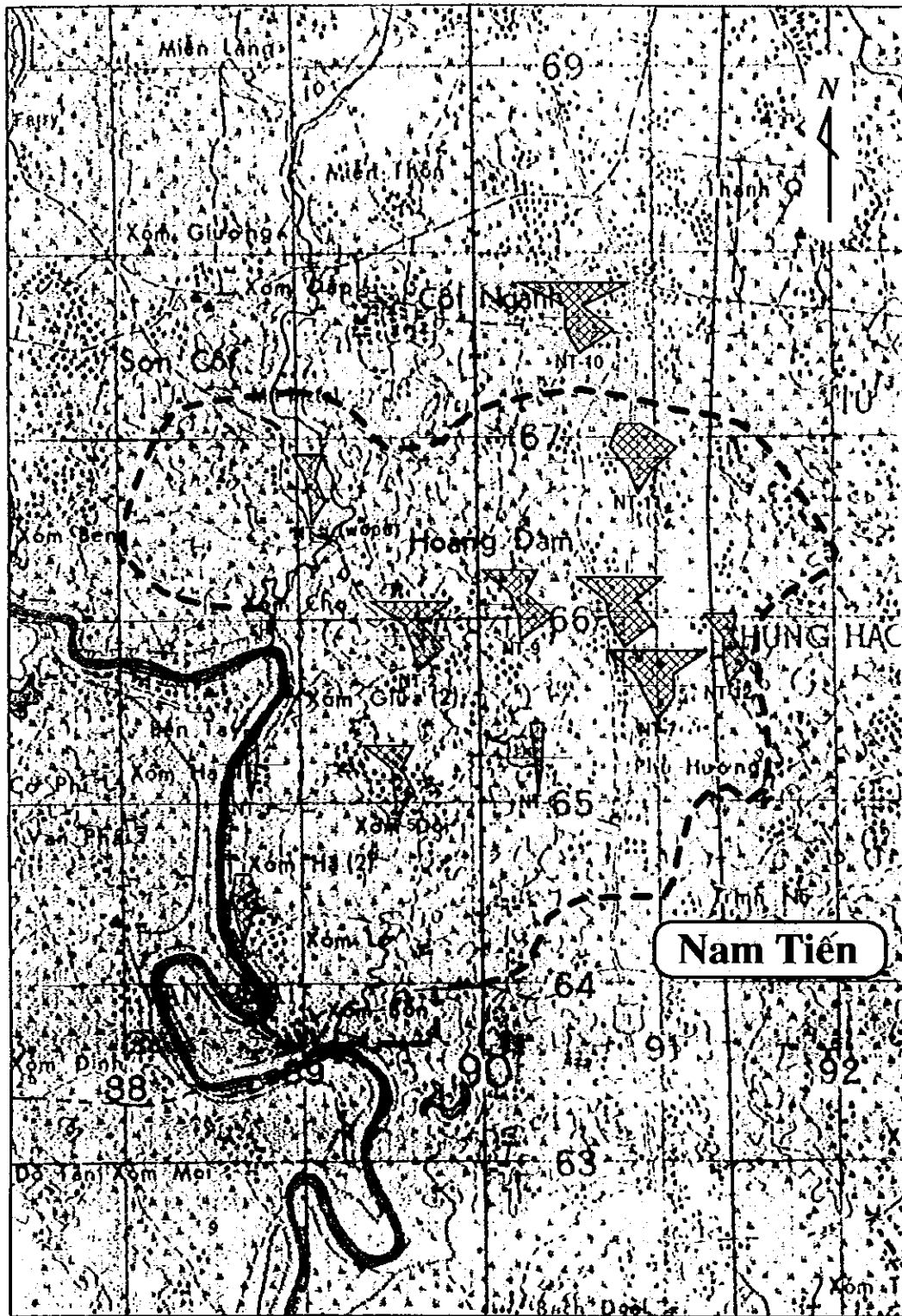


Figure 1.9 Stiff Diagram of Nam Tiên Commune, Thái Nguyên Province

THE STUDY ON GROUNDWATER DEVELOPMENT IN THE RURAL PROVINCES OF NORTHERN PART IN THE SOCIALIST REPUBLIC OF VIETNAM

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