

#### **4.4.4 Results of Field Measurement**

The results of field measurements of water quality of the existing wells as well as the JICA test wells are presented in the Appendix in this main report. The individual data sheet for each surveyed well is presented in the data report.

##### **(1) Simultaneous Observation**

Based on the results of the simultaneous groundwater observation, groundwater quality maps for 4 observation times (February, May, August and November 2001) were prepared.

##### **1) PH**

###### **a ) Existing Dug Wells (see Figure 4.4.4.1 and Figure 4.4.4.2)**

Throughout the 4 time observations, it is common that the eastern Kg. Cham province and most parts in Kg. Chhnang province have pH values less than 7, whereas the central part of the study area has alkaline groundwater. However, the areas of alkaline water and pH values changed over time.

In February 2001, the areas having pH values more than 7 were distributed widely from central to western Kg. Cham province. In May 2001, the pH values decreased and the area of alkaline groundwater became smaller. In August 2001, the areas having pH values more than 7 were expanded and the pH values in the area less than 7 in pH slightly increased. In November 2001, the areas more than 7 in pH decreased in central to western Kg. Cham province, however, the areas more than 7 in northeastern Kg. Chhnang province was expanded.

###### **b ) Existing Borehole Wells (see Figure 4.4.4.3 and Figure 4.4.4.4)**

The pH values show less than 7 in eastern Kg. Cham province throughout the simultaneous observation period, however, there are changes in the location of pH=7 contour line and pH values in central Kg. Cham province to Kg. Chhnang province.

In February 2001, the area having relatively higher values of pH was widely distributed in the central part of the stud area. In May 2001, the pH values generally decreased and the areas having pH<7 were expanded in western Kg. Cham province and in Kg. Chhnang province. In August 2001, the areas having pH>7 further decreased and the pH values in the area of pH<7 decreased in Kg. Chhnang province. In November 2001, the areas of pH>7 was slightly

expanded and the increase of pH values was observed.

## **2) ORP**

### **a ) Existing Dug Wells (see Figure 4.4.4.5 and Figure 4.4.4.6)**

Although the ORP values were generally higher in February 2001 with showing more than 200 mV in many places, the values in May 2001 decreased in the whole study area and the values became less than 200 mV except eastern Kg. Cham province. The distribution pattern of ORP values in August 2001 is similar to that of May 2001, however, increase of ORP values was observed in Memot district and the values were decreased in the areas along the Mekong River and the Tonle Sap river. In November 2001, the area of ORP<100 mV appeared in the central part of the study area and the negative values of ORP were found in some wells in western Kg. Cham province and northern Kg. Chhnang province.

### **b ) Existing Borehole Wells (see Figure 4.4.4.7 and Figure 4.4.4.8)**

In February 2001, negative values of ORP were found in some areas along the Mekong River and the Tonle Sap River. In May 2001, almost all the ORP values in the study area were decreased and the areas of ORP<0 mV were increased. In August 2001, the ORP values slightly increased and the areas of ORP>100 mV were expanded in western Kg. Cham province. The increase of ORP values were also observed in Memot district. In November 2001, the ORP values in Memot district were decreased, and the slight decrease of the value were also observed in the central part of the study area.

## **3) EC**

### **a ) Existing Dug Wells (see Figure 4.4.4.9 and Figure 4.4.4.10)**

There is no significant change in EC distribution pattern and EC values in Kg. Cham province, but there are some changes in EC values in northern Kg. Chhnang province. In the northwestern part of the province, increase of EC values was observed in some wells. The increase of EC values were also observed in northern Kg. Chhnang from August to November 2001.

### **b ) Existing Borehole Wells (see Figure 4.4.4.11 and Figure 4.4.4.12)**

The distribution pattern of EC remained almost the same through the simultaneous observation period. More than 150 mS/m of EC values are always found in northeastern Kg. Chhnang province and western Kg. Cham province.

#### **4) F**

##### **a ) Existing Dug Wells (see Figure 4.4.4.13 and Figure 4.4.4.14)**

Significant changes in F distribution and F values were not found by the simultaneous observation. The higher values of F more than 1.5 mg/L were found in northern and southern Kg. Chhnang province and western Kg. Cham province. The main reasons of the minor changes of contour lines and F values in the maps are due to the no access to some of the target wells during the flooding and the accuracy of measurement by the pack test.

##### **b ) Existing Borehole Wells (see Figure 4.4.4.15 and Figure 4.4.4.16)**

Significant changes in F distribution and F values were not found by the simultaneous observation. The higher values of F more than 1.5 mg/L were found in northern and southern Kg. Chhnang province and western and central Kg. Cham province along the Mekong River. The main reasons of the minor changes of contour lines and F values in the maps are due to the no access to some of the target wells during the flooding time and the accuracy of measurement by the pack test.

#### **5) NO<sub>3</sub>**

##### **a ) Existing Dug Wells (see Figure 4.4.4.17 and Figure 4.4.4.18)**

There is no significant seasonal change in NO<sub>3</sub> concentrations and their distributions by the simultaneous observation. There is no well having NO<sub>3</sub> concentration more than the WHO guideline value by the pack test measurement. Relatively higher values more than 10 mg/L were found sporadically in eastern to central and western Kg. Cham province and northern and southern Kg. Cham province. The main reasons of the minor changes of contour lines and NO<sub>3</sub> values in the maps are due to the no access to some of the target wells during the flooding time and the accuracy of measurement by the pack test.

##### **b ) Existing Borehole Wells (see Figure 4.4.4.19 and Figure 4.4.4.20)**

In southern Kg. Chhnang province, F concentrations increased from February to August 2001, but the concentrations decreased in November 2001. In the rest of the area, there was no significant seasonal change in NO<sub>3</sub> concentrations and their distributions by the simultaneous observation. There is no well having NO<sub>3</sub> concentration more than the WHO guideline value by the pack test measurement. Relatively higher values more than 10 mg/L were found sporadically in western Kg. Cham province and northern and southern Kg. Cham province. The NO<sub>3</sub> concentrations in eastern Kg. Cham province in borehole wells are lower than that of dug wells.

The main reasons of the minor changes of contour lines and  $\text{NO}_3$  values in the maps are due to the no access to some of the target wells during the flooding time and the accuracy of measurement by the pack test.

#### **6) $\text{NH}_4$**

##### **a ) Existing Dug Wells (see Figure 4.4.4.21 and Figure 4.4.4.22)**

There are a few wells in central Kg. Cham and central Kg. Chhnang provinces having  $\text{NH}_4$  concentrations more than the WHO guideline value by the pack test measurement. In central Kg. Chhnang province, there was an area having  $\text{NH}_4 > 0.5$  mg/L in February 2001, but the area disappeared from May 2001. Except this, there was no significant change in  $\text{NH}_4$  distribution.

The main reasons of the minor changes of contour lines and  $\text{NH}_4$  values in the maps are due to the no access to some of the target wells during the flooding time and the accuracy of measurement by the pack test. In addition, it should be noted that the results of  $\text{NH}_4$  measurements by the pack test are disturbed when the groundwater is rich in Fe concentration.

##### **b ) Existing Borehole Wells (see Figure 4.4.4.23 and Figure 4.4.4.24)**

In February 2001, relatively higher values of  $\text{NH}_4$  were detected in some wells in Kg. Chhnang province, however, the values decreased from May 2001. In southern Kg. Cham province along the Mekong River,  $\text{NH}_4$  concentrations in a few wells show a increasing trend from February to November 2001. In November 2001, three (3) borehole wells in northern Kg. Cham province along the Mekong River had  $\text{NH}_4$  concentrations ranging from 2 to 5 mg/L. Except these events, there is no significant variations in  $\text{NH}_4$  distribution.

The main reasons of the minor changes of contour lines and  $\text{NH}_4$  values in the maps are due to the no access to some of the target wells during the flooding time and the accuracy of measurement by the pack test. In addition, it should be noted that the results of  $\text{NH}_4$  measurements by the pack test are disturbed when the groundwater is rich in Fe concentration.

#### **7) Fe**

##### **a ) Existing Dug Wells (see Figure 4.4.4.25 and Figure 4.4.4.26)**

From the period from February to May 2001, the Fe concentrations tended to increase along the Tonle Sap River in Kg. Chhnang province. Except this, there is no significant change in Fe concentrations. The areas having Fe concentrations above the WHO guideline value are sporadically distributed in the study area.

There are minor changes in Fe distribution, however, the reasons are due to the no access to some of the target wells during the flooding time and the accuracy of the measurement by the pack test.

**b ) Existing Borehole Wells (see Figure 4.4.4.27 and Figure 4.4.4.28)**

The distribution patterns of Fe concentrations are almost the same throughout the simultaneous observations. Along the Mekong River, a zone of higher Fe concentrations was well traced in May and November 2001 because a number of wells near the river could be measured without the flooding. In the rest of the study area, elevated Fe concentrations above the WHO guideline value were found in eastern and western Kg. Cham province and in the area along the Tonle Sap River in Kg. Chhnang province.

**8) As**

**a ) Existing Dug Wells (see Figure 4.4.4.29 and Figure 4.4.4.30)**

From the dug wells, As concentrations more than 0.05 mg/L were not found throughout the simultaneous observation. There are some well having As concentration ranging from 0.001 to 0.01 mg/L by the field kit, however, it should be considered that the values are almost below the detection level of the field kit. In the dug wells, there is only one suspect well of actual As contamination, which is located in northwestern Kg. Chhnang province with As level of 0.02 mg/L by field kit.

**b ) Existing Borehole Wells (see Figure 4.4.4.31 and Figure 4.4.4.32)**

In the borehole wells, the As levels more than 0.05 mg/L were detected in northern Kg. Chhnang province and central to northern Kg. Cham province along the Mekong River. The results of the observations in May and November 2001 show that the highly contaminated zone by As is located along the Mekong River.

**(2) Periodic Observation**

Based on the results of the periodic groundwater observation, changes of each groundwater quality parameter were examined.

**1) PH**

**a ) Existing Dug Wells and Combined Wells (see Figure 4.4.4.33)**

The pH values at some wells in Kg. Chhnang province and in northwestern Kg. Cham

province show a slight increasing trend of pH values from August 2001. The pH values in Suong and Memot areas in Kg. Cham province were fluctuated within a certain range

**b ) Existing Borehole Wells (see Figure 4.4.4.34)**

The borehole wells in Kg. Chhnang province and in northwestern Kg. Cham province show a increasing trend of pH values from August 2001.

**2) ORP**

**a ) Existing Dug Wells and Combined Wells (see Figure 4.4.4.35)**

Although some wells show irregular fluctuations of ORP values over time, the ORP values in Kg. Chhnang province and northwestern Kg. Cham province decreased from January to April 2001. These ORP values once rose in June but again decreased gradually from July to December 2001. The ORP values Suong and Memot areas also show a decreasing trend of ORP values from January to December 2001.

**b ) Existing Borehole Wells (see Figure 4.4.4.36)**

The changes in ORP values of borehole wells show a wider range of irregular fluctuations over time. However, the wells in Kg. Chhnang province and in the northwestern part and Memot of Kg. Cham province area have a decreasing trend of ORP values.

**3) EC**

**a ) Existing Dug Wells and Combined Wells (see Figure 4.4.4.37)**

The EC values having relatively lower values of EC in Kg. Chhnang province tend to increase slightly from May to December 2001. On the other hand, the EC values in the wells having relatively higher values of EC fluctuated within a certain range. In northwest Kg. Cham province, the changes in EC values are small in the wells with relatively smaller EC values, but the greater EC values irregularly fluctuated over time. In Suong area, the EC values in the wells having smaller values of EC tend to decrease from January to June 2001 then increase from August. In the wells having greater values of EC, one well has a gradual decrease of EC values over time, whereas another has decrease of EC values from January to October 2001 then sharp increase of EC values. In Memot area, the EC values are generally lower than 15 mS/m. Most of the wells have a slight decreasing trend of EC values from February to July 2001 then show a clear increasing trend from August.

**b ) Existing Borehole Wells (see Figure 4.4.4.38)**

In Kg. Chhnang province, R189G well shows higher EC values in the rainy season. But the

rest of the wells show that the EC values fluctuated within a limited range of variation. In northwestern Kg. Cham province, the EC values have slight increasing trend over time. The EC values at R321M well in Suong area clearly decreased over time.

#### **4) Fe**

##### **a ) Existing Dug Wells and Combined Wells (see Figure 4.4.4.39)**

Considering the accuracy of the pack test measurement, significant changing trend of Fe concentrations cannot be found from the results.

##### **b ) Existing Borehole Wells (see Figure 4.4.4.40)**

The range of variation in Fe concentrations is greater when the wells have relatively greater concentrations of Fe. However, some of the wells show irregular patterns of fluctuation. There are three (3) wells having higher Fe concentrations in May to July 2001. In northwestern Kg. Cham province, some wells have increasing trend of Fe levels coinciding the changes in groundwater levels.

#### **5) F**

##### **a ) Existing Dug Wells and Combined Wells (see Figure 4.4.4.41)**

Considering the accuracy of the pack test measurement, significant changing trend of F concentrations cannot be found from the results.

##### **b ) Existing Borehole Wells (see Figure 4.4.4.42)**

There is one well in Kg. Chhnang province having an increasing of F concentrations. In the rest, there is no significant change of F concentrations over time considering the accuracy of the pack test.

#### **6) NO<sub>3</sub>**

##### **a ) Existing Dug Wells and Combined Wells (see Figure 4.4.4.43)**

In the dug wells, some wells in northwestern Kg. Cham province seem to have a decreasing trend of NO<sub>3</sub> concentrations from July to September 2001. However, considering the accuracy of the pack test measurement, significant changing trend of NO<sub>3</sub> concentrations cannot be found in other areas.

##### **b ) Existing Borehole Wells (see Figure 4.4.4.44)**

In the borehole wells, some wells in northwestern Kg. Cham province tend to increase the

NO<sub>3</sub> concentrations from June to September 2001. However, there is no significant change of NO<sub>3</sub> concentrations over time considering the accuracy of the pack test.

## **7) NH<sub>4</sub>**

### **a ) Existing Dug Wells and Combined Wells (see Figure 4.4.4.45)**

Although the NH<sub>4</sub> levels in the wells having greater NH<sub>4</sub> values fluctuated with a wide range, there is no clear correlation with the seasonal change. Some wells have higher concentrations in the rainy season but the other has higher values in the dry season.

### **b ) Existing Borehole Wells (see Figure 4.4.4.46)**

The NH<sub>4</sub> concentrations in the borehole wells are generally low so that any significant changing trends of the concentrations cannot be found.

## **8) As**

### **a ) Existing Dug Wells and Combined Wells (see Figure 4.4.4.47)**

Considering the accuracy and detection limit of As by the filed kit, there is no significant trend in changes of arsenic levels.

### **b ) Existing Borehole Wells (see Figure 4.4.4.48)**

R197G borehole well has increasing trend of As level with oscillation. By March 2001 the As level was below 0.05 mg/L, however, it went up from April and reached 0.2 mg/L in August, September and December 2001. In other wells, no significant trends in As level changes were found considering the field kit limitations.

## **(3) JICA Test Well Monitoring**

Based on the results of the groundwater monitoring of the JICA test wells, changes of each groundwater quality parameter were examined.

### **1) pH (see Figure 4.4.4.49)**

The pH values in most test wells show a decreasing trend. Particularly the decreasing trend is clear in Suong and Memot areas in Kg. Cham province from August to October 2001.

### **2) ORP (see Figure 4.4.4.50)**



Very high ORP values were found at some wells in September. This is due to the disinfection of the wells by bleaching powder. Except this event, most test wells show decreasing trends of ORP values.

**3) EC (see Figure 4.4.4.51)**

About a half of the test wells show increasing trends of EC levels. However, slight drops of EC values were observed in some wells in Kg. Cham province.

**4) Fe (see Figure 4.4.4.52)**

Fe concentrations at No.23 well in northwestern Kg. Cham province show a decreasing trend. The concentration decreased from 8 mg/L in August to 4 mg/L in December 2001. On the other hand, No.20 test well in Memot area shows an increasing trend of Fe level. No. 23 well and No. 27 well have a peak of Fe concentration in October 2001.

**5) F (see Figure 4.4.4.53)**

No.4 well in Kg. Chhnang province has an increasing trend of F concentration, starting from 1.5 mg/L in August and reaching 4.5 mg/L in December 2001. The rest of the wells do not show any significant trends in changes of F concentrations.

**6) NO<sub>3</sub> (see Figure 4.4.4.54)**

The NO<sub>3</sub> concentrations in No.10 and No.11 wells show a wide range of variations with irregular fluctuations. No.30 test well has more than 50 mg/L in NO<sub>3</sub> concentration from September to December 2001.

**7) NH<sub>4</sub> (see Figure 4.4.4.55)**

The NH<sub>4</sub> concentration in No.23 well increased from 0.1 mg/L in July 2001 to 2.0 mg/L in December 2001. The rest of the test wells have NH<sub>4</sub> concentrations below 0.2 mg/L with no significant changing trends.

**8) As (see Figure 4.4.4.56)**

The As concentration of No.10 well in Kg. Chhnang province exceeded 0.05 mg/L in September and December 2001. In No.23 well in Kg. Cham province, 0.3 mg/L of As

concentration was detected in November 2001.

#### **(4) Coliform and Bacteria**

##### **1) Existing Wells**

Almost all the dug wells and combined wells were polluted by coliform and bacteria. On the other hand, borehole wells were polluted from 23% to 85% by bacteria in Kg. Chhnang province, and were polluted from 19% to 50% by coliform. In Kg. Cham province, borehole wells were polluted from 40% to 88% by bacteria and from 15% to 46% by coliform. Pollution levels of existing wells on the 3rd simultaneous observations are lower than the 1st and 2nd simultaneous observations.

##### **2) JICA Test Wells**

In October 2001, coliform and bacteria contamination was found at No.8 well in Kg. Chhnang province. In Kg. Cham province, No.11 and No.18 wells were contaminated by bacteria. Moderate contamination by coliform and bacteria was found at No. 5 well in Kg. Chhnang province.

In November 2001, moderate contamination by coliform and bacteria was found at No.2 well in Kg. Chhnang province.

In December 2001, only slight contamination by coliform and bacteria was found at five (5) wells. However, the filtered sample at No.6 well was contaminated by bacteria and coliform. Moderate contamination by bacteria was also found from the filtered samples No.23 and No.30 wells in Kg. Cham province.

#### **[References]**

WHO (1996): Guidelines for drinking-water quality, 2nd edition. Volume 2, Health criteria and other supporting information, WHO, Geneva.











