CHAPTER 5

IMPROVED DEEP WELL

Supporting Report 1

CHAPTER 5 IMPROVED DEEP WELL

The JICA Study Team improved the manpowered jetting method widely used in the rural area of Bangladesh and examined several techniques for the drilling and construction of a well structure that would not allow the intrusion of contaminated water from surface and shallow layers. After site geology and local drilling skills were examined, the specifications for the improved deep well (properly sealed) were developed. A total of 9 improved deep wells are to be drilled in the three model rural areas (3 wells per model rural area).

5.1 Necessity of the Improved Deep Well

In Bangladesh, the slugger method (up to the depth of 50 m) and the donkey method (up to the depth of 100 to 200 m) are used for well drilling. The slugger method is to drill a borehole by sucking the soil using drilling pipe about 50 mm in diameter. It is mainly used for drilling wells for domestic use.

On the other hand, the donkey method is to manually operate a donkey pump, circulate mud water (made from cow dung and bentnite), and rotate a rod. It is used for drilling deeper wells such as DPHE wells, which are constructed as an arsenic protection measure.

A well becomes completed by the installation of a screen pipe. Sand or gravel is filled between the screen pipe and the borehole as a filter. The sand filter is expected to be naturally created. In addition, sealing of a well is not usually conducted because it is said that the borehole wall is naturally stuck to the well casing due to the swelling of clay.

However, it is well known in Samta village that the arsenic concentration of an arsenic -safe well has increased gradually since completion of the well though it was lower than the standard value at the beginning. This tendency is recognized in the area where the arsenic level is extremely high in the shallow aquifer. It is thought that arsenic contaminated water in the shallow aquifer may have intruded into the deep aquifer along the well casing because the annulus between the well casing and the borehole is not sealed (see Figure 5.1).

To utilize a safe deep aquifer and prevent arsenic contamination due to the well structure, it is necessary to establish an improved well construction technique which enables firm sealing for the donkey method.

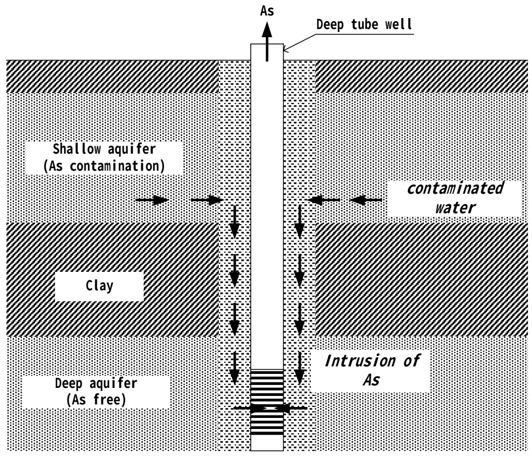


Figure 5.1 Arsenic contamination of a deep well due to no sealing

5.2 Type of Improved Deep Well

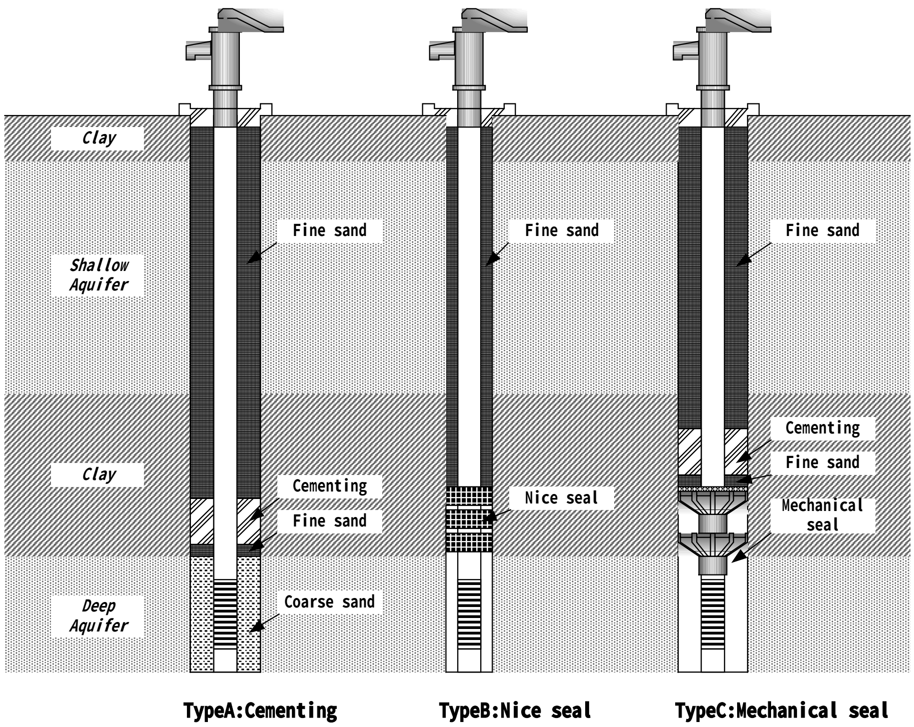
The following three types of deep wells dug by the donkey method were examined in this study:

a) Type A： Sealing with cement by enlarging the drill diameter.

b) Type B： Using a special sealing material (Nice seal)

c) Type C： Using mechanical seal

Figure 5.2 Structure of Improved Deep Well



5.3 Construction methods of Improved Deep Well

(1) Type A: Cementing Method

1) Outline

Enlarging the borehole diameter, filling with sand, and cementing.

2) Borehole diameter and depth

Diameter: 150 mm

Depth: 150 m (It is adjusted based on the aquifer condition of the site)

3) Materials

a) ϕ38mm G.I.Pipe (with thread M.S.welded flat bar)	1.52m
b) ϕ38mm PVC Pipe Class D (actual external ϕ48mm)	136m
c) ϕ38mm Screen (actual external dia. 48mm: Fig.5.3)	10m
d) ϕ38mm Sand trap (PVC Pipe class D)	3m
e) Coarse sand （filling depth: 40m）	0.79m^3
f) Portland cement （Water/cement ratio :50%, 5m cementing）	120 kg
g) Fine sand（filling depth 105m）	2.07 m^3
h) Hand pump No.6	1
i) C.C.Platform (DPHE design: Fig.5.4)	1

Figure 5.3 ϕ38mm Screen

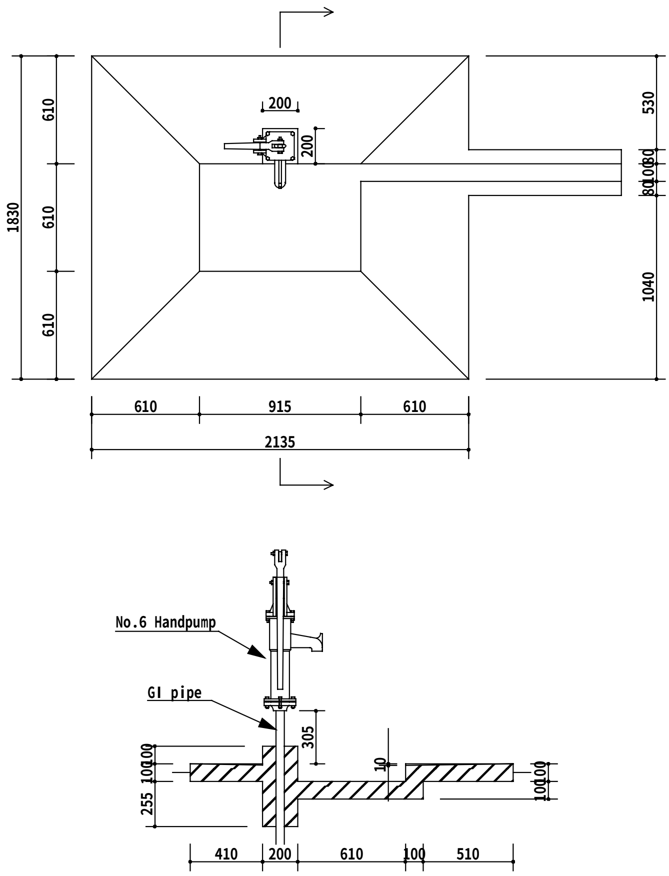


Figure 5.4 C.C.Platform (DPHE design)

4) Particular Tools

a) Cutter with diamond tip (ϕ90mm and 150mm: Fig.5.5.)	1 for each diameter
b) Tremie tube for cementing (ϕ38mm vinyl pipe)	120m
c) Resistivity logging equipment (IDOPACK-10: Fig.5.6.)	1
d) Resistivity logging cable (l=200m)	1 roll

Figure 5.5 Cutter with diamond tips


Figure 5.6 Logging equipment IDO-PACK10

5) Construction method

Figure 5.7 shows the construction method of Type A.

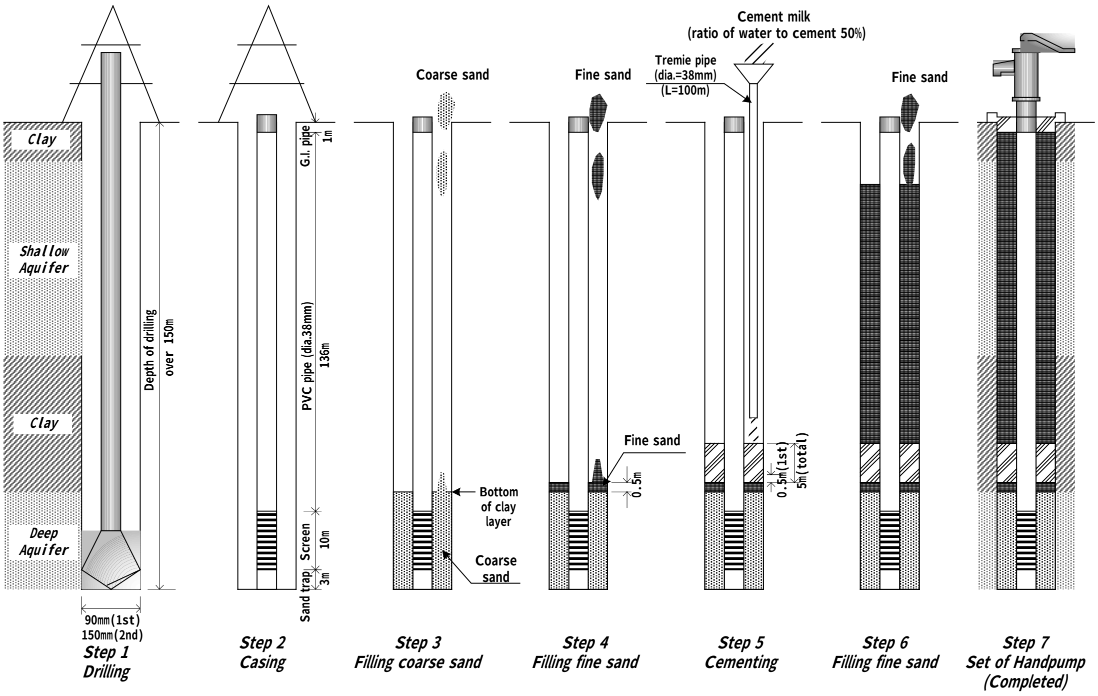


Figure 5.7 Construction method of Type A

(a) Drilling

Because Tremie pipe to fill cement is inserted into the borehole after the placement of the casing, the borehole diameter is increased to 150mm by two steps of drilling. The first step of drilling used the 90mm diameter cutter, and the second step of drilling used the 150mm diameter cutter. Diamond tips are attached to these cutters for drilling stone layers (Fig.5.8).

Figure 5.8 Drilling by Donkey method

(b) Casing program

After completion of the first step of drilling (90mm diameter), a resistivity logging is conducted, and the log is interpreted by comparing the record of drilling log. Based on the interpretation, the casing program is prepared. The resistivity logging is conducted by using IDOPACK-10. The method employed is 4 electrodes with a distance interval of 0.5m. The resistivity is measured every 1.0m.

(c) Sealing

Spaces between the wall of the borehole and the screen section of the well casing is filled with coarse sand up to the boundary of the clay layer. Fine sand is filled in the upper part of the coarse sand filter with the depth of 0.5m, and cement is filled with the depth of 5m from the upper part of the fine sand filter. Then, fine sand is filled up to the surface. Portland cement with a water/cement ratio of about 50% is used for cementing. Injection of the cement milk is for the depth of 0.5m on the first day (Fig 5.9).

a) Coarse sand filling

b) Fine sand filling

c) Tremie pipe incertion

d) Cement milk making

e) Cement milk injection

Figure 5.9 Sealing method of Type A

(d) Well development

After cementing, well development by the pumping method is conducted. It is continued until water from the well turns apparently clean.

(2) Type B: Nice Seal Method

1) Outline

The borehole diameter of Type B is the same as the donkey method; however, the casing is covered with a special swelling material (Nice Seal).

2) Borehole diameter and depth

Diameter: 90 mm

Depth: 150 m (It is adjusted based on the aquifer condition of the site)

3) Materials

a) ϕ38mm G.I.Pipe (with thread M.S.welded flat bar)	1.52 m
b) ϕ38mm PVC Pipe Class D (actual external ф48mm)	136 m
c) ϕ38mm Screen (actual external ф48mm)	10 m
d) ϕ38mm Sand trap (PVC Pipe class D)	3 m
e) Nice seal D type (t=4.4mm, l=163mm)	3 pieces
f) Nice seal E type (t=3.0mm, l=183, 198, 218mm)	3 pieces for each
g) Wire (ø 1.2mm)	2 m
h) Vinyl tape (t=0.2mm, w=19mm)	5 m
i) Insert smoother (ϕ49-75mm, t=0.27mm, l=200mm)	1 piece
j) Fine sand（filling depth 100m）	0.62 m^3
k) Hand pump No.6	1
l) C.C.Platform (DPHE design)	1

The Nice seal is a packer material made from acrylic acid ester and S.R.B. synthetic rubber and swells only when it absorbs water.

4) Particular Tools

a) Cutter with diamond tip (ϕ90mm)	1
b) Resistivity logging equipment (IDOPACK-10)	1
c) Resistivity logging cable (l=200m)	1 roll

5) Construction method

Figure 5.10 shows the construction method of Type B.

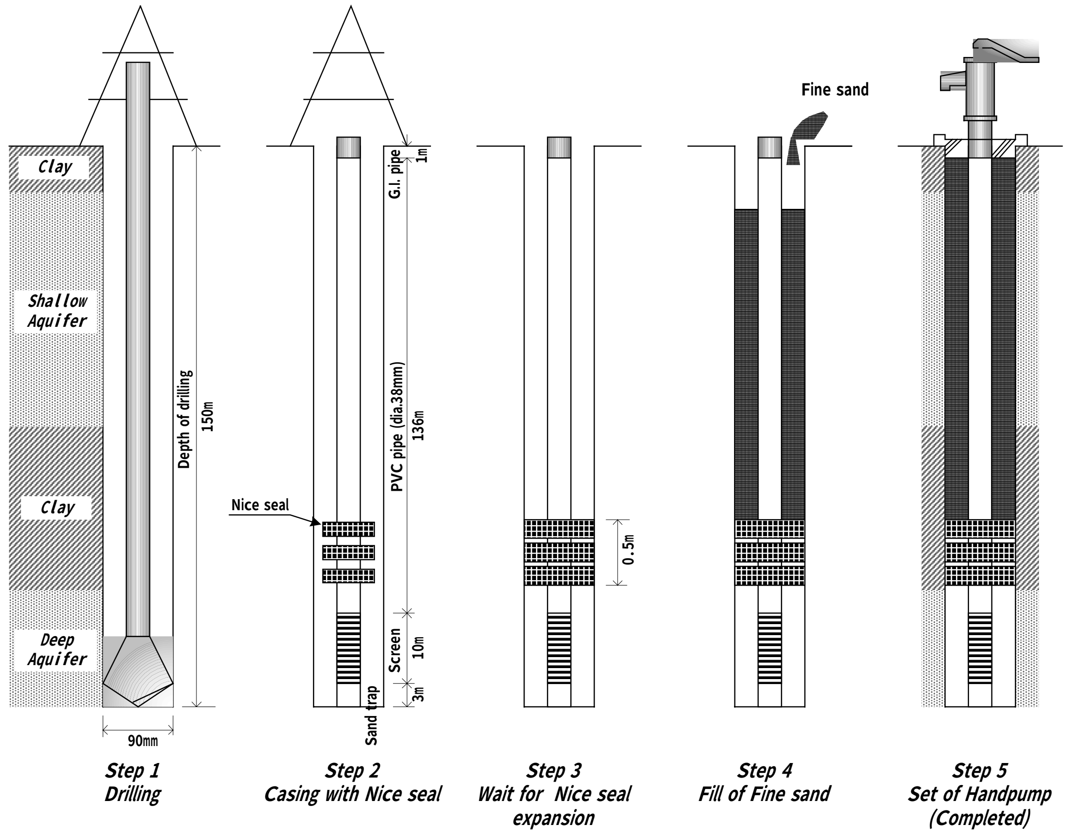


Figure 5.10 Construction method of Type B

(a) Drilling

The borehole is drilled using the 90mm cutter.

(b) Casing program

Same as Type A

(c) Sealing

The casing pipe is wrapped with the Nice seal at the level of the upper part of the screen section where the lower boundary of the clay formation exists. The way of wrapping is as follows: (Fig.5.11)

1. Wrap the casing pipe with Nice seal D type (t = 4.5 mm) once
2. Wrap the casing pipe with Nice seal E type (t = 3 mm) 3 times

(The casing pipe is wrapped in a total of 4 layers of Nice seal.)

The Nice seal completes its expansion in about two days (Fig.5.12). After the casing pipe installation, spaces over the upper seal are filled with fine sand the next day.

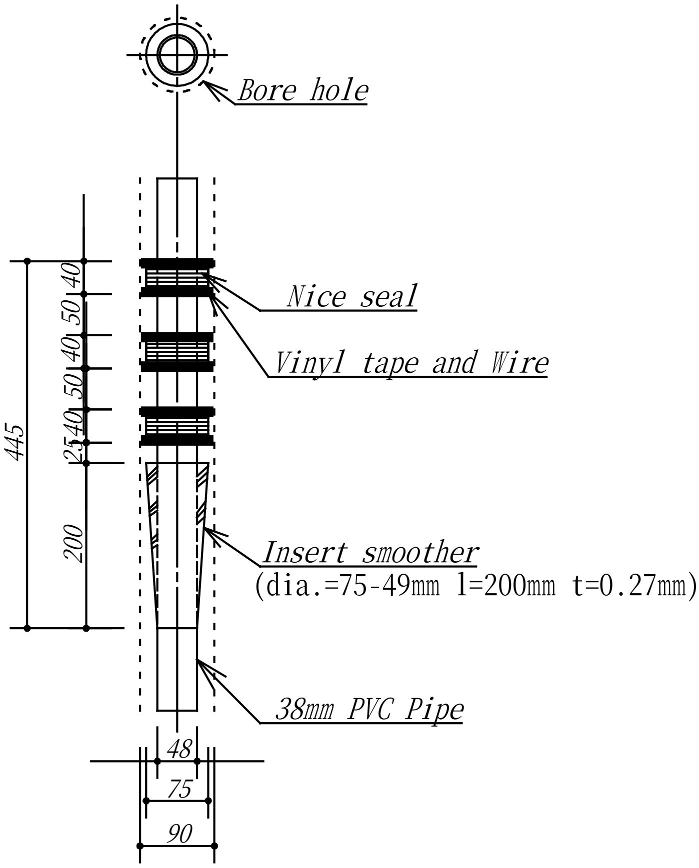


Figure 5.11 Wrapping of the casing with the Nice seal

Right after wrapping

One day after being soaked in water

Figuere 5.12 Expansion of Nice seal

(d) Well development

Same as Type A.

(3) Type C: Mechanical Seal Method

1) Outline

The borehole diameter of Type C is the same as the original one. A basket type mechanical seal and *fatrra* fiber are attached to the casing pipe, and cementing is performed.

2) Drill diameter and depth

Diameter: 150 mm

Depth: 150 m (It is adjusted based on the aquifer condition of the site)

3) Equipment

a) ϕ38mm G.I.Pipe (with thread M.S.welded flat bar)	1.52 m
b) ϕ38mm PVC Pipe Class D (actual external ϕ48mm)	136 m
c) ϕ38mm Screen (actual external ϕ48mm)	10 m
d) ϕ38m Sand trap (PVC Pipe class D)	3 m
e) Metal-petal-basket (ϕ180mm)	2 pieces
f) *Fatrra* (bark of date palm in Bengali)	4 seats
g) Insert smoother (diameter 49-110mm, l=300mm, t=0.27mm)	1 piece
h) Fine sand（filling depth 105m）	2.07 m^3
i) Portland cement （Water/cement ratio :50%, 5m cementing）	120 kg
j) Hand pump No.6	1
k) C.C.Platform (DPHE design)	1

4) Particular Tools

a) Cutter with diamond tip (ϕ90mm and 150mm)	1 for each
b) Tremie tube for cementing (ϕ38mm vinyl pipe)	120 m
c) Resistivity logging equipment (IDOPACK-10)	1
d) Resistivity logging cable (l=200m)	1 roll

5) Construction method

Figure 5.13 shows the construction method of Type C.

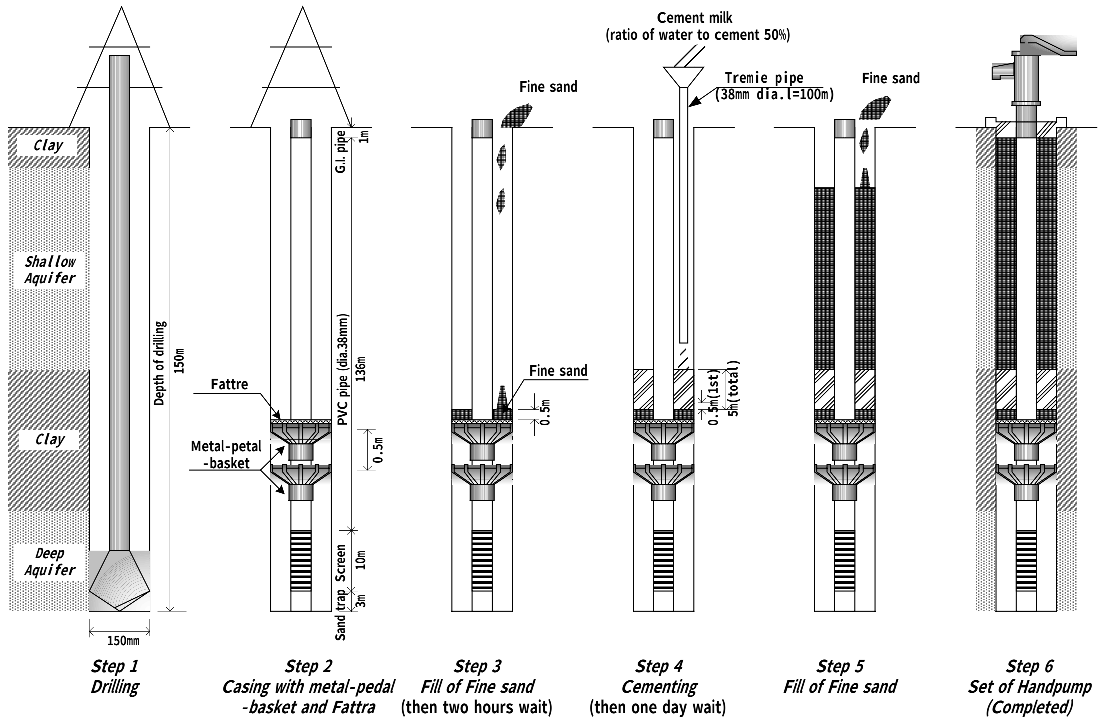


Figure 5.13 Construction method of Type C

(a) Drilling

The method is the same as Type A.

(b) Casing program

Same as Type A.

(c) Sealing

The mechanical seal is attached at 0.5m intervals in the upper part of the screen where the clay formation exists. The *fatrra* is placed on the basket, and then some clay is put into the basket (Fig.5.8). The borehole is filled with fine sand to the depth of 0.5m and then cement to the depth of 5 m.

The mechanical seal is commonly called a ‘metal-petal-basket’ and used for observation wells for land subsidence. The filling material is prevented from dropping down from the upper part as the seal spreads like petals (Fig.5.7).

The method of cementing is the same as Type A.

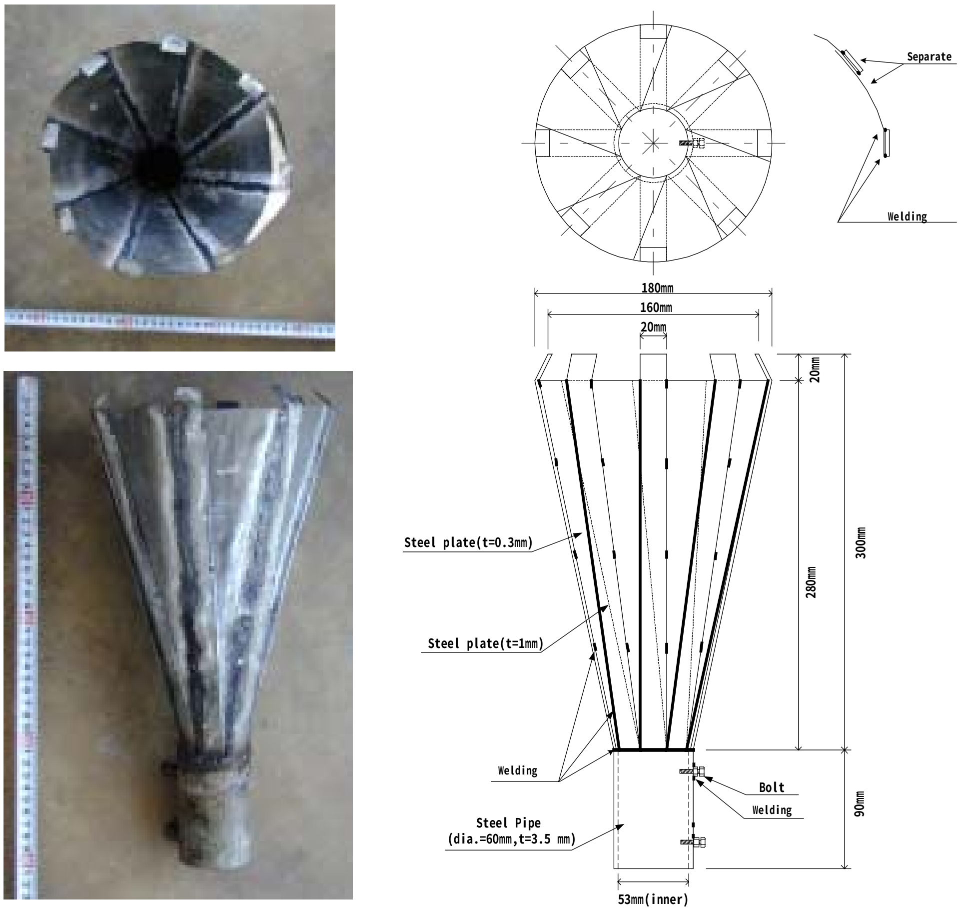


Figure 5.14 Metal-petal-basket

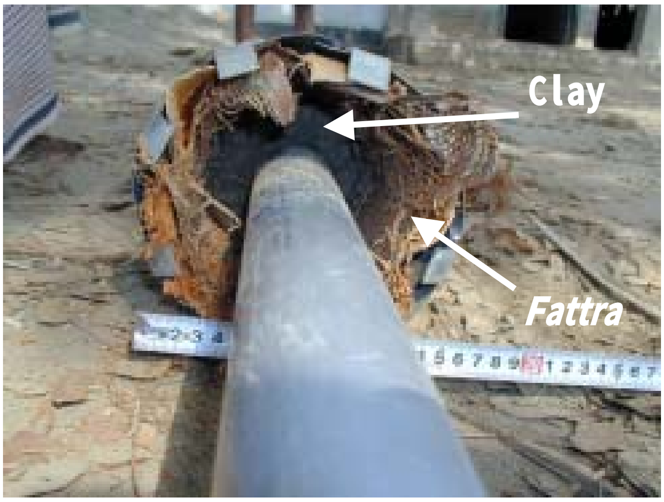


Figure 5.15 Inner of Metal-petal-basket

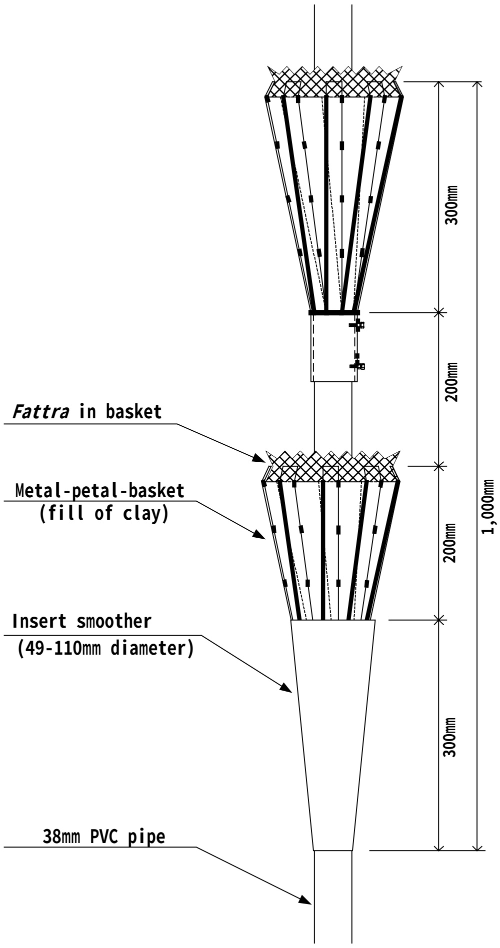


Figure 5.16 Set of mechanical seal

(d) Well development

Same as Type A.

(4) Simple Pumping Test

To estimate aquifer parameters, three improved wells are drilled at the same location close to each other. When one well is pumped, the water levels of the other two wells are measured. The pumping test is comprised of the continuous drawdown test for 6 hours and the recovery test for 2 hours. Intervals of the measurement are as follows:

1-6 minutes from the start or the stop: every minute

6-10 minutes: every 2 minutes

10-60 minutes: every 5 minutes

60-120 minutes: every 10 minutes

120-180 minutes: every 20 minutes

180-360 minutes: every 30 minutes

The record of this pumping test was analyzed by the Thiem's method, Jacob's method and recovery method, and then transmissivity, hydraulic conductivity (permeability coefficient) and storativity were calculated.

5.4 Results of improved deep well construction

The three types of the improved deep wells were drilled in each of the model rural areas, namely Rajnagar Bankabarsi, Krishna Chandrapur, and Bara Dudpatila. The three types of improved deep wells are not scattered in each village but located in line at 5m intervals. The three deep wells needed to be drilled at the same location to compare the performance of each type of improved well.

(1) Rajnagar Bankabarsi vil.

a) Hydrogeology

Each type of improved deep well was drilled on the premise of a primary school at the southern part of the village, and each has a depth of 222m (see Fig.5.17-18 Table 5.1). The geological conditions of this site are the followings:

Surface to 12m depth: clay layer

12m to 28m depth: fine to medium sand layer

28m to 30m depth: thin clay layer

28m to 103m depth: thick fine to medium sand layer (thickness: 5m)

103m to 200m depth: thick clay layer (thickness: 96m)

200 to 222m depth: medium to course sand layer

These are divided into shallow aquifer (12m to 103m in depth) and deep aquifer (about 200m below) from a hydrogeological point of view (see Table 5.2).

b) Problems during well construction

The depths of completed wells are 217.8m (Type A), 212.2m (Type B), and 214.6m (Type C). Well screens with a length of 10 m were installed at the deep aquifer with a depth of 200 to

215m. The seal was to be installed on the clay layer with a depth of 100 to 200m. Although the sealing was possible at the lower silty clay layer (GL-189.0-194.0m) for Type A (nothing around the PVC pipe), it was thought to be impossible to insert Type B and C with the Nice seal and the metal-petal basket into the lower silty clay layer. Therefore, the sealing was installed at the upper silty clay layer for Type B and C (Type B: 121.0-121.5m, Type C: 104.0-104.6m) (see Fig.5.19-21).

There were two problems concerning Type C. One was about well development. With the donkey method, after the casing is installed, drilling water mainly composed of cow dung used for drilling is washed out by clean water (back washing). Because Type C has a metal-petal basket that fits the size of the borehole, once the well is back washed, the water creates spaces between the wall of the borehole and the metal-petal basket (see fig.5.22). During the cementing, fine sand and cement milk may drop down through the spaces, which may result in the failure of not only the sealing but also water withdrawal due to the fallen cement sticking to the screen. Therefore, in the case of Type C, back washing was replaced with washing the well by withdrawing water for a long time. Type C took about 2 weeks for well development while Type A and B took only 2 days.

The other problem was about cementing. Cementing was originally to be carried out for two days in order to avoid the breakdown of the seal due to the cement weight. However, at the time of starting cementing on the second day, most of the borehole wall had collapsed, and the second cementing could not be carried out. Therefore, cementing had to be completed at one time.

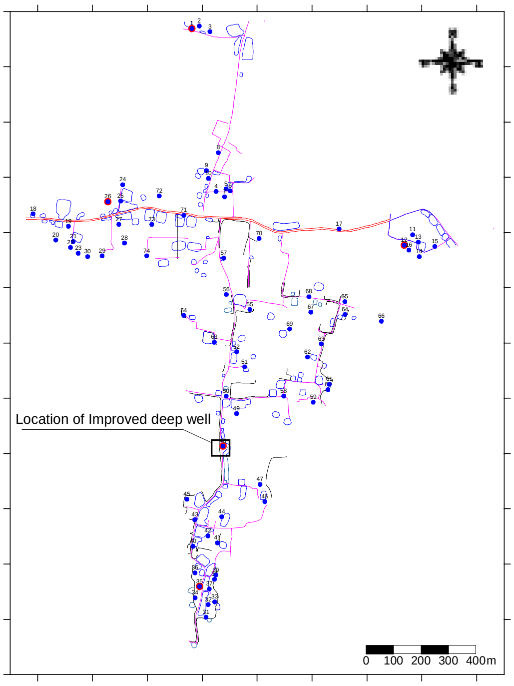


Figure 5.17 Location of improved deep wells at Rajnagar Bankabarsi

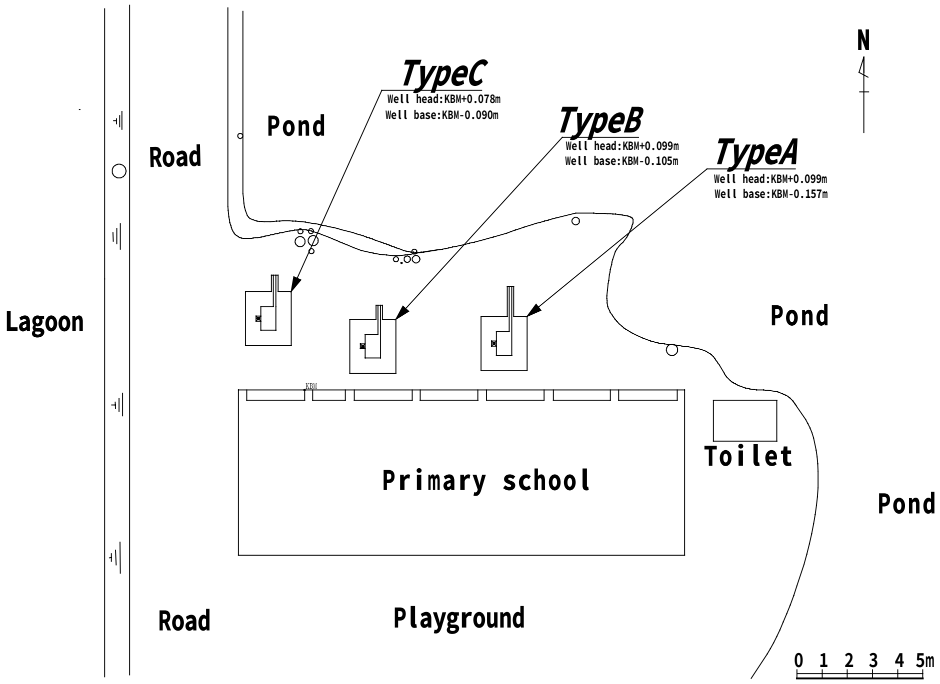


Figure 5.18 Arrangement of improved deep wells at Rajnagar Bankabarsi

Table 5.1 Summary of drilling improved deep wells at Rajnagar Bankabarsi

Location	District	Jessore		
	Upzilla	Keshabpur		
	Union	Panjia		
	Village	Rajnagar Bankabarsi		
	Lat. Long.	22°54'29"N 89°15'22"E		
Well No.		ImJK-1	ImJK-2	ImJK-3
Well Type		Type A	Type B	Type C
Drilling depth (m)		222.0	222.0	222.0
Casing depth (m)		217.84	212.20	214.61
Drilling diameter (mm)		90-150	90	90-150
Casing diameter (mm)		48	48	48
Well structure	GI pipe (m)	1.00	1.00	1.00
	PVC pipe (m)	204.02	198.45	201.23
	Screen (m)	10.35	10.25	10.40
		(205.02-215.37)	(199.45-209.70)	(202.23-212.63)
	Sand trap (m)	2.47	2.50	1.98
Sealing	Fine sand (m)	0.0-189.0	0.0-121.0	0.0-104.0
	Cementing (m)	189.0-194.0		104.0-105.0
	Fine sand (m)	194.0-194.5		105.0-106.1
	Nice seal (m)		121.0-121.5	
	Mechanical Seal			106.1-106.6
	Coarse sand (m)	194.5-219		
Drilling date	Start	21-Oct-00	06-Nov-00	12-Nov-00
	Casing	05-Nov-00	10-Nov-00	20-Nov-00
	Sealing finish	06-Nov-00	14-Nov-00	21-Nov-00
	Total (days)	17	9	10
	Speed (m/day)	13.1	24.7	22.2
Washing	Start	07-Nov-00	14-Nov-00	21-Nov-00
	Finish	08-Nov-00	15-Nov-00	17-Dec-00
	Total (days)	2	2	14
Platform		22-Nov-00	19-Nov-00	24-Nov-00
Water level	Static water level	GL-1.511m	GL-1.554m	GL-1.560m
	Date	30-Nov-00		
Pumping test	Date	30-Nov-00	04-Mar-01	04-Mar-01
Water quality	Date	29-Nov-00	29-Nov-00	29-Nov-00
	As by F.K. (mg/l)*	0.01	not detected	0.01
	Fe by P.T.(mg/l)*	0.2	0.2	0.5
	Temprature (C)	25.9	25.3	25.5
	pH	7.71	7.75	7.59
	ORP (mv)	-63	-84	-62
	EC_{25} (ms/m)	60.1	60.0	59.1

*F.K.=Field kit(AAN) P.T.=Pack Test Kit

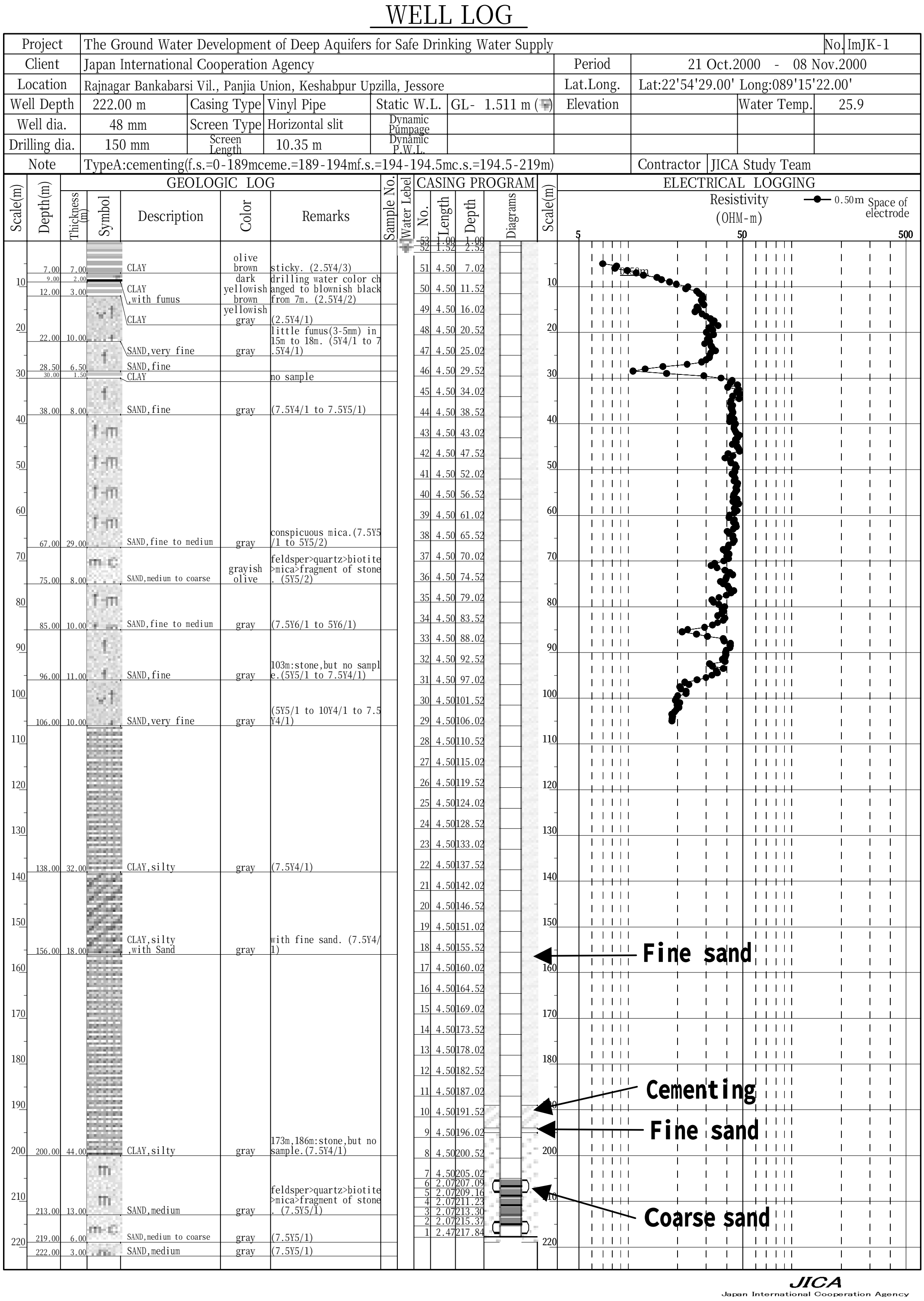


Figure 5.19 Improved deep well log of Type A at Rajnagar Bankabarsi

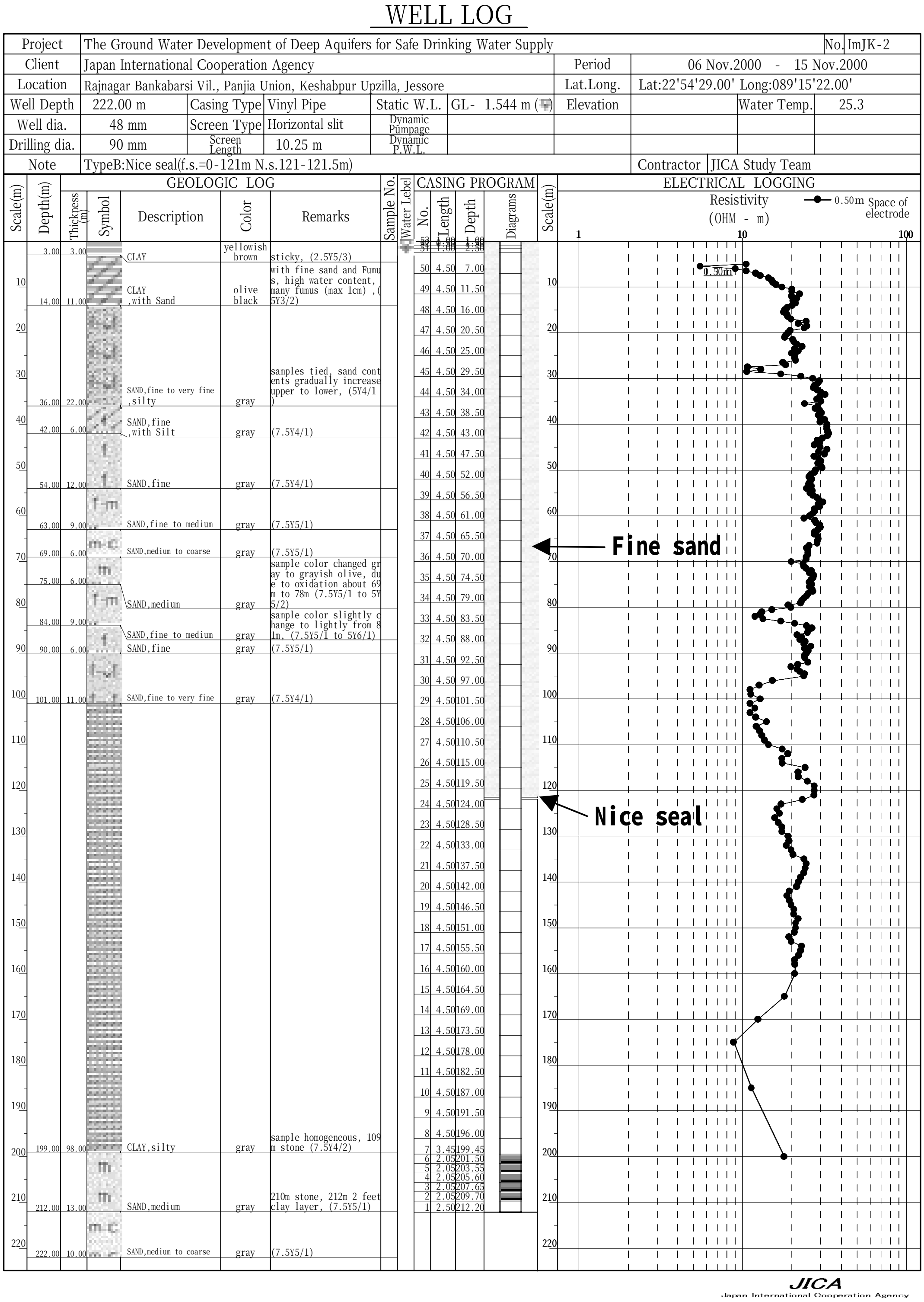


Figure 5.20 Improved deep well log of Type B at Rajnagar Bankabarsi

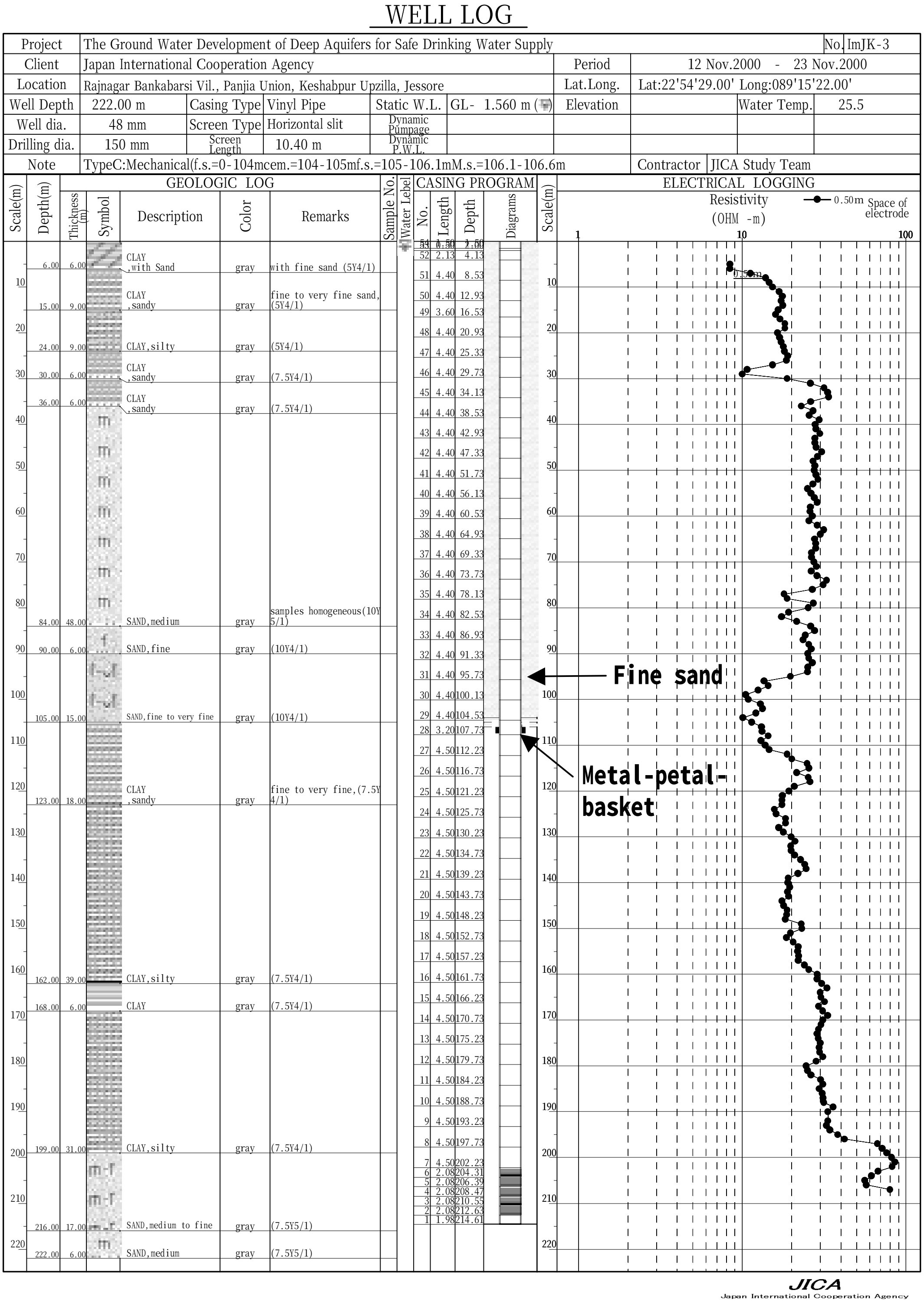


Figure 5.21 Improved deep well log of Type C at Rajnagar Bankabarsi

Table 5.2 Geologic log at Rajnagar Bankabarsi vil.

Depth	Symbol	Description	Thickness		Aquifer
12-15m		CLAY,with fumus	12-15m		(aquiclude)
28m		SAND,very fine to fine,silty	14-16m		Shallow aquifer
30m		CLAY	2m		
50m		SAND,fine to medium	33-37m	71-76m	
63-67m		SAND,medium to fine	6-8m		
69-75m		SAND,very fine to medium	31-32m		
100m / 101-106m / 150m		CLAY,silty	94-98m		(aquiclude)
200m / 199-200m		SAND,medium to coarse	22m over		Deep aquifer

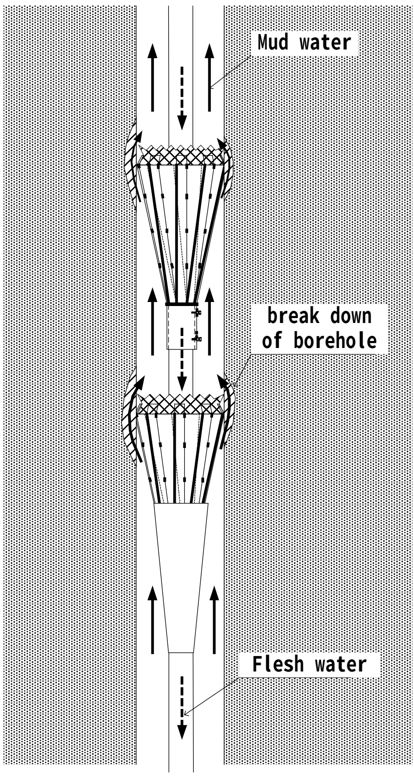


Figure 5.22 Break down of borehole by back-washing

(2) Krishna Chandrapur

a) Hydrogeology

The three types of improved deep wells with the depth of 130 to 156m were drilled on the premises of a primary school at the central part of the village (Fig.5.23-24, Table 5.3). The geological conditions of this site are as follows (depths are approximate, see Table 5.4):

surface to 6 m: silt layer

6 m to 12 m: very fine sand layer

12 m to 15 m: silt layer

15 m to 110 m: very fine sand to medium sand layer (thickness: 95m)

110 m to 128 m: medium to coarse sand layer with gravel

128 m to 156 m: medium to coarse sand layer with gravel

It is difficult to classify aquifers because there is no sand layer dividing them. Therefore, based on changes in facies, the fine sand to medium sand layer up to the depth of 109 m is considered as a shallow aquifer, and the further layer of fine to coarse sand with gravel as a deep aquifer.

b) Problems during well construction

As one can tell from the geological conditions, there is no layer suitable for seal as the clay layer, and there is a gravel layer hard to be drill by the donkey method. The depths of completed wells are 125 m (Type A), 148.5 m (Type B) and 147.0 m (Type C), and well screens with a length of 10 m were installed between the depth of 114 m and 146 m. The seals were installed at the depth of 92.0 m to 101.0 m for Type A, 125.5 m to 126.0 m for Type B and 123.7 m to 130.7 m for Type C (see Table 5.3 and Fig. 5.25-27). These seals could not be installed on the clay layer, because it does not exist. The effectiveness of the seals will be clear when monitoring data of water quality is available.

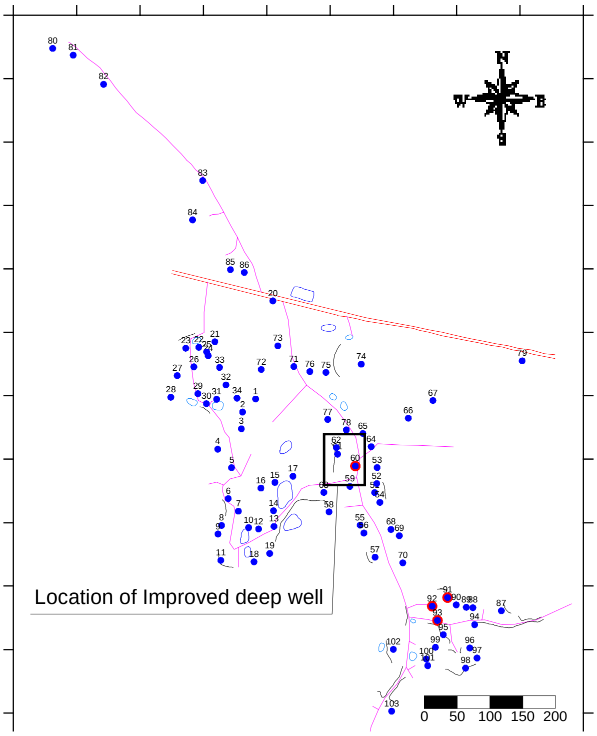


Figure 5.23 Location of improved deep wells at Krishna Chandrapur

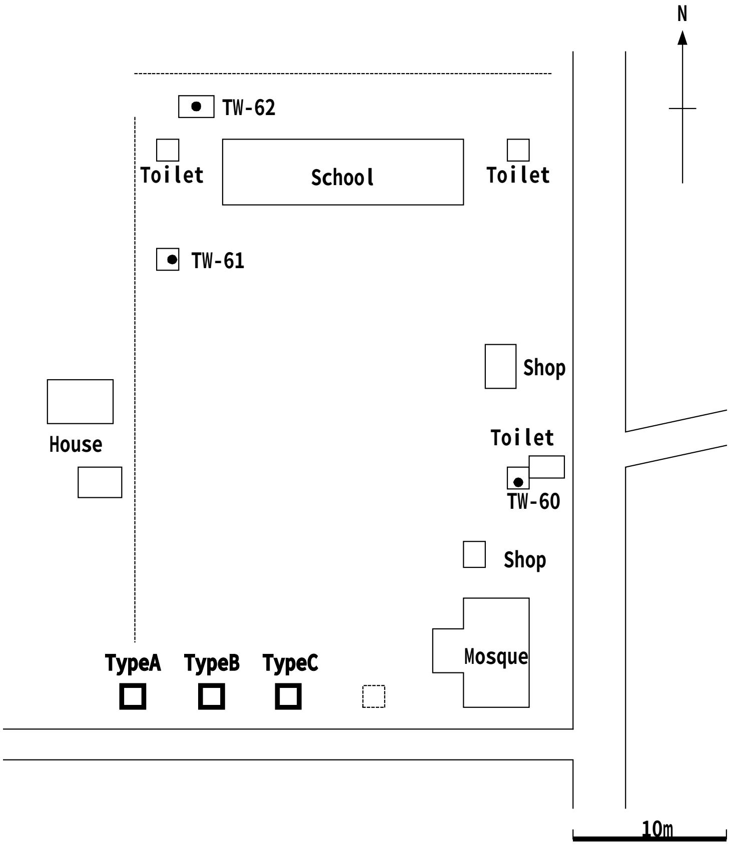


Figure 5.24 Arrangement of improved deep wells at Krishna Chandrapur

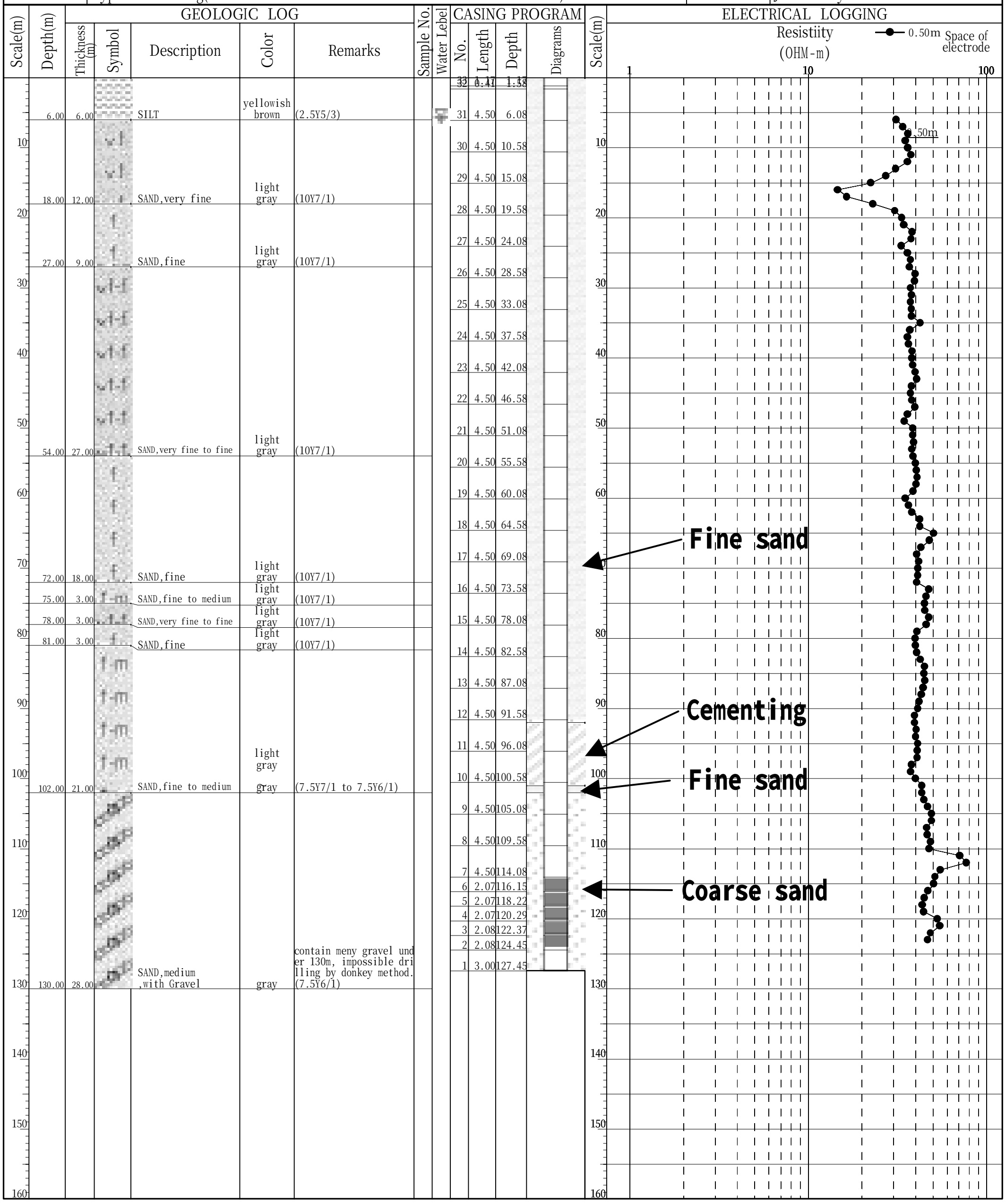
Table 5.3 Summary of drilling improved deep wells at Krishna Chandrapur

<table>
<tr><td rowspan="5">Location</td><td>District</td><td colspan="3">Jhenaidah</td></tr>
<tr><td>Upzilla</td><td colspan="3">Maheshpur</td></tr>
<tr><td>Union</td><td colspan="3">Fatehpur</td></tr>
<tr><td>Village</td><td colspan="3">Krishna Chandrapur</td></tr>
<tr><td>Lat. Long.</td><td colspan="3">23°23'24"N 88°54'25"E</td></tr>
<tr><td colspan="2">Well No.</td><td>ImHM-1</td><td>ImHM-2</td><td>ImHM-3</td></tr>
<tr><td colspan="2">Well Type</td><td>Type A</td><td>Type B</td><td>Type C</td></tr>
<tr><td colspan="2">Drilling depth (m)</td><td>130.0</td><td>156.0</td><td>153.0</td></tr>
<tr><td colspan="2">Casing depth (m)</td><td>127.45</td><td>148.50</td><td>147.00</td></tr>
<tr><td colspan="2">Drilling diameter (mm)</td><td>90-150</td><td>90</td><td>90-150</td></tr>
<tr><td colspan="2">Casing diameter (mm)</td><td>48</td><td>48</td><td>48</td></tr>
<tr><td rowspan="5">Well structure</td><td>GI pipe (m)</td><td>1.17</td><td>1.00</td><td>1.00</td></tr>
<tr><td>PVC pipe (m)</td><td>112.90</td><td>134.10</td><td>132.50</td></tr>
<tr><td rowspan="2">Screen (m)</td><td>10.37</td><td>10.40</td><td>10.50</td></tr>
<tr><td>(114.08-124.45)</td><td>(135.10-145.50)</td><td>(133.50-144.00)</td></tr>
<tr><td>Sand trap (m)</td><td>3.00</td><td>3.00</td><td>3.00</td></tr>
<tr><td rowspan="6">Sealing</td><td>Fine sand (m)</td><td>0.0-92.0</td><td>0.0-125.5</td><td>0.0-123.7</td></tr>
<tr><td>Cementing (m)</td><td>92.0-101.0</td><td></td><td>123.7-130.7</td></tr>
<tr><td>Fine sand (m)</td><td>101.0-102.0</td><td></td><td>130.7-131.2</td></tr>
<tr><td>Nice seal (m)</td><td></td><td>125.5-126.0</td><td></td></tr>
<tr><td>Mechanical Seal</td><td></td><td></td><td>131.2-131.7</td></tr>
<tr><td>Coarse sand (m)</td><td>102.0-127.45</td><td></td><td></td></tr>
<tr><td rowspan="5">Drilling date</td><td>Start</td><td>04-Feb-01</td><td>21-Nov-00</td><td>14-Jan-01</td></tr>
<tr><td>Casing</td><td>16-Feb-01</td><td>25-Nov-00</td><td>22-Jan-01</td></tr>
<tr><td>Sealing finish</td><td>17-Feb-01</td><td>27-Nov-00</td><td>24-Jan-01</td></tr>
<tr><td>Total (days)</td><td>14</td><td>7</td><td>11</td></tr>
<tr><td>Speed (m/day)</td><td>9.3</td><td>22.3</td><td>13.9</td></tr>
<tr><td rowspan="3">Washing</td><td>Start</td><td>17-Feb-01</td><td>27-Nov-00</td><td>25-Jan-01</td></tr>
<tr><td>Finish</td><td>25-Feb-01</td><td>29-Nov-00</td><td>28-Jan-01</td></tr>
<tr><td>Total (days)</td><td>5</td><td>3</td><td>4</td></tr>
<tr><td colspan="2">Platform</td><td>22-Feb-01</td><td>20-Feb-01</td><td>19-Feb-01</td></tr>
<tr><td rowspan="2">Water level</td><td>Static water level</td><td>GL-5.80m</td><td>GL-5.54m</td><td>GL-5.95m</td></tr>
<tr><td>Date</td><td colspan="3">24-Feb-01</td></tr>
<tr><td>Pumping test</td><td>Date</td><td>27-Feb-01</td><td>24-Feb-01</td><td>24-Feb-01</td></tr>
<tr><td rowspan="7">Water quality</td><td>Date</td><td>27-Feb-01</td><td>24-Feb-01</td><td>24-Feb-01</td></tr>
<tr><td>As by F.K. (mg/l)*</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Fe by P.T.(mg/l)*</td><td>4.0</td><td>2.0</td><td>4.0</td></tr>
<tr><td>Temprature (C)</td><td>26.5</td><td>26.6</td><td>26.8</td></tr>
<tr><td>pH</td><td>6.92</td><td>6.88</td><td>6.83</td></tr>
<tr><td>ORP (mv)</td><td>-68</td><td>-58</td><td>-69</td></tr>
<tr><td>EC_{25} (ms/m)</td><td>91.1</td><td>89.7</td><td>89.8</td></tr>
</table>

*F.K.=Field kit(AAN) P.T.=Pack Test Kit

WELL LOG

Project	The Ground Water Development of Deep Aquifers for Safe Drinking Water Supply							No.	ImHM-1
Client	Japan International Cooperation Agency					Period	04 Feb.2001 - 25 Feb.2001		
Location	Krishna Chandrapur Vil., Fatehpur Union, Maheshpur Upzilla, Jhenaidah					Lat.Long.	Lat:23'23'24. ' Long:088'54'25. '		
Well Depth	127.45 m	Casing Type	Vinyl Pipe	Static W.L.	GL- 5.800 m	Elevation		Water Temp.	26.5
Well dia.	48 mm	Screen Type	Horizontal slit	Dynamic Pumpage					
Drilling dia.	90～150mm	Screen Length	10.37 m	Dynamic P.W.L.					
Note	TypeA:Cementing(c.s.127.45-102mf.s.102-101mcement101-92mf.s.92-0m)					Contractor	JICA Study Team		



JICA
Japan International Cooperation Agency

Figure 5.25 Improved deep well log of Type A at Krishna Chandrapur

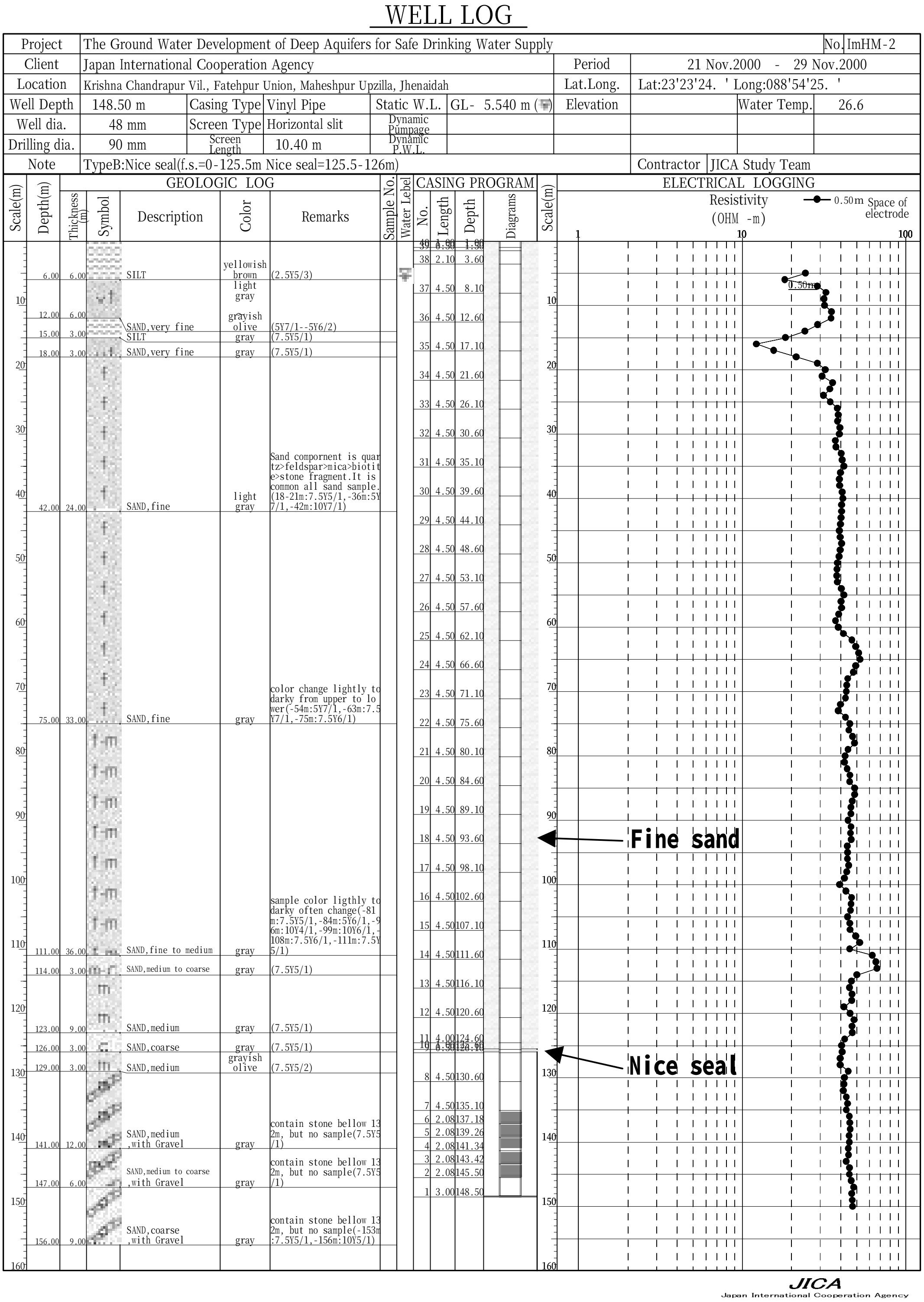


Figure 5.26 Improved deep well log of Type B at Krishna Chandrapur

WELL LOG

Project	The Ground Water Development of Deep Aquifers for Safe Drinking Water Supply					No.	ImHM-3
Client	Japan International Cooperation Agency				Period	14 Jan.2001 - 28 Jan.2001	
Location	Krishna Chandrapur Vil., Fatehpur Union, Maheshpur Upzilla, Jhenaidah				Lat.Long.	Lat:23'23'24. ' Long:088'54'25. '	
Well Depth	150.00 m	Casing Type	Vinyl Pipe	Static W.L.	GL- 5.950 m	Elevation	Water Temp. 26.8
Well dia.	48 mm	Screen Type	Horizontal slit	Dynamic Pumpage			
Drilling dia.	150 mm	Screen Length	10.50 m	Dynamic P.W.L.			
Note	TypeC:Mechanical(fs=0-123.7mCem=123.7-130.7mfs=130.7-131.2mMS=131.2-131.7m					Contractor	JICA Study Team

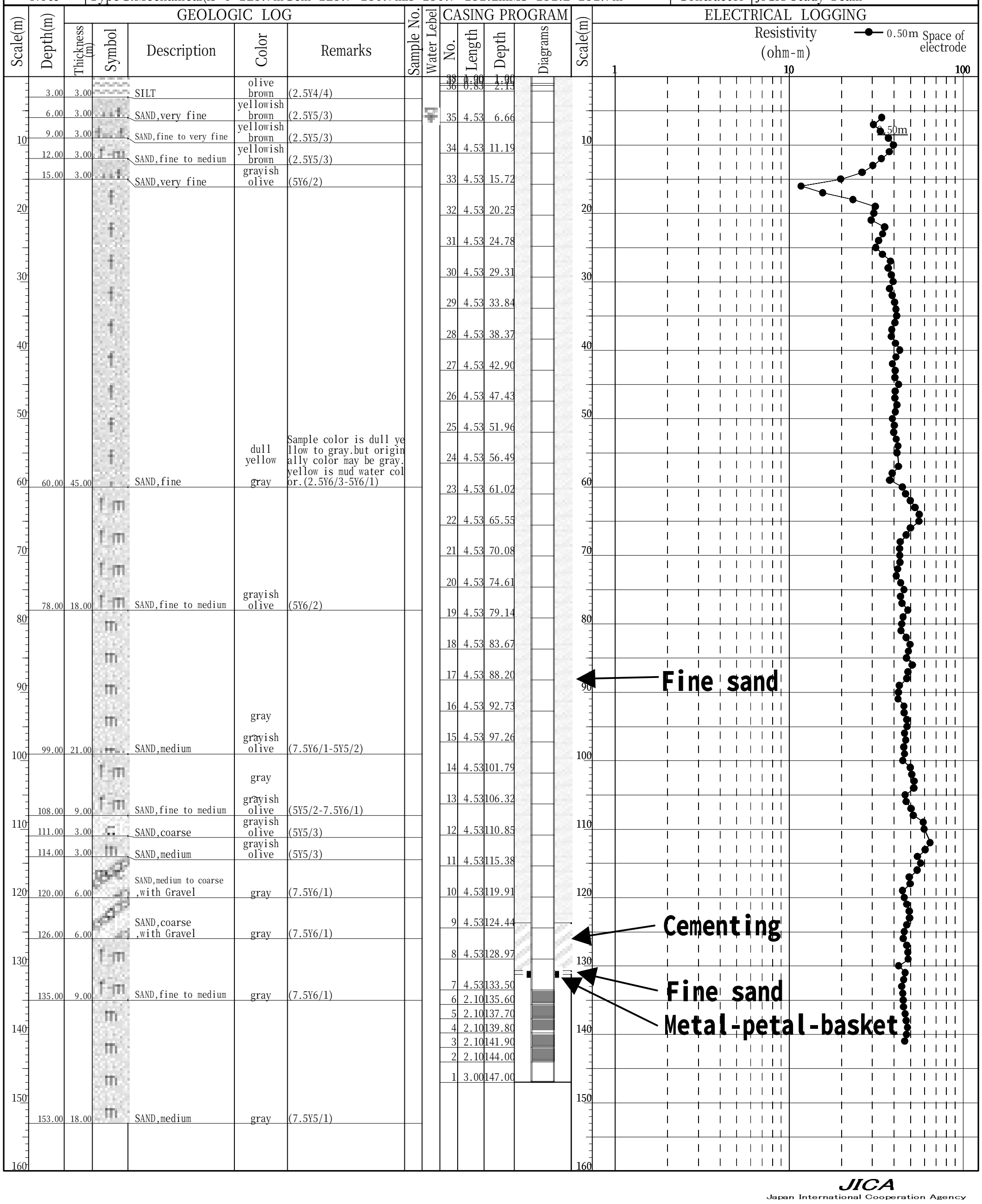


Figure 5.27 Improved deep well log of Type C at Krishna Chandrapur

Table 5.4 Geologic log at Krishna Chandrapur Vil.

Depth	Symbol	Description	Thickness	Aquifer
3-6m		SILT	3-6m	(aquiclude)
12m		SAND,very fine	6-9m	
15m		Silt	3m	
50m 100m		SAND,fine to medium	93-96m	Shallow aquifer
108-111m		SAND,medium to coarse,with gravel	18m	? Deep aquifer
126-129m 150m		SAND,fine to coarse,with gravel	27m over	

3) Bara Dudpatila

a) Hydrogeology

The three improved deep wells with depths from 107 m to 108 m were drilled at the central part of the village (Fig.5.28-29, Table5.5). The geological conditions of this site are as follows (Table 5.6):

surface to about 6 m: silt layer

about 6 m to 21 m: very fine sand to fine sand layer

about 21 m to 96 m: fine sand to medium sand layer

about 96 m to 109 m: medium sand to coarse sand layer with gravel

below 109 m: gravel layer

As in the case of Krishna Chandrapur, it is difficult to distinguish between aquifers due to a lack of the clay layer dividing them. Based on the changes in facies, the fine sand to medium sand layer up to the depth of about 96 m is considered as a shallow aquifer, and the further layer with medium to coarse sand with gravel as a deep aquifer.

b) Problems during well construction

The drilling depth was originally 150 m, but the drilling was stopped at the depth of 108 m to 109 m because it was impossible to drill the gravel layer deeper than 108m to 109m by the donkey method.

There is no layer suitable for seal as the clay layer (Fig.5.30). These seals could not be installed on the clay layer, because it does not exist. The effectiveness of the seals will be clear when monitoring data of water quality is available.

While drilling, the sand layer often collapsed, and jamming occurred. When the casing was being inserted into the Type C well, PVC pipe was caught on the wall of the borehole. The drilling of the first well was unsuccessful because the casing had the metal-petal basket attached to it, and it could not be pulled up.

Drilling of the Type C deep well again did not seem promising and was cancelled; Two Type A wells and one Type B well were constructed.

Therefore, it has become clear that it is necessary to manage drilling water to prevent the collapse of the borehole and that there are issues to be solved for drilling Type C deep wells.

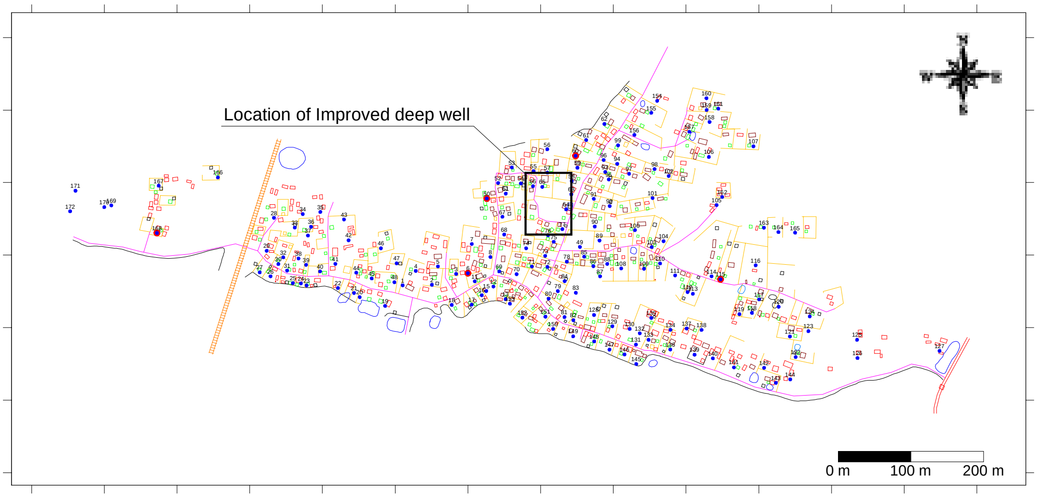


Figure 5.28. Location of Improved deep well at Bara Dudpatila

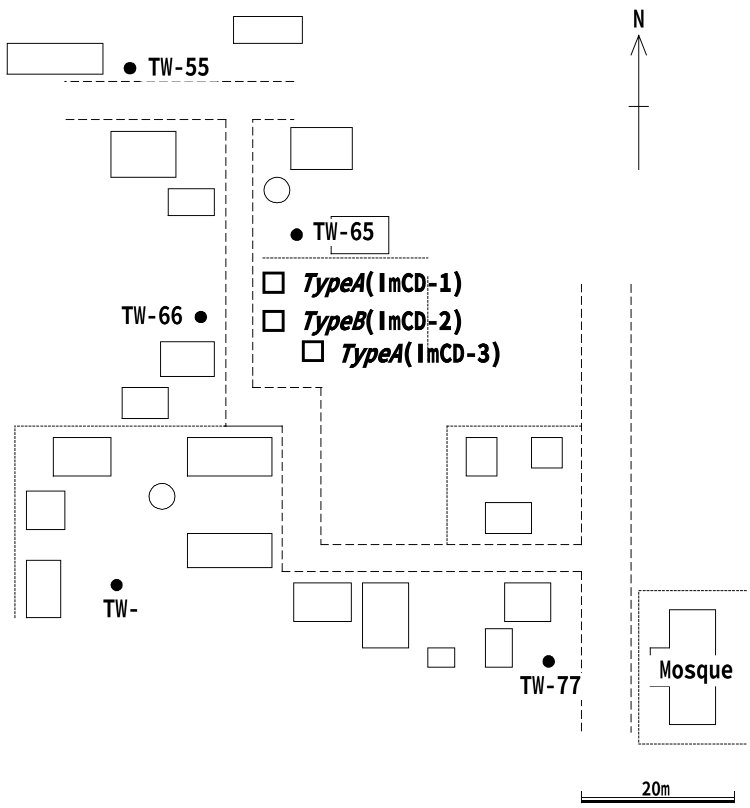


Figure 5.29 Arrange of Improved deep well at Bara Dudpatila

Table 5.5 Summary of drilling improved deep wells at Bara Dudpatila

Location	District	Chuadanga		
	Upzilla	Damurhuda		
	Union	Howli		
	Village	Bara Dudpatila		
	Lat. Long.	23°32'57"N 88°48'27"E		
Well No.		ImCD-1	ImCD-2	ImCD-3
Well Type		Type A	Type B	Type A
Drilling depth (m)		108.0	106.6	108.0
Casing depth (m)		103.52	105.04	101.57
Drilling diameter (mm)		150	90	90-150
Casing diameter (mm)		48	48	48
Well structure	GI pipe (m)	1.16	0.82	1.16
	PVC pipe (m)	88.69	90.62	87.00
	Screen (m)	10.74	10.64	10.34
		(89.85-100.59)	(91.44-102.08)	(90.23-98.50)
	Sand trap (m)	2.93	2.96	3.07
Sealing	Fine sand (m)	0-23.0	0-33.7(clay)	0-41.0
	Cementing (m)	23.0-31.0		41.0-48.0
	Fine sand (m)	82.5-83.5		80.6-81.6
	Nice seal (m)		33.7-33.8 34.7-34.8 87.8-88.3	
	Mechanical Seal			81.6-101.57
	Coarse sand (m)	83.5-103.5		
Drilling date	Start	18-Feb-01	21-Feb-01	13-Feb-01
	Casing	22-Feb-01	23-Feb-01	20-Feb-01
	Sealing finish	23-Feb-01	24-Feb-01	21-Feb-01
	Total (days)	6	4	9
	Speed (m/day)	18.0	26.7	12.0
Washing	Start	23-Feb-01	25-Feb-01	21-Feb-01
	Finish	25-Feb-01	26-Feb-01	24-Feb-01
	Total (days)	3	2	4
Platform		26-Feb-01	27-Feb-01	24-Feb-01
Water level	Static water level	GL-4.23m	GL-4.44m	GL-4.74m
	Date	01-Mar-01	02-Mar-01	02-Mar-01
Pumping test	Date	02-Mar-01	01-Mar-01	01-Mar-01
Water quality	Date	02-Mar-01	01-Mar-01	01-Mar-01
	As by F.K. (mg/l)*	-	-	-
	Fe by P.T.(mg/l)*	3.0	5.0	5.0
	Temperature (C)	26.8	26.6	26.6
	pH	6.91	6.89	6.87
	ORP (mv)	-65	-72	-65
	EC_{25} (ms/m)	60.9	61.6	61.4

*F.K.=Field kit(AAN) P.T.=Pack Test Kit

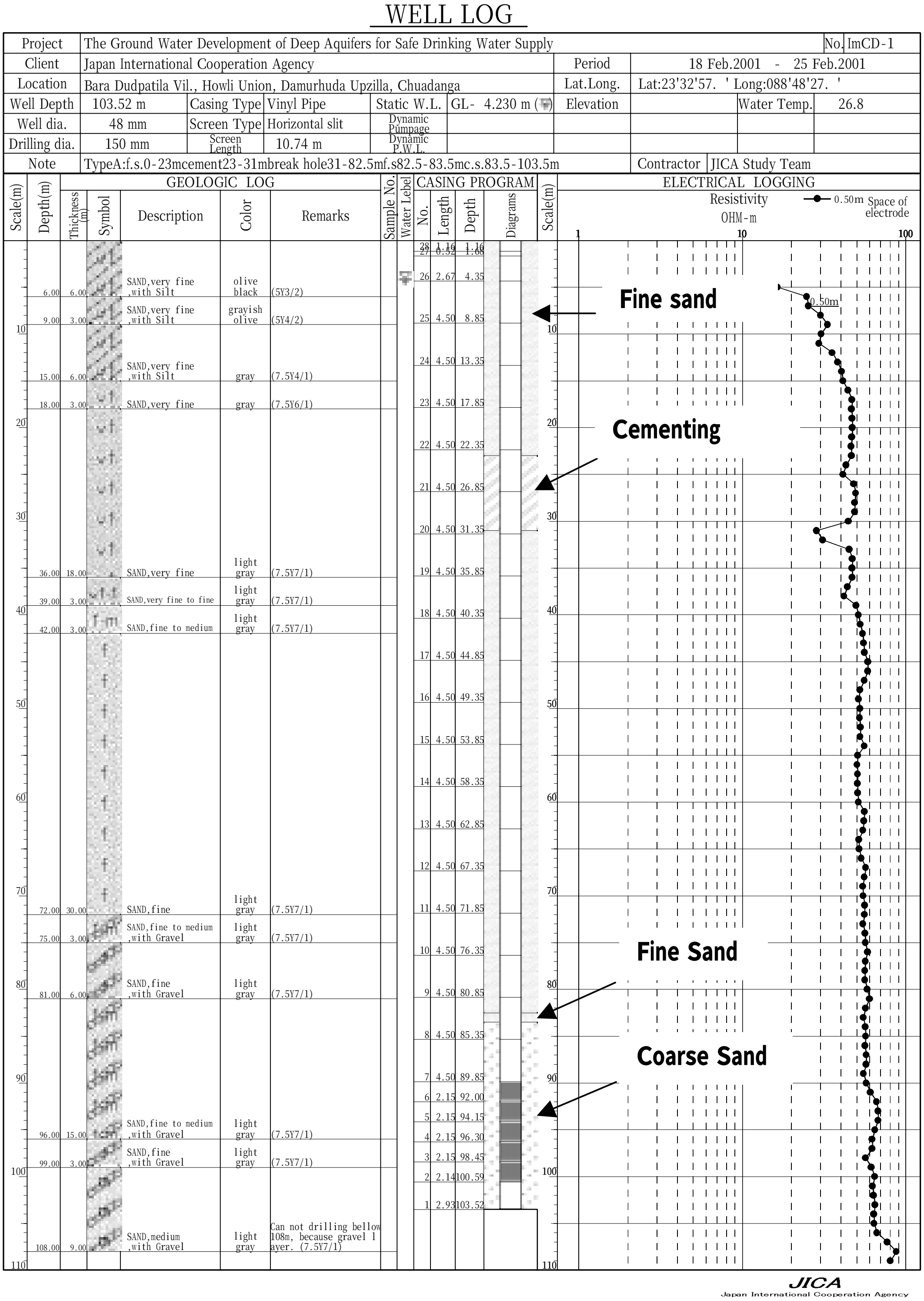


Figure 5.30 Improved deep well log of Type A at Bara Dudpatila

WELL LOG

Project	The Ground Water Development of Deep Aquifers for Safe Drinking Water Supply					No.	ImCD-2
Client	Japan International Cooperation Agency				Period	21 Feb.2001 - 27 Feb.2001	
Location	Bara Dudpatila Vil., Howli Union, Damurhuda Upzilla, Chuadanga				Lat.Long.	Lat:23'32'57. ' Long:088'48'27. '	
Well Depth	105.04 m	Casing Type	Vinyl Pipe	Static W.L.	GL- 4.440 m	Elevation	Water Temp. 26.6
Well dia.	48 mm	Screen Type	Horizontal slit	Dynamic Pumpage			
Drilling dia.	90 mm	Screen Length	10.64 m	Dynamic P.W.L.			
Note	TypeB: Nice seal 33.7-33.8m34.7-34.8m87.8-88.3m					Contractor	JICA Study Team

GEOLOGIC LOG

Depth(m)	Thickness (m)	Description	Color	Remarks
3.00	3.00	SAND,very fine ,with Silt	olive black	(5Y3/1)
24.00	21.00	SAND,very fine	grayish olive	(5Y6/2)
42.00	18.00	SAND,fine	gray	(7.5Y6/1)
75.00	33.00	SAND,fine to medium	gray	(7.5Y6/1)
81.00	6.00	SAND,fine ,with Gravel	gray	(7.5Y6/1)
105.00	24.00	SAND,fine to medium ,with Gravel	gray	(7.5Y6/1-7.5Y5/1)
106.60	1.60	SAND,medium ,with Gravel	gray	Can not drilling bellow 106.6m, because gravel .7.5Y5/1)

CASING PROGRAM

No.	Length	Depth
28	0.82	0.82
27	0.50	1.32
26	4.52	5.84
25	4.52	10.36
24	4.52	14.88
23	4.52	19.40
22	4.52	23.92
21	4.52	28.44
20	4.52	32.96
19	4.53	37.49
18	4.53	42.02
17	4.53	46.55
16	4.53	51.08
15	4.53	55.61
14	4.53	60.14
13	4.53	64.67
12	4.53	69.20
11	4.53	73.73
10	4.53	78.26
9	4.53	82.79
8	4.53	87.32
7	4.12	91.44
6	2.13	93.57
5	2.13	95.70
4	2.13	97.83
3	2.13	99.96
2	2.12	102.08
1	2.96	105.04

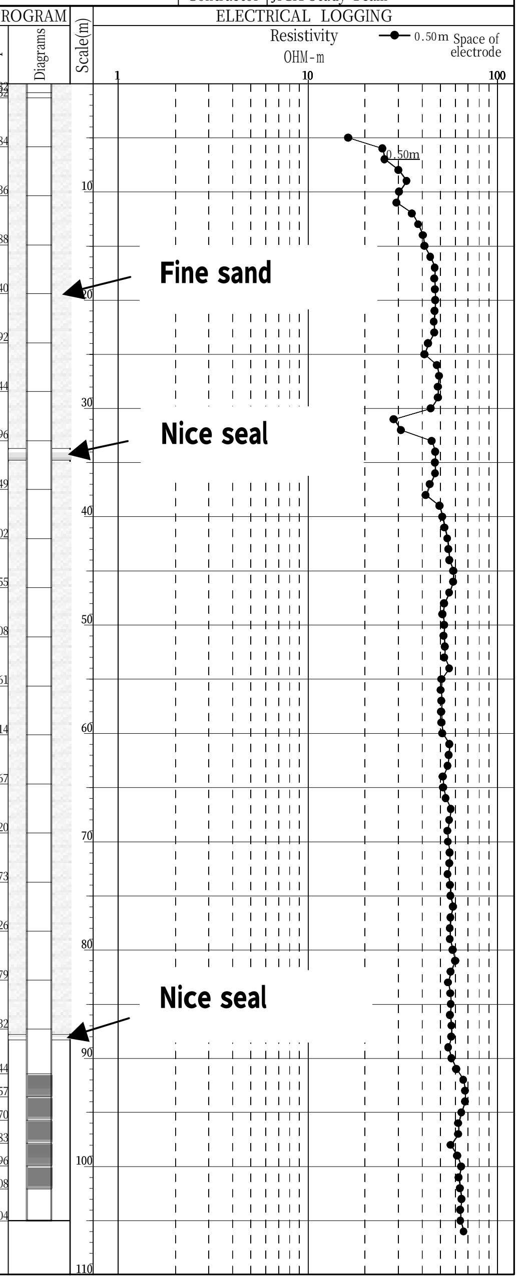


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Figure 5.31 Improved deep well log of Type B at Bara Dudpatila

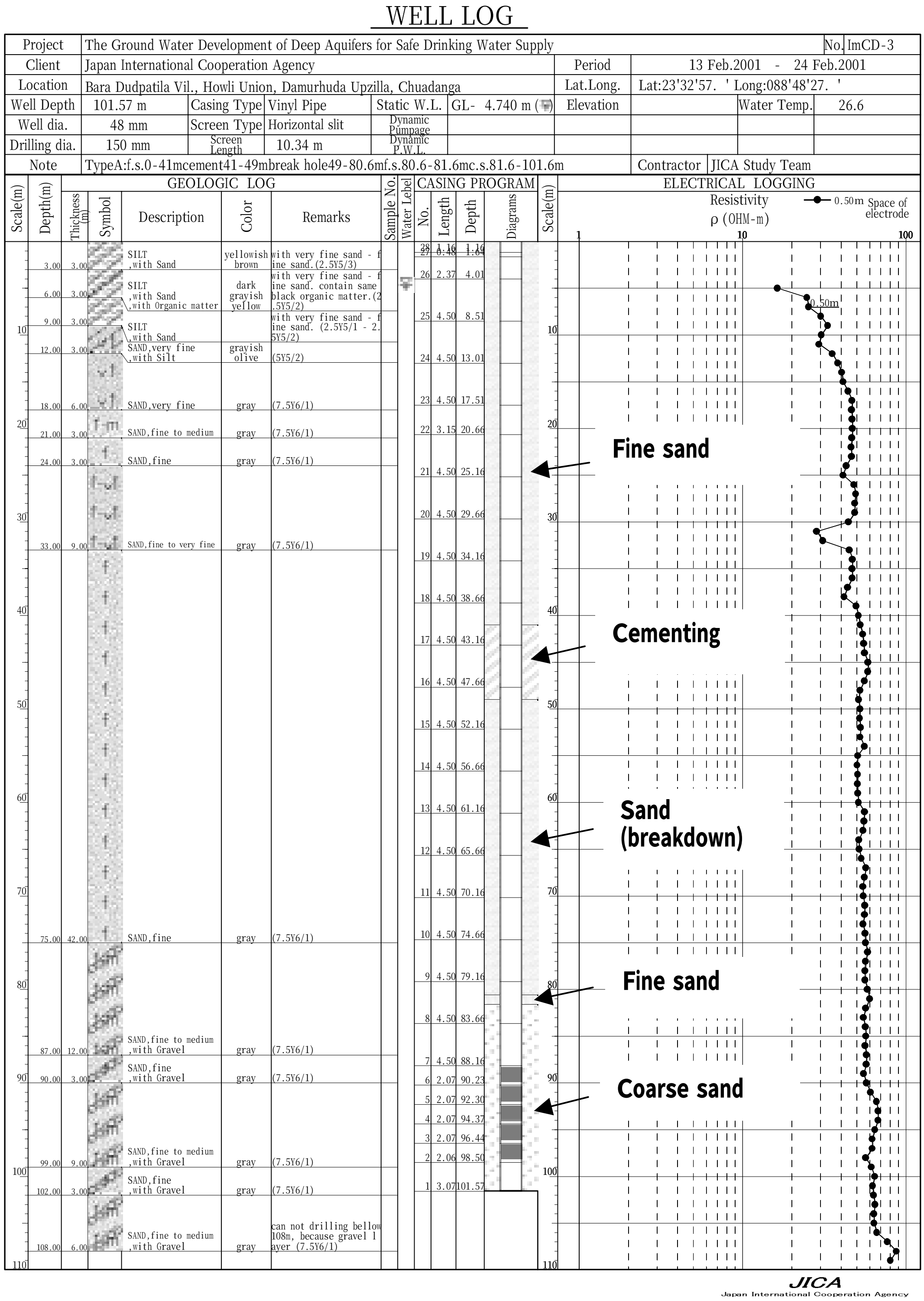


Figure 5.32 Improved deep well log of Type C at Bara Dudpatila

Table 5.6 Geologic log at Bara Dudpatila

Depth	Symbol	Description	Thickness	Aquifer
6m		SILT,with very fine sand	6m	(aquiclude)
21m		SAND,very fine to fine	15m	Shallow aquifer
96m (50m)		SAND,fine to medium	75m	Shallow aquifer
(100m)		SAND,medium to coarse,with gravel	13m	? Deep aquifer
109m		GRAVEL	7m?	Deep aquifer

(4) Simple pumping test

A simple pumping test was conducted to identify the aquifer constant of the deep aquifer. The three improved deep wells were used for the pumping test. An engine pump was installed at one well (a pumping well); while water was withdrawn from the pumping well, drawdown was measured at the other two wells (observation wells). The test data was analyzed by Thiem's method, Jacob's method and recovery method (Table 5.7, Figure 5.33 and Appendix). Based on the analysis, transmissivity (T) was 1758m^2/d in Rajinagar Bankabarsi, 1405m^2/d in Krishna Chandrapur, and 3613m^2/d in Bara Dudpatila; hydraulic conductivity (k) was 175.8m/d in Rajinagal Bankabarsi, 140.5m/d in Krishna Chandrapur, and 361.3m/d in Bara Dudpatila.

Table 5.7 Results of simple pumping test

Location		Rajinagar Bankabarsi	Krishna Chandrapur	Bara Dudpatila
T: Transmissivity (m^2/d)	Average	1758	1405	3613
	Range	989 to 3505	785 to 2255	2307 to 5071
k:Hydraulic conductivity (m/d)	Average	175.8	140.5	361.3
	Range	98.9 to 350.5	78.5 to 225.5	230.7 to 507.1

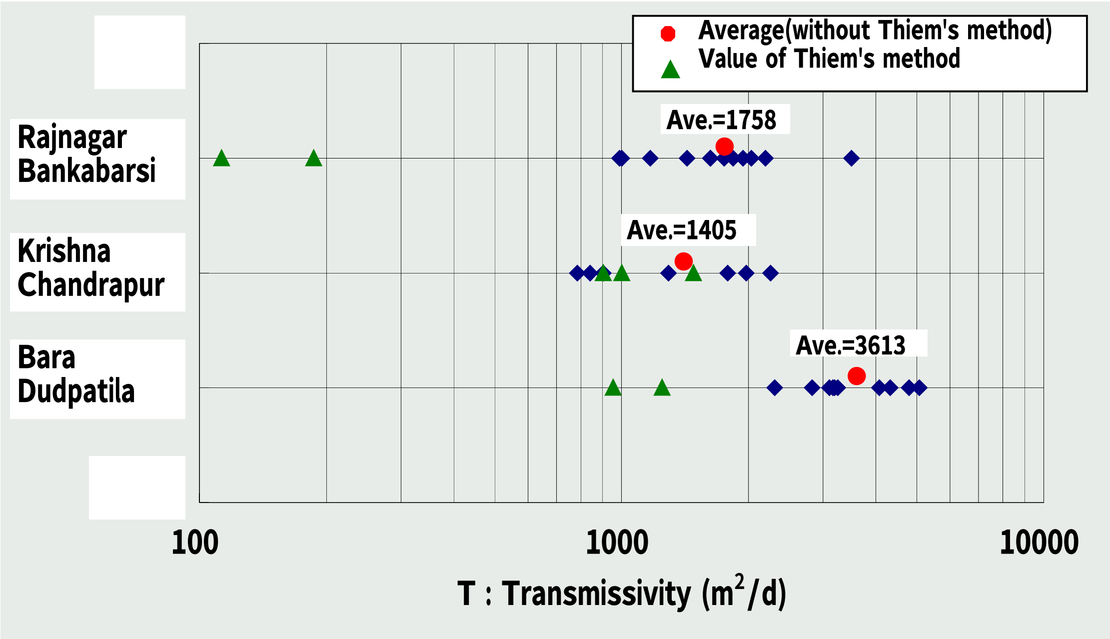


Figure 5.33 Comparison of transmissivity

5.5 Water quality monitoring of improved deep wells

The effectiveness of the sealing of improved deep wells is to be evaluated based on the results of water quality monitoring for 3 months.

(1) Rajinagal Bankabarsi vil.

The arsenic concentration of water from the improved deep wells at Rajinagal Bankabarsi vil. is under 0.0005 mg/l (detection limit) to 0.0013 mg/l. These levels are far below the Bangladesh standard (0.05 mg/l). However, it is in the middle of water quality monitoring, and careful observation is still required.

Table 5.8 Monitoring result at Rajinagal Bankabarsi village

Well	Date		EC(ms/m)	PH	ORP(mv)	Temp(℃)	As by AAS(mg/l)
TypeA (ImJK-1)	2000/11/26	after conpletion					<0.0005
	2000/11/30	pumping test(before)	60.1	7.71	-63.0	25.9	0.0005
	2000/11/30	pumping test(5min)					<0.0005
	2000/11/30	pumping test(1hour)					<0.0005
	2000/11/30	pumping test(2hour)					<0.0005
	2000/11/30	pumping test(4hour)					<0.0005
	2000/11/30	pumping test(6hour)					<0.0005
	2000/11/30	pumping test(after)					<0.0005
	2001/1/3	monitoring(1/3)	60.2	7.79	76.0	24.6	0.0006
TypeB (ImJK-2)	2000/11/26	after conpletion					<0.0005
	2000/11/30	pumping test(before)					<0.0005
	2000/11/30	pumping test(after)					0.0008
	2001/1/3	monitoring(1/3)	59.8	7.76	127.0	25.4	0.0009
TypeC (ImJK-3)	2000/11/26	after conpletion					0.0007
	2000/11/30	pumping test(before)					0.0011
	2000/11/30	pumping test(after)					0.0011
	2001/1/3	monitoring(1/3)	55.8	7.72	142.0	24.2	0.0013

(2) Krishna Chandrapur vil.

(under investigation now)

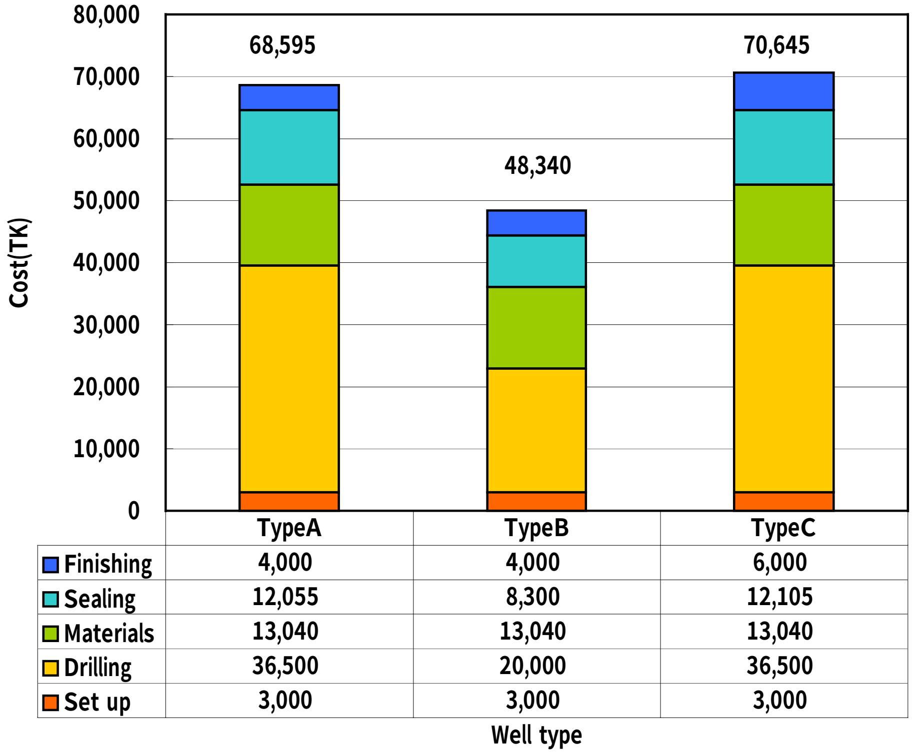
(3)Bara Dudpatila vil.

(under investigation now)

5.6 Comparison of improved deep well types

(1) Construction costs

The construction costs of the three types of deep improved wells with the depth of 150m are 68,595Tk for Type A, 48,340Tk for Type B, and 70,645Tk for Type C. The construction costs of Type C and Type A wells are higher than those of Type B (Fig.5.34). Because after the drilling of the borehole with the diameter of 90 mm, reaming to the diameter of 150 mm is required for Type A and Type C, these two types have much higher drilling costs than Type B, which influence the total costs. The total cost of Type C is higher than those of Type A because the former requires a longer time for well washing.



	TypeA	TypeB	TypeC
Finishing	4,000	4,000	6,000
Sealing	12,055	8,300	12,105
Materials	13,040	13,040	13,040
Drilling	36,500	20,000	36,500
Set up	3,000	3,000	3,000

Figure 5.34 Cost comparison of improved deep wells (depth: 150m)

Table 5.9 Breakdown of construction cost of Improved deep well

Well Type	Item	Contents	Quantity	Unit	Price	Sum	Subtotal	Total(TK)
Type A	Transport and set up of equipment		1	Unit	3,000	3,000	3,000	
	Drilling	0-50m(150mm)	50	m	210	10,500		
		50-150m(150mm)	100	m	260	26,000	36,500	
	Materials	G.I.Pipe	1.52	m	270	410		
		PVC Pipe Class D	136	m	70	9,520		
		Screen	10	m	130	1,300		
		Sand trap	3	m	70	210		
		Solvent cement(100mg)	3	Tube	200	600		
		Hand pump (no.6)	1	no.	1,000	1,000	13,040	
	Sealing	coarse sand(40m)	0.79	m^3	5,000	3,950		
		Cementing(5m)	1	unit	5,000	5,000		
		fine sand	2.07	m^3	1,500	3,105	12,055	
	Finishing	Well washing	1	Unit	1,000	1,000		
		Platform	1	Unit	3,000	3,000	4,000	68,595
Type B	Transport and set up of equipment		1	Unit	3,000	3,000	3,000	
	Drilling	0-50m(90mm)	50	m	100	5,000		
		50-150m(90mm)	100	m	150	15,000	20,000	
	Materials	G.I.Pipe	1.52	m	270	410		
		PVC Pipe Class D	136	m	70	9,520		
		Screen	10	m	130	1,300		
		Sand trap	3	m	70	210		
		Solvent cement(100mg)	3	Tube	200	600		
		Hand pump (no.6)	1	no.	1,000	1,000	13,040	
	Sealing	Nice seal(typeD)	0.49	m	3,000	1,470		
		Nice seal(typeE)	1.8	m	3,000	5,400		
		Nice seal set	1	Unit	500	500		
		fine sand	0.62	m^3	1,500	930	8,300	
	Finishing	Well washing	1	Unit	1,000	1,000		
		Platform	1	Unit	3,000	3,000	4,000	48,340
Type C	Transport and set up of equipment		1	Unit	3,000	3,000	3,000	
	Drilling	0-50m(150mm)	50	m	210	10,500		
		50-150m(150mm)	100	m	260	26,000	36,500	
	Materials	G.I.Pipe	1.52	m	270	410		
		PVC Pipe Class D	136	m	70	9,520		
		Screen	10	m	130	1,300		
		Sand trap	3	m	70	210		
		Solvent cement(100mg)	3	Tube	200	600		
		Hand pump (no.6)	1	no.	1,000	1,000	13,040	
	Sealing	Mecanical seal	2	no.	2,000	4,000		
		Cementing(5m)	1	unit	5,000	5,000		
		fine sand	2.07	m^3	1,500	3,105	12,105	
	Finishing	Well washing	1	Unit	3,000	3,000		
		Platform	1	Unit	3,000	3,000	6,000	70,645

(2) Comparison and evaluation of improved deep wells

Improved deep wells are evaluated based on the following points:

- Easiness of procuring sealing materials
- Reliability of the sealing
- Easiness of installing the seal

As a result, Type A is the most suitable for development of deep aquifers in Bangladesh (see Table 5.10).

a) Local availability of sealing materials

Sealing materials for Type A and Type C are locally available (either they are in the market or can be made locally); however, Nice seal used for Type B is made from a special material and not locally available (it should be imported from Japan).

b) Reliability of the sealing

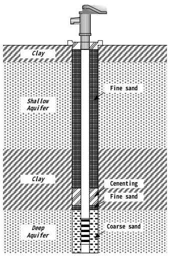
Since Type A and Type C employs cement for the sealing material, rigid sealing is expected. However, since Type B is sealed only with Nice seal, the Nice seal may not function as the seal if the wall of the borehole around the Nice seal collapses.

c) Easiness of installation

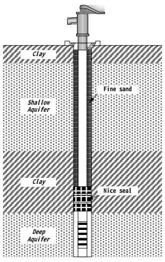
There is no problem in sealing in the case of Type A because only PVC pipe is inserted into the borehole. However, the insertion of the PVC pipe is often impossible in the case of Type B and Type C because Nice seal or a metal-petal-basket is attached to the pipe. Especially, Type C faces difficulty in inserting the PVC pipe into the borehole due to the large size of the metal-petal basket.

Table 5.10 Characteristic and evaluation of Improved deep well

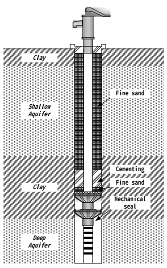
<table>
<tr><th>Well type</th><th colspan="3">Characteristic</th><th>Evaluation</th></tr>
<tr><td rowspan="5">TypeA



</td><td>Local availability of sealing materials</td><td>Available</td><td>○</td><td rowspan="5">○ Sealing is reliable if the seal is carefully installed.</td></tr>
<tr><td>Reliability of the seal</td><td>Cement sticks to the earth tightly.
It is possible to seal at optional level.</td><td>○</td></tr>
<tr><td>Easiness of construction</td><td>A casing pipe can be inserted smoothly because nothing is attached to the PVC pipe. However, the pipe could be blocked on its way unless the pipe is incerted slowly, being shaked.</td><td>△</td></tr>
<tr><td>Cost</td><td>68,595TK</td><td></td></tr>
<tr><td>Construction period</td><td>10-20days</td><td></td></tr>
<tr><td rowspan="5">TypeB



</td><td>Local availability of sealing materials</td><td>Not available (need to be imported from Japan)</td><td>×</td><td rowspan="5">× Durability of the sealing materials is unknown, and construction of Type B well is difficult. Sealing materials have to be imported.</td></tr>
<tr><td>Reliability of the seal</td><td>Since there is a space below the Nice seal, intrusion of arsenic contaminated water could not be prevented if the wall of the borehole around the Nice seal is broke down. The life of the Nice seal is unknown.</td><td>△</td></tr>
<tr><td>Easiness of construction</td><td>The Nice seal is likely to prevent smooth insertion of the PVC pipe into the borehole, which results in failure of inserting the pipe to the planned depth (one failure was experienced in the study).</td><td>△</td></tr>
<tr><td>Cost</td><td>48,340TK</td><td></td></tr>
<tr><td>Construction period</td><td>7-14days</td><td></td></tr>
<tr><td rowspan="5">TypeC



</td><td>Local availability of sealing materials</td><td>Available, but making Metal-petal-basket is difficult.</td><td>△</td><td rowspan="5">× If Type C well is constructed properly, the sealing is reliable. However, the construction of the well is difficult.</td></tr>
<tr><td>Reliability of the seal</td><td>Cement sticks to the earth tightly.</td><td>○</td></tr>
<tr><td>Easiness of construction</td><td>The metal-petal basket, which is attached to the PVC pipe, is likely to prevent smooth insertion of the pipe. This may results in failure of inserting the pipe to the planned depth (one failure was experienced in the study). The sealing could not be sucessful when cement milk drops down through the spaces that would be created between the metal-petal basket and the wall of the borehole.</td><td>×</td></tr>
<tr><td>Cost</td><td>70,645TK</td><td></td></tr>
<tr><td>Construction period</td><td>10-20days</td><td></td></tr>
</table>

5.7 Future agenda

Although there will not be any difficulty in the sealing of the improved deep well Type A if the sealing materials are carefully performed, the following technology transfer to Bangladeshi experts is necessary to drill a large number of the Type A wells.

a) Control of drilling water

In the donkey method used for deep well drilling, drilling water is mainly composed of cow dung. Bentnite is also used for drilling water, but the level of its usage is not satisfactory. The drilling water commonly used in Bangladesh has a low density and consequently a low viscosity, which often results in the collapse of the walls of the borehole and jamming. This is due to the inability of the drilling water to hold the wall of the borehole when drilling a sand or gravel layer. Therefore, to drill a large number of improved deep wells with the donkey method, it is indispensable to transfer well drilling technology including the control of drilling water.

b) Electrical logging (resistivity)

Even in the areas without a clay layer functioning as a sealing layer, the improved deep well with the sealing is expected to perform better than the traditional deep well with the pipe just inserted in the borehole. In these areas, the sealing should be done at the fine sand layer that has the minimum permeability available, and electrical logging must be performed so that the sealing depth is decided based on the identification of changes in layers, which is not possible from observing slime. Therefore, it is also indispensable to transfer technology on borehole logging to Bangladeshi experts.

CHAPTER 6

SOCICAL SURVEY

CHAPTER 6 SOCIAL SURVEY

6.1 Selection of Model Rural Areas

6.1.1 Definition of Model Rural Areas

Model Rural Areas are the villages that are selected for conducting several activities to collect hydro-geological information about the study area and socioeconomic information to consider the applicability of arsenic mitigation measures. The collected information will be used for preparing the master plan to cope with arsenic problems in the study area.

6.1.2 Planned Activities in Model Rural Areas

The following activities are planned in the Model Rural Areas:

1) Socio-economic Study

To consider the applicability of mitigation measures, basic information on water fetching and consumption practices, health injury due to arsenic poisoning, sanitary condition, eating habits, and economic condition will be collected through household interviews. Two hundred household interviews were conducted in each Model Rural Area. Details of the socioeconomic study are described in Section 6.4.

2) Water Sampling and Analysis

To identify arsenic contamination levels of shallow aquifers in the village, almost all the tube wells in each Model Rural Area were tested by the AAN field kit. Water samples were also taken from the same tube wells to analyze arsenic concentration at a laboratory. To examine the possibility of pond water for drinking water supply, water from ponds that have enough water during the dry season was tested by the AAN field kit, and water samples were taken from the same ponds to analyze arsenic concentration and other water quality at a laboratory.

3) Drilling of Improved Deep Wells

To examine whether deep aquifers can provide safe drinking water and whether traditional methods would be effective to drill arsenic safe wells, the JICA Study Team has hired a local contractor to drill three deep wells (150m depth) by the traditional method with different sealing methods. Monitoring water level and water quality of the three deep wells is underway by the JICA Study Team and DPHE staff. The drilling sites have been decided based on the levels of arsenic contamination of tube wells, accessibility of a truck carrying drilling machines, availability of land, and discussions at community meetings. Hand pumps were installed after the drilling; after water quality was tested and confirmed to be arsenic safe, the villagers started using the deep wells. When water level and quality is monitored, the hand pumps will be removed and again installed after the monitoring.

4) Performance Test of Arsenic Removal Equipment

To identify the best technology for arsenic removal from technical and socioeconomic points of view, the JICA Study Team has designed several kinds of arsenic removal equipment and asked several households and *Baris (a group of 5 to 10 houses)* to use and evaluate the equipment. The equipment is serving either one household (capacity: 20 litter/day) or one *Bari* (capacity: 500-1,000 litter/day). Households and *Baris* that provide cooperation for the performance test of arsenic removal equipment have been selected according to several criteria such as severity of health injury due to arsenic poisoning, arsenic contamination of nearby tube wells, availability of other water sources, their willingness to cooperate, and discussions at community meetings. The JICA Study Team provides the equipment, installation costs, and necessary materials such as chemicals for about one year use. After installation of the equipment, the JICA Study Team tests water quality periodically, and an assisting NGO will conduct interviews with the households and *Baris* on easiness of use of the equipment.

5) Core Boring

To examine the safety of groundwater in deep aquifers, the JICA Study Team has hired contractors to carry out one core boring (depth: 300m) in each Model Rural Area and arsenic analysis of 80 soil samples. The boring sites were selected based on the levels of arsenic contamination of tube wells, accessibility of a truck carrying drilling machines, availability of land, and discussions at community meetings. The JICA Study Team and DPHE staff monitor water level and water quality in the hole.

6) Diagnosis of Arsenic Patients

To identify the number and characteristics of arsenic patients in the Model Rural Area, the JICA Study Team employed a medical doctor to diagnose patients in November 2000. Information on age, sex, symptom, and drinking water source of the patients was collected. Vitamin tablets were provided to the needy patients to improve their health conditions.

7) Setting Up A Community Organization to Lead Community Activities

The JICA Study Team asked Union Parishad Members and the social elite to organize villagers to set up a community organization. The community organization leads community activities related to arsenic problems, such as organizing community meetings to discuss arsenic issues and making decisions on sties for drilling, installation of arsenic removal equipment, and core boring. The community organization in each Model Rural Area has about 20 members (half are male and the other half are female). To form and run the community organization, a local NGO provides assistance to the village.

8) Raising Awareness towards Arsenic Problems

The JICA Study Team will asked the community organization to nominate two village leaders to attend a one-day training session on awareness raising activities and disseminate information about current conditions of arsenic levels of tube well water, the cause of arsenicosis and its prevention methods to the villagers. The follow-up interviews with the 200 households on their understanding of arsenic problems are conducted to see the effectiveness of the awareness raising activity.

6.1.3 Process of Model Rural Area Selection

1) Number of Model Rural Areas

One Model Rural Area is selected for one District; therefore, a total three Model Rural Areas are selected in the study area.

Table 6.1.1 Number of Model Rural Area

District	# of Model Rural Areas
Chuadanga	1
Jessore	1
Jhenaidah	1
Total	3

2) Selection Criteria for Model Rural Areas

The following criteria are set to select Model Rural Areas from the villages in the study area:

(a) Within the District

- Villages are not located in Pourashava (Municipal) areas.
- A number of patients have been found.
- No effective mitigation activities have been taken place.
- A truck carrying drilling machines is accessible.
- A local community group or a village leader is willing to make efforts to tackle arsenic problems.

(b) Within the Study Area (The Three Districts)

- Three Pourashavas and three Model Rural Areas where hydro-geological information is collected through the drilling of deep wells and core boring represent geological characteristics of the study area.

The process of selecting the Model Rural Area within the District is shown in Figure 6.1.1.

3) Prospective Villages for Model Rural Areas

According to the selection criteria, a list of the villages that are located outside of Pourashavas and that have patients was prepared for each District. The information used for the preparation of the lists is as follows:

1. Socio-economic study in the rural areas carried out as a part of this study during June and July 2000 (see the details in Chapter 2, Section 2.5; referred as JICA in the lists)
2. JICA Expert. 2000. "Activity Report of JICA Expert Team in DPHE for Arsenic Mitigation" (referred as JICA Expert in the lists)
3. Dhaka Community Hospital. 2000. Arsenic in Bangladesh: Report on the 500-Village Rapid Assessment Project (referred as DCH in the lists)
4. School of Environmental Studies, Jadapur University and Dhaka Community Hospital. 2000. Groundwater Arsenic Contamination in Bangladesh: Summary of 239 days field survey from August 1995 to February 2000, Twenty seven days detailed survey information from April 1999 to February 2000.
5. Asia Arsenic Network's information on number of arsenic patients (referred as AAN in the lists)

The prospective villages are shown in Tables 6.1.2a, 6.1.2b, and 6.1.2c.

6.1.4 Selected Villages for Model Rural Areas

1) Narrowing Down Prospective Villages for Model Rural Area in Each District

(a) Chuadanga

According to the existing information, there are seven villages where arsenic patients have been reported in Chuadanga, and no effective mitigation activity has been taken place in the villages (see Table 6.1.1a). The largest number of patients (100 patients have been reported by JICA and 205 by JICA Expert) was found in Bara Dudpatila (Howli Union), and the second largest number of patients (97 patients have been reported by DCH) was found in Benagari (Nagbana Union). During the site visits to both villages, the JICA study team found that a truck carrying drilling machines is accessible to the villages and that a local NGO (ATMABISWAS) has been working in Benagari to help villagers establish an arsenic prevention committee and improve their diet. ATMABISWAS also expressed their interest in helping Bara Dudpatila if it is selected as the Model Rural Area; A Union Parishad member was also enthusiastic about coping with arsenic problems. Since Benagari has only 6 tube wells, it would be impossible to collect enough water samples to understand the hydro-geological conditions in the area (The JICA Study Team plans to sample water from about 200 tube wells for arsenic analysis). Because Bara Dudpatila has a larger number of patients, the JICA Study Team tentatively selected Bara

Dudpatila for the Model Rural Area for Chuadanga.

(b) Jessore

According to the existing information, there are 20 villages where arsenic patients have been reported in Jessore. In Samta where the largest number of patients was reported in Jessore, AAN has tested arsenic concentration of tube wells. In Marua, G.U.S. has tested arsenic concentration of tube wells in two *Paras* and provided two arsenic removal buckets through the route of NGO Forum. In Bagachura DPHE drilled deep wells to provide arsenic safe water. Ganganandapur and Sagrpur were covered by the UNICEF project to test all the tube wells, diagnose patients, and provide arsenic removal equipment and/or facility to use surface or rain water. In Rajnagar Bankabarsi, DPHE drilled one deep tubewell at the periphery of the village (see Table 6.1.2b).

Since it seems that no effective mitigation measures have been taken in Marua and Rajnagar Bankabarsi, the JICA study team visited the villages and found that a truck carrying drilling machines is accessible to the villages. The JICA Study Team also learnt that a teacher in Rajnagar Bankabarsi is enthusiastic about coping with arsenic problems in his village and that a local NGO (Kapatakha Memorial Mohila Shangsta) working in Rajnagar Bankabarsi to promote informal educational programs expressed their cooperation to help villagers tackle arsenic problems. Therefore, the JICA Study Team narrowed it down to two prospects for the Model Rural Area in Jessore: Marua and Rajnagar Bankabarsi.

(c) Jhenaidah

According to the existing information, there are seven villages where arsenic patients have been reported in Jhenaidah. In Majdia, AAN and Goriber Ashroy have been working to assist the village in establishing an arsenic prevention committee, diagnosing patients and testing arsenic concentrations of tube wells and are planning to build a pond sand filter. In Achintyanagar, AAN and AID have been working to assist the villagers, and there is a plan to build a pond sand filter with the help of NGO Forum. In Krishna Chandrapur, DPHE drilled one deep well with a depth of 460 feet (see Table 6.1.2c).

When the JICA Study Team visited Krishna Chandrapur in August 2000, it found the arsenic concentration of the deep well to be 0.2mg/l by the AAN field kit. The JICA Study Team also found that a truck carrying drilling machines is accessible to the villages and that a local NGO (AID) expressed their interest in helping Krishna Chandrapur to cope with arsenic problems. Therefore, the JICA Study Team tentatively selected Krishna Chandrapur for the Model Rural Area for Jhenaidah.

2) Selecting Model Rural Area in Each District

After tentatively selecting four villages (one in Chuadanga and Jhenaidah, and two in Jessore), the JICA Study Team considered the geographical distribution of the tentative Model Rural Areas. The criterion to select the Model Rural Areas within the study area (the three Districts) is that three Pourashavas and three Model Rural Areas where hydro-geological information is collected through drilling of deep wells and core boring represent geological characteristics of the study area. The three Pourashavas are located in the Thanas having the District name (Chuadanga Sadar, Jhenaidah Sadar, and Jessore Sadar).

Geographical distribution of the three Pourashavas and the four prospective villages for Model Rural Areas suggests that Marua is located on the line between Krishna Chandrapur and the Pourashava in Jessore Sadar. It also suggests that selecting Rajnagar Bankabarsi for the Model Rural Area in Jessore would enable us to collect hydrogeological information in a wider area. Since the three Pourashavas and Bara Dudpatila, Krishna Chandrapur, and Rajnagar Bankabarsi appear to represent the geological characteristics, they are confirmed as Model Rural Areas.

6.1.5 Features of the Model Rural Areas

Based on the existing information including the results of the JICA Study Team activities up to February 2001, features of the selected villages for Model Rural Area are summarized in Table 6.1.3, and so are socioeconomic conditions based on the interviews with villager leaders in Table 6.1.4.

Reference

BBS 1994. *Population Census 1991*.

DCH (Dhaka Community Hospital) (2000): *Arsenic in Bangladesh: Report on the 500-Village Rapid Assessment Project*.

JICA experts (Naoaki Shibasaki, Kazuyuki Suenaga, Kazuro Bando) (2000): “Activity Report of JICA Expert Team in DPHE for Arsenic Mitigation.”

SOES and DCH (School of Environmental Studies, Jadapur University, and Dhaka Community Hospital) (2000): *Groundwater Arsenic Contamination in Bangladesh: Summary of 239 days field survey from August 1995 to February 2000, Twenty seven days detailed survey information from April 1999 to February 2000*.

Table 6.1.2a List of Prospective Villages for Model Rural Area in Chuadanga

Upazila	Union	Mauza/Village	# of Patients	Mitigation Activity	Model Rural Area	Reference
Damurhuda	Howli	Dudpatila/Bara Dudpatila	100-205	No	Selected	JICA, JICA Expert
Alomdanga	Nagbana	Nagbana/Benagari	97	No		DCH*
Alomdanga	Baradi	Notidanga	75	No		JICA Expert
Alomdanga	Nagbana	Shayghoria/Takpara	56	No		DCH*
Damurhuda	Joranpur	Goimapur/Ramnagar	20-30	No		JICA Expert
Chuadanga	Begampur	Jhajri	18-22	No		JICA, JICA Expert
Damurhuda	Kuralgachhi	Kuralgachhi	1	No		JICA

Notes: *DCH = Dhaka Community Hospital

Table 6.1.2b List of Prospective Villages for Model Rural Area in Jessore

Upazila	Union	Mauza/Village	# of Patients	Mitigation Activity	Model Rural Area	Reference
Sharsha	Bagachara	Samta	363	AAN**		JICA
Chaugachha	Jaradishpur	Marua	59(22)*	GUS**		JICA
Sharsha	Bagachara	Bagachara	15-20	DPHE		JICA Expert
Jikharagacha	Ganganathpur	Ganganandapur	14-20	UNICEF		SOES**/ DCH, JICA Expert
Jikharagacha	Ganganathpur	Sagarpur	1-10	UNICEF		JICA, AAN
Keshabpur	Panjia	Rajnagar Bankabarsi	8(6)*	No	Selected	JICA Expert
Abhaynagar	Prembar	Prembar	6	No		JICA Expert
Keshabpur***	Bidyanandakati	Hijaldanga	5	No		DCH
Chaugachha	Paulsara	Aradaha	4	No		JICA
Abhaynagar	Mahakal	Pombhag	2	No		JICA
Keshabpur	Mangalkot	Panchri	2	No		JICA
Manirampur	Jhanpa	Jhanpa	2	No		JICA Expert
Manirampur	Mangalkot	Panchakoli	2	No		AAN
Chaugachha	Pashapole	Durali	1	No		JICA
Jessore Sadar	Churamankati	Asannagar	1	No		JICA
Manirampur	Dhakuria	Brahmapur	1	No		JICA
Manirampur	Kultia	Padmangthpur	1	No		JICA
Manirampur	Shyamkur	Sundalpur	1	No		JICA
Sharsha	Goga	Kalini	1	No		JICA
Sharsha	Goga	Goga	1	No		AAN

Notes: *Numbers of patients in the parenthesis are the original numbers reported, and those before the parenthesis are updated based on the information collected by the JICA study team in August 2000.
**AAN = Asian Arsenic Network, GUS = Grameen Unnayan Sangstha , SOES = School of Environmental Studies, Jadapur Univeresity, India
***DCH reported a number of patients in the following villages in Bidyanandakati Union, Keshabpur Upazila: Uttarchandipur (28), Dakhin Chandipur (62), Paschimchandipur (15), Purbachandipur (51), Farmaiskhana (28), Shungadhi (26); however, these villages could not be identified in the said Union nor said Upazila.

Table 6.1.2c List of Prospective Villages for Model Rural Area in Jhenaidah

Upazila	Union	Mauza/Village	# of Patients	Mitigation Activity	Model Rural Area	Reference
Kaliganj	Baro Bazar	Gram Majdia/ Majdia	76-100	AAN		AAN, JICA Expert, JICA
Jhenaidah	Padmakor	Achintyanagar	25-30	NGO Forum		SOES/DCH, JICA
Maheshpur	Fatehpur	Chandpur/Krishna Chandrapur	25+	(DPHE)*	Selected	JICA Expert
Kaliganj	Sunsarpur Durgapur	Kamlapur	3	No		JICA Expert
Maheshpur	Manderbari	Syamnagor	3	No		JICA
Harinakundu	Jouradah	Jouradah	1	No		JICA Expert
Harinakundu	Thearhuda	Bhabanipur	1	No		JICA Expert

Notes: *DPHE installed one deep tube well, but arsenic concentration of its water was 0.2mg/l by JICA study team's test using the AAN field kit as of August 2000.

Table 6.1.3 Features of Model Rural Areas

District	Chuadanga	Jessore	Jhenaidah
Thana	Damurhuda	Keshabpur	Maheshpur
Union	Howli	Panjia	Fatehpur
Mauza	Dudpatila	Rajnagar Bankabarsi	Chandpur
# of Villages in the Mauza (Other Villages)	2 (Chhota Dudpatila)	1	3 (Chandpur, Rakhal Bhoga)
Village	Bara Dudpatila	Rajnagar Bankabarsi	Krishna Chandrapur
Population	2,300	1,800	1,000
Pop. Density	High	High in the South, Medium in the North, Low in the Center	High in the North, Low in the South
# of Households	515	380	220
# of Paras	350	7	8
Land Use	Paddy field (periphery), farm land (in the village)	Paddy field and farm land in the North, ponds in the South	Paddy field (periphery), farm land (in the village)
# of Patients	73	23	45
# of Wells	175	74	115
Arsenic Level	n.d.-1.05mg/l	0.01-1.16mg/l	n.d.-1.21mg/l
Distribution of Arsenic Affected Wells	Concentrated in the center of the village (300m x 300m)	All over the village	Concentrated in the Center (300m x 200m) and the South (200m x 100m)
# of Ponds	Medium 5, Small 5	Large 50+	Large 3, Medium 3
Electricity	Available	Available	Not available
Access Road Condition	Unpaved for 2km from a paved road	Unpaved for 1km from a paved road	Unpaved for 2km from a paved road
Assisting NGO	ATMABISWAS	KMMS (Kapatakha Memorial Mohila Shangsta)	AID (Action In Development)
Note	One of the patients is Union Parishad Member and willing to share costs of mitigation measures.	One of the patients is school teacher.	DPHE installed one DTW, but arsenic concentration of the TW water was 0.2mg/l as of August 11, 2000.

Notes: Population and the number of households are estimated based on the results of the household interviews conducted as a part of this study. The number of arsenicosis patients is based on the diagnosis by Dr. Faruquee, and the number of wells and their arsenic levels are based on the results of the water quality survey as a part of this study.

Table 6.1.4 Socioeconomic Conditions of Model Rural Areas

		Chuadanga	Jessore	Jhenaidah
		Bara Dudpatila	Rajnagar Bankabarsi	Krishna Chandrapur
Religion		Islam	Islam	Islam (major) Hinduism
Roof materials	Straw	50%+	30%+	80%+
	Tile	None	50%+	None
	Tin	30%+	30%-	30%-
	Concrete	30%-	None	30%-
Daily diet (Other than rice, green leafy vegetables, and other vegetables)		Fish, Fruits	Fish, eggs, fruits	Beans
Community organization	Religious facility (years of experience)	Dudpatila Jame Mosque Committee (15)	Rajnagar Bankabarsi Paschmpara (45)	Sher Ali Secretary (6)
	School activity	School managing Committee (2)	None	Ahadul Rahman Secretary (5)
NGO activity	Knowledge dissemination	BRAC, WAVE	None	None
	Assistance to the poor/handicapped	BRAC, WAVE	ASA, BRAC	None
Major communication tool in the village		Community meeting	Loudspeaker	Person to person speech
Diffusion of mass media	Radio	80%+	50%+	50%+
	TV	30%-	30%-	30%-
	Newspapers	30%-	None	None
Water consumption (Liter/day)		50	50	60
Water source	Drinking	Shallow wells	Shallow wells	Shallow wells
	Cooking	Shallow wells	Shallow wells	Shallow wells
	Other	Shallow wells	Ponds	Shallow wells
# of wells for domestic use	Communal	50	6	46
	Private	250	100	174
Communal well (domestic use) management by caretakers		Repair of facility (not paid)	Repair of facility (some are paid, some are not paid)	Repair of facility (paid)
# of wells for agricultural use	Communal	0	0	100
	Private	30	120	0
	Operation hours	18	12	12
Communal well (agricultural use) management by caretakers		n.a.	n.a.	Monitoring water withdrawal, fee collection, repair of facility (paid)
Arsenic patients	# of Patients	100	n.a.	300
	Treated ratio	30%-	n.a.	50%+
Community attitude	Unfair treatment of patients	None	n.a.	Eating and drinking
Access to medical facility	Travel time	Less than 1 hour	Less than 1 hour	Less than 1 hour
	Travel costs	5Tk by rickshaw	20Tk by rickshaw	n.a.
Action taken by community		None	None	None

	Chuadanga	**Jessore**	**Jhenaidah**
	Bara Dudpatila	Rajnagar Bankabarsi	Krishna Chandrapur
Action taken by households	More than 80% of the households use arsenic safe wells	None	None

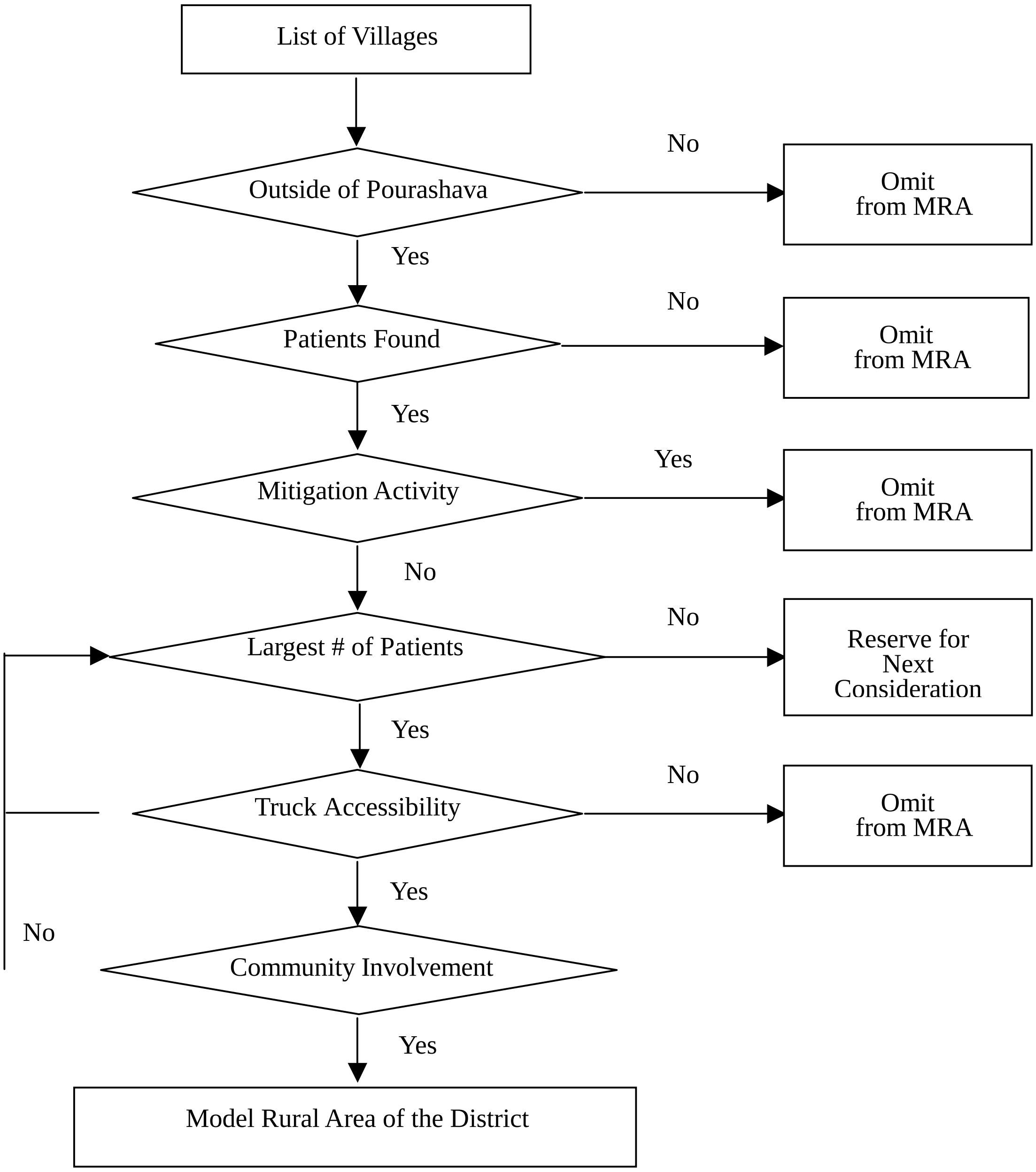


Figure 6.1.1 Process of Model Rural Area Selection within District

6.2 Overview of Socioeconomic Conditions in the Rural Areas

Based on the socioeconomic study carried out in June and July of the year 2000 as a part of the JICA study, interviews with local people, and existing information, socioeconomic conditions (of mainly villages) and its implications to arsenic problems are summarized in the following sections.

6.2.1 General Characteristics of the Villages in the Study Area

Characteristics of villages regarding population, religion, literacy, dietary habitat, and household income, and their implications to arsenic problems are summarized in Table 6.2.1.

Table 6.2.1 General Characteristics of the Villages and Their Implications to Arsenic Problems

	Characteristics	Implication to Arsenic Problems
Population	- Population is increasing - The average population of the villages is about 2500 to 3500, but the population size of villages has a wade range. - The average household size is about 5 to 6, but about 5% of the households has more than 11 family members (BBS, 1994).	- Potentially arsenic affected people are increasing. - A village with a small population may lack financial and human resources to cope with arsenic problems as a community. - The average arsenic removal equipment for one household should have a capacity to meet the water demand of 6 family members, and there should be variations to fit the demand of a large family.
Religion	- Islam is major religion, followed by Hinduism. - Muslims and other religious groups such as Hindus exist in one village	- Since women are not allowed to go to mosques, women may not be able to fetch water from arsenic safe wells located in mosques. - The purdah system, which discourages women to appear in the society, may prevent women from going to a doctor for diagnosis and treatment of arsenicosis. - A stratified society, which has the caste and the like, may discourage a village community to share arsenic safe wells among different social classes. - When more than one religious group exist in one village, special attention should be paid for coordinating them to cope with arsenic problems.
Literacy	- Adult (7 years +) literacy rate	- Oral communication and visual

	Characteristics	Implication to Arsenic Problems
Rate	is low (Chuadanga 25.2%, Jessore 38.8%, Jhenaidah 27.5% in 1991) (BBS, 1991). - Female literacy rate is lower than male (BBS, 1991).	presentation should be used to disseminate information about arsenic problems, especially when target population is female.
Diet	- Daily diet is mainly composed of rice and vegetables, and foods rich in protein are not consumed every day in most of the houses. - Wife usually eats after other family members finish meals. - Malnutrition is more prevalent in girls than in boys (UNICEF, 1999).	- Villagers may be in lack of protein and vitamins that help methylation of inorganic arsenic in the body. - Females might be more vulnerable to arsenicosis than males if they consume the same amount of arsenic contaminated water per body weight.
Income	- The average monthly income and expenditure of a household in rural area is 3,658Tk and 3,426Tk respectively in 1995-96 (nation wide) (BBS, 1998). - More than 85% of expenditure is essential to support daily life, such as food, clothing, housing, fuel and the like (BBS, 1998). - DPHE well users are getting water at free of charge.	- It would be difficult for the average household to pay extra 100 Tk per month for obtaining arsenic safe water.

6.2.2 Water Fetching and Consumption

Characteristics of villages regarding water fetching and consumption, and their implications to arsenic problems are summarized in Table 6.2.2.

Table 6.2.2 Water Fetching and Consumption Practices and its Implications to Arsenic Problems

	Characteristics	Implication to Arsenic Problems
Water Source	- Main source for drinking and cooking water is shallow wells, and the average number of users per well has a wide range (5 - 500) by village. - For bathing and washing, shallow wells, ponds, and rivers are used. - Rainwater is not utilized.	- A priority for mitigation activity should be given to arsenic contaminated wells with larger number of users. - Rainwater harvesting would be a viable option to get arsenic safe water for villages that have no arsenic safe wells.
Water Fetching	- Wives are mainly in charge of water fetching - Water containers are carried in women's hand or by handcart. - Women often suffer from back pain and other problems due to	- Women's opinion should be reflected to developing measure to provide arsenic safe water. - Arsenic safe water sources should be designed and located so that women's workload of

	Characteristics	Implication to Arsenic Problems
	lifting and carrying filled pitchers (Ahmed, 2000).	water fetching would be reduced.
Water Consumption	- Estimated average water consumption for drinking and cooking for a household with 6 family members is about 70 to 80 liters per day (this number includes water for washing dishes and utensils).	- Actual water consumption for drinking and cooking excluding washing dishes and utensils would be less than 70 to 80 liters per day for a household with 6 people.
Maintenance of Wells	- Few villages have experiences in managing communal wells for domestic water use by establishing a community organization and by contributing their financial resources to compensate caretakers for their services and recover repair costs, but some have in managing agricultural communal wells. - Most of the villages have their own community organizations to manage religious facilities and/or discuss school activities. - Several local and national NGOs are active in the villages in the field of disseminating knowledge about nutrition and sanitation and assisting poor and handicapped.	- Although most of the villages do not have experiences to mange communal wells for domestic water use, they could make use of their experiences in other fields and assistance from NGOs for organizing villagers to cope with arsenic problems.

6.2.3 Arsenic Problems

Characteristics of villages regarding arsenic problems and their implications to mitigation measures are summarized in Table 6.2.3.

Table 6.2.3 Characteristics of Arsenic Problems and their Implications to Mitigation Measures

	Characteristics	Implication to Mitigation Measures
Arsenic Patients	- Total number of patients would be at least 1,157 in the study area, and many patients have been found in Sharsha, Damurhda, Alamdanga, and Jikargacha Thanas (JICA experts, 2000). - Since all the villages and Pourashava have not been	- Priority for implementing mitigation measures should be given to the areas with high concentration of patients. - Diagnosis of patients should be carried out in the areas with high concentration of arsenic in groundwater. - An experienced female worker

	Characteristics	Implication to Mitigation Measures
	screened for arsenic patients, actual number of the patients cannot be identified. - Some households do not allow outsiders (especially male workers) to examine their womenfolk, particularly unmarried girls (DCH, 2000). - Misdiagnosis of arsenic patients has enormously disturbed their social lives (SOES and DCH, 2000).	should be in the diagnosis team to have an access to households and to correctly screen woman for signs of arsenicosis.
Community Attitudes toward Arsenic Patients	- Village leaders are aware of visible symptoms of arsenic poisoning, but not all the leaders. - In some villages, arsenic patients are unfairly treated on the occasions such as going to school and getting married.	- Priority for dissemination of information about arsenic problems should be given to the areas with high arsenic contamination. - Educational programs should include a component to alleviate the unfair treatment of arsenic patients in the community.
Actions by Residents	- Most of the villages with many patients have held community meetings and took mitigation measures with the help of NGOs while villages with a few patients are not active in taking community actions. - At household level, some actions to obtain arsenic water or reduce arsenic concentration of water have been taken but are quite limited in ratio of the households.	- It would be useful to carry out case studies on the villages having taken community actions in order to identify factors that contributed to and hindered from the successful community actions.
Actions by NGOs	- Several local and national NGOs are active in assisting villagers to cope with arsenic problems such as arsenic test of well water, information dissemination, and diagnosis of patients. - These NGOs are also working on other issues in the villages.	- These NGOs would provide precious inputs for developing the master plan to cope with arsenic problems. - The NGOs currently working on other issues in the villages have potentials to expand their activities to assisting the villagers to cope with arsenic problems.

Reference

Ahmed, M. Feroze (2000): "Possible Solutions to Water Supply Problems in Bangladesh," in *World Water Day Seminar 2000: Water for the 21st Century: Bangladesh Perspective*.

BBS (Bangladesh Bureau of Statistics) (1998): *Household Expenditure Survey 1995-96*.

BBS (1994): *Population Census 1991*.

DCH (Dhaka Community Hospital) (2000): *Arsenic in Bangladesh: Report on the 500-Village Rapid Assessment Project*.

JICA experts (Naoaki Shibasaki, Kazuyuki Suenaga, Kazuro Bando) (2000): "Activity Report of JICA Expert Team in DPHE for Arsenic Mitigation."

SOES and DCH (School of Environmental Studies, Jadapur University, and Dhaka Community Hospital) (2000): *Groundwater Arsenic Contamination in Bangladesh: Summary of 239 days field survey from August 1995 to February 2000, Twenty seven days detailed survey information from April 1999 to February 2000*.

UNICEF (1999): *Progotir Pathey: Achieving the Goals for Children in Bangladesh*.

6.3 Water Quality

6.3.1 Groundwater Quality

1) Survey Method

In the model rural areas, groundwater quality of all the existing tube wells was investigated by the Study Team. Figures 6.3.1 to 6.3.3 show the location of existing tube wells in Bara Dudpatila village, Krishna Chandrapur village and Rajnagar Bankabarsi village, respectively. As of October 2000, there are 172 tube wells in Bara Dudpatila, 115 wells in Krishna Chandrapur, and 74 in Rajnagar Bankabarsi.

During the field survey in October 2000, groundwater samples from the existing wells were collected for the arsenic analysis by the AAS in Jhenaidah Laboratory. At the time of the groundwater sampling, groundwater quality including arsenic was tested in the field. The tested parameters in the field and their methods are shown below:

① Arsenic (AAN Field Kit)

② Dissolved iron, Fe^{2+} (Fe^{2+} pack test kit)

③ pH (potable pH meter)

④ Oxidation-reduction potential, ORP (potable ORP meter)

⑤ Electric conductivity, EC (potable EC meter)

In the field survey, 5 groundwater samples for general water quality analysis were collected from each model village.

In addition, groundwater sampling and field water quality measurements were also carried out in December 2000. The numbers of collected/measured samples were 113 in Bara Dudpatila, 76 in Krishna Chandrapur and 50 in Rajnagar Bankabarsi. The reason for the second sampling and measurement carried out in December 2000 was to compare the groundwater quality just after the unusual flooding occurred in September to October 2000 with the groundwater quality three months after the flooding.

Tables 6.3.1 to 6.3.3 show the results of groundwater quality measurements including arsenic analysis by AAS in October 2000 in the model villages. Tables 6.3.4 to 6.3.6 show the results of the measurements/analysis in December 2000.

2) Arsenic

(a) Arsenic concentration by AAS

Figure 6.3.4 summarizes the results of arsenic analysis by AAS in the model rural areas. The results show that the degree of arsenic contamination in the existing wells varies by village. About 2/3 of the wells in Bara Dudpatila are contaminated by arsenic. In Krishna Chandrapur, about 3/4 of the wells are contaminated. Most of the tube wells in Rajnagar Bankabarsi village are contaminated by arsenic.

In Bara Dudpatila village, about 20% out of 172 existing wells show arsenic concentrations below 0.01 mg/l, which is the WHO guideline value. The wells having As concentrations between 0.01 and 0.05 mg/l are 15.7% of the total wells. Therefore, 35.5% of the wells satisfy the Bangladeshi drinking standard of 0.05 mg/l. On the other hand, 1.16% of the wells have As concentrations more than 1.0 mg/l. 12.79% of the wells have 0.5 to 1.0 mg/l in As concentration. The wells having As concentrations of 0.1 to 0.5 mg/l are major in the village, occupying 36.63% to the total.

In Krishna Chandrapur, 9.57% of the total of 115 wells show arsenic concentrations within 0.01 mg/l. The percentage of the wells having 0.01 to 0.05 mg/l in As concentration is 15.65%. Therefore, 25.27% of the total wells have As concentrations within the Bangladesh standard value. On the other hand, there is one (1) well having more than 1.0 mg/l of As. 26.96% of the wells have As concentrations between 0.5 and 1.0 mg/l. 38.26% of the wells having 0.1 to 0.5 mg/l in As concentration represent the majority in the village.

In Rajnagar Bankabarsi village, there is only one well showing an As concentration less than 0.05 mg/l. The well is a deep tube well drilled by DPHE. The rest of the wells are shallow wells contaminated with arsenic. There is no well showing more than 1.0 mg/l of As, however, 53.42% of the wells show As concentrations between 0.5 and 1.0 mg/l. The wells having 0.1 to 0.5 mg/l in As concentration occupy 42.47% to the total.

(i) Bara Dudpatila village

Figure 6.3.5 shows the arsenic concentration map of the village in October 2000. The highly contaminated zone with more than 0.5 mg/l is distributed in the central to the northern part of the village. On the other hand, less contaminated areas with less than 0.05 mg/l are found in the western part, southern part, and eastern part of the village. In the western part of the village, the groundwater is almost free of arsenic, showing less than 0.01 mg/l in As concentration.

Figure 6.3.6 shows the arsenic concentration map in December 2000. Compared with the map in October, the area of highly contaminated zone has become small. However, the general distribution pattern of contaminated area and less contaminated area is almost same.

Figure 6.3.7 shows the changes in arsenic concentration in the village between October and December 2000. The As concentration has significantly decreased at 0.1 to 0.7 mg/l in the highly contaminated zone. In the rest of the area, the absolute values of changes in As concentration are small.

Therefore, a map showing change rate of the arsenic concentrations from October to December 2000 has been prepared. It is clearly shown that the As decreased areas are located in the central, western and eastern part of the village. In those areas, the change rate ranges from 0.67 (1/1.5 times) to 0.5 (1/2 times). On the other hand, the As increased areas are located in the eastern part of the village and in the central area surrounding the highly contaminated zone. Although the groundwater levels have not been monitored in the village, it is presumed that the groundwater levels have declined from October to December due to the dry season. The changes in As concentration indicate that the irregular distribution of As concentration in the rainy season tends to flatten in the dry season as groundwater levels go down.

(ii) Krishna Chandrapur village

Figure 6.3.9 shows the arsenic concentration map of the village in October 2000. The highly contaminated zone with more than 0.5 mg/l is distributed in the northern part and the eastern part of the village. The less contaminated area with less than 0.05 mg/l in As concentration are found in the western part. The As concentration in the southern part ranges from 0.1 to 0.2 mg/l.

In December 2000, the As concentrations in the northern to central parts of the village have decreased. The highly contaminated zone with more than 0.5 mg/l in the northern part has been disappeared. But the general distribution pattern of As concentration in December 2000 is similar to that in October 2000.

Figure 6.3.11 shows the changes in As concentration between the two periods. The As concentrations in the northern part to central part decreased at 0.1 to 0.7 mg/l. On the other hand, the concentrations in the eastern part and southern part of the village increased 0.1 to 0.2 mg/l.

Figure 6.3.12 shows the change rate of As concentration from October to December 2000. The change rate in the northern part and central part ranges from 0.8 (1/1.25 times) to 0.5 (1/2 times). In the western part and southern part of the village, the rate ranges 1.5 to 2 times.

(iii) Rajnagar Bankabarsi village

Figure 6.3.13 shows the arsenic concentration map of the village in October 2000. There is no arsenic safe shallow tube well in the village. The highly contaminated groundwater with more than 0.5 mg/l of As is distributed in wide areas from the central to southern parts and western part of the village. In the eastern part, the As concentrations range from 0.1 to 0.2 mg/l.

Figure 6.3.14 shows the arsenic concentrations in December 2000. The As concentrations in the central part of the village are now below 0.5 mg/l, but the concentrations in the western part and southern part show more than 0.5 mg/l. It seems that the highly contaminated zone with more than 0.5 mg/l moved to west.

Figure 6.3.15 shows the changes in As concentration between October and December 2000. The concentrations decreased 0.2 to 0.5 mg/l in the central to eastern part of the village. On the other hand, in the western part and southern part the As concentrations increased 0.2 to 0.5 mg/l.

Figure 6.3.16 shows the change rate of As concentration. In the central to eastern part, the change rate ranges from 0.667 (1/1.25 times) to 0.5 (1/2 times). The change rate in the northern, western and southern part ranges from 1.25 to 2 times.

(b) Arsenic concentration by FK

The As measurement by the AAN Field Kit was carried out when the groundwater samples were collected in October and December 2000.

Figure 6.3.17 shows the As concentration map of Bara Dudpatila village. Compared with the AAS results shown in Figure 6.3.5, the FK results show higher values of As concentrations in the central part and a wider area of less contaminated areas. The general distribution patterns of As concentration is similar to the AAS results, but the concentration value at each well sometimes differs greatly.

In Krishna Chandrapur, the FK results show good agreement with the results of AAS. The FK results show higher concentrations in the northern and eastern parts of village, and lower values in the west. However, there is a tendency that the FK results show smaller values of As in less contaminated areas and greater values in highly contaminated areas.

Figure 6.3.19 shows the As concentration map of Rajnagar Bankabarsi village based on the FK results. According the FK results, the groundwater in the western part and southern part is highly contaminated, showing a wider area than the AAS results. On the other hand, the FK results show smaller values in the eastern part.

Figure 6.3.20 shows the comparison of As concentrations measured by FK and AAS in the model rural areas. From the graph, it is understood that the FK results tend to show smaller values when the samples have less than 0.1957 mg/l of As concentration and to show higher values when the samples have more than 0.1957 mg/l by AAS. From the results, it can be said that the AAN Field Kit can be used for screening of detecting As contaminated areas in a village roughly, but there is a limitation for the field kit to quantify accurate values of As concentration.

3) Electric Conductivity (EC)

The electric conductivity was measured at each existing well in the model villages by potable EC meters. Figure 6.3.21 summarizes the results of EC measurements. In Bara Dudpatila village, 91 wells out of 172 wells show EC values between 50 and 75 mS/m. There are 56 wells having 75 to 100 mS/m. There is no well more than 150 mS/m of EC.

In Krishna Chandrapur, 62 wells out of 115 wells show EC values between 75 and 100 mS/m. Then there are 36 wells with EC from 50 to 75 mS/m.

The EC values of Rajnagar Bankabarsi are very much higher than those of Bara Dudpatila and Krishna Chandrapur. There are 24 wells out of 50 showing 250 to 275 mS/m in EC. There is no shallow well having less than 125 mS/m. The DPHE deep tube well has good groundwater having less than 75 mS/m of EC. It can be said that the shallow groundwater of Rajnagar Bankabarsi is influenced by saline water.

(i) Bara Dudpatila village

Figure 6.3.22 shows the EC map of the village in October 2000. The higher EC values ranging from 100 to 140 mS/m are distributed in the southwestern and southeastern part of the village where arsenic concentration is small. The areas are situated at relatively lower ground elevation. The EC values in the rest show 50 to 100 mS/m.

Figure 6.3.23 shows the EC map measured in December 2000. The brief distribution pattern is similar to October 2000, however, the area of higher EC values of more than 100 mS/m slightly increased towards the center of the village.

Figure 6.3.24 shows the changes in EC values between October and December 2000. In the central area, the EC values slightly increased from 0 to 17 mS/m. On the other hand, the EC values in the western and eastern parts decreased 10 to 30 mS/m.

(ii) Krishna Chandrapur village

Figure 6.3.25 shows the EC map of the village in October 2000. Most of the area has EC values less than 100 mS/m. There are some small areas having more than 100 mS/m in the western and southern parts of the village.

Figure 6.3.26 shows the EC map in December 2000. The area of the higher EC zone in the north-central area has been slightly expanded.

Figure 6.3.27 shows the changes in EC values between October and December 2000. The EC values increased in the western to central area at 10 to 30 mS/m. On the other hand, the values have been decreased 5 to 20 mS/m in the eastern, western, and southern parts of the village.

(iii) Rajnagar Bankabarsi village

Figure 6.3.28 shows the EC map of the village measured in December 2000. The EC values are higher than 200 mS/m except in the eastern part of the village. The EC values more than 260 mS/m are found in the central to northern part and southern part.

Figure 6.3.29 shows the EC map in February 2001. The higher EC values more than 260 mS/m are distributed from the central to northern parts and in the southern part of the village.

Figure 6.3.30 shows the changes in EC values from December 2000 to February 2001. There are some locally up or down of the EC values, however, the difference between the two (2) periods is almost negligible

4) Iron (Fe^{2+})

The iron (Fe^{2+}) concentrations were measured by the Iron Pack Test Kit. Although the accuracy of the measurements is limited, but the results show rough figures of iron concentration in the model villages. Figure 6.3.31 show the results of iron concentration measurements. In Bara Dudpatila village, there are 58 wells out of 172 having iron concentrations between 0.0 and 0.2 mg/l. The second largest group is the wells having 2 to 5 mg/l. In Krishna Chandrapur, 36 wells out of 115 have more than 10 mg/l of iron. Then, 33 wells have 5 to 10 mg/l and 19 wells have 2 to 5 mg/l. In Rajnagar Bankabarsi village, most wells have more than 2 mg/l of iron. 36 wells out of 73 have 5 to 10 mg/l.

(i) Bara Dudpatila village

Figure 6.3.32 shows the iron concentration map in October 2000. The distribution pattern is similar to that of As concentration. The higher iron concentration was found in the central area. On the other hand, the southwestern part and southeastern part of the village have smaller concentrations less than 0.2 mg/l.

Figure 6.3.33 shows the iron concentration map in December 2000. The area having more than 5 mg/l of iron expanded in the central area. But there is no significant change of general distribution patterns.

Figure 6.3.34 shows the changes in Fe^{2+} concentrations between October and December 2000. In the highly contaminated zone by iron, there are some fluctuations in iron concentrations. However, the concentrations did not change in the rest of the area.

(ii) Krishna Chandrapur village

Figure 6.3.35 shows the Fe^{2+} concentrations in October 2000. Most of the areas except for the western part of the village have more than 2 mg/l of iron. Fe^{2+} concentrations of more than 10 mg/l were found in the central and northern part.

Figure 6.3.36 shows the distribution of Fe^{2+} concentrations in December 2000. The brief distribution patterns are similar to that in October 2000, however, the concentration tends to slightly decrease.

Figure 6.3.37 shows that the concentration has decreased in the northern part to central part in the village. On the other hand, the concentrations have increased in the eastern and southern part of the village.

(iii) Rajnagar Bankabarsi village

There are no shallow wells having less than 1 mg/l of iron in October 2000. The concentrations more than 10 mg/l were found in the eastern part. The areas having more than 5 mg/l are widely distributed in the southern, eastern and northern parts of the village.

In December 2000, the Fe^{2+} concentrations were higher in the southern part as shown in Figure 6.3.39. However, the area having more than 5 mg/l has disappeared in the central area.

Figure 6.3.40 shows the changes in Fe^{2+} concentrations between October and December 2000. It is clearly shown that the concentrations from the central to northern part have decreased from 2 to 5 mg/l. On the other hand, the iron concentrations in the southern part of the village have increased.

5) pH

The pH values were measured at the site during the groundwater sampling. Figure 6.3.41 summarizes the results of measurement by village. The groundwater in Bara Dudpatila village has pH values from 7.0 to 7.5. There 55 wells out of 72 showing pH values between 7.2 and 7.3. In Krishna Chandrapur, 72 wells out of 115 have 7.1 to 7.2 in pH. The pH values of Rajnagar Bankabarsi show slight acidic water compared with the former two villages. Although 27 wells out of 73 shows 7.1 to 7.2 in pH, the pH values of most wells range from 6.8 to 7.3.

(i) Bara Dudpatila village

Figure 6.3.42 shows the pH map in October 2000. The values are higher in the northern part and lower in the south-central part. The pH values less than 7.1 are found in the south-central area where As concentrations are less. The high As zone in the central area of the village has pH values ranging from 7.1 to 7.3.

Figure 6.3.43 shows the distribution of pH values in December 2000. Higher pH values of more than 7.3 are found in the central part, southern part and western part of the village.

Figure 6.3.44 shows the changes in pH between October and December 2000. The pH values have increased 0.1 to 0.2 in the central area and western part of the village. On the other hand, the values decreased in the northeastern, eastern and southern parts. Particularly in the northeastern part, the pH values decreased 0.2 to 0.3.

(ii) Krishna Chandrapur village

Figure 6.3.45 shows the pH values in October 2000. Major parts of the village have pH values from 7.1 to 7.2. The values less than 7.1 are found at small areas in the northern part, central part and southern part.

In December 2000, the area having pH values less than 7.1 slightly expanded in the northern and central parts.

Figure 6.3.47 shows the changes in pH values between October and December 2000. In the central area, pH values have slightly decreased at the maximum of 0.23. On the other hand, pH values increased slightly in the northern part and southeastern part of the village.

(iii) Rajnagar Bankabarsi village

Figure 6.3.48 shows the pH map in October 2000. The values are high in the central area, showing 7.1 to 7.2. On the other hand, the pH values in the southern most area show less than 7.0.

In December 2000, the area having more than 7.1 in pH expanded in the central area. The pH values in the southern part are still below 7.0.

Figure 6.3.50 shows the changes in pH values between October and December 2000. Along the east-west main road, the pH values decreased slightly. The values in the south-central to eastern parts have slightly increased.

6) Oxidation-Reduction Potential (Eh)

The occurrence of Eh values in October 2000 is summarized in Figure 6.3.51. It is common in the 3 target villages that most Eh values are below 150 mV. In Bara Dudpatila, 80 wells out of 172 show Eh values from 50 to 100 mV. In Krishna Chandrapur, 80 wells out of 115 show Eh values between 50 and 100 mV. In Rajnagar Bankabarsi, 66 wells out of 73 show Eh values between 50 and 100 mV.

(i) Bara Dudpatila village

Figure 6.3.52 shows the Eh map in October 2000. The central area of the village where As concentration is higher has lower values of Eh, less than 75 mV. Higher Eh values of more than 200 mV are found in the western part and southwestern part of the village.

Figure 6.3.53 shows the Eh distribution in December 2000. In the central area, the Eh values decreased at –40 to –58 mV. The higher Eh zone was divided into two small areas in the southwestern part.

Figure 6.5.54 shows the changes in Eh between October and December 2000. The Eh values increased in the eastern half of the village and the southwestern part. On the other hand, Eh values declined in the central part and western part of the village.

(ii) Krishna Chandrapur village

Figure 6.3.55 shows the Eh map in October 2000. The Eh values from the central to southern parts of the village show less than 100 mV. Eh values more than 200 mV are found in the northern part.

In December 2000, the higher Eh values in the northern part disappeared as shown in Figure 6.3.53. However, small areas having more than 200 mV in Eh appeared in the western and southern parts.

Figure 6.3.57 shows the changes in Eh between October and December 2000. The map indicates that the Eh values in the northern part decreased more than 100 mV. On the other hand, the values in the central to southern parts slightly increased.

(iii) Rajnagar Bankabarsi village

The Eh values in October 2000 are shown in Figure 6.3.58. The values in the village are generally lower than 100 mV except one well.

Figure 6.3.59 shows the Eh values in December 2000. The Eh values from the central to the western parts declined and the areas having less than 0 mV appeared.

Figure 6.3.60 shows the changes in Eh between October and December 2000. In the central to western parts, the Eh values declined 40 to 120 mV. On the other hand, the Eh values in the eastern part increased at 40 to 100 mV.

7) General Parameters

Figure 6.3.61 shows the trilinear diagram of the shallow groundwater taken from the model villages. The diagram shows that the chemical composition of Bara Dudpatila water and Krishna Chandrapur water is similar. However, the chemical composition of Rajnagar Bankabarsi water is different from the others, characterized by high percentages of Cl and Na.

Figure 6.3.62 shows the Stiff diagram of shallow groundwater in Bara Dudpatila village. The five samples show a similar shape of the diagram, indicating the water is rich in Ca in cations and rich in HCO_3 in anions.

Figure 6.3.63 shows the Stiff diagram of shallow groundwater in Krishna Chandrapur. The chemical composition is similar to the Bara Dudpatila water, but the percentage of Mg in cations is slightly high.

The Stiff diagram of shallow groundwater in Rajnagar Bankabarsi is shown in Figure 6.3.64. The chemical composition is characterized by higher Na+K in cations and higer Cl in anions.

6.3.2 Pond Water Quality

1) Survey Method

Water samples from ponds in the model rural areas were collected in October 2000 to analyze arsenic concentration and general water quality parameters. From each model village, target ponds were selected considering the pond size, location, usage and availability in the dry season.

The location maps of the ponds are shown in Figures 6.3.65 to 6.3.67. The samples were collected from 2 ponds in Bara Dudpatila, 5 ponds in Krishna Chandrapur, and 20 ponds in Rajnagar Bankabarsi village.

At the time of sampling, pond water quality including arsenic was tested in the field. The tested parameters in the field and their methods are shown below:

① Arsenic (AAN Field Kit)
② Dissolved iron, Fe^{2+} (Fe^{2+} pack test kit)
③ pH (potable pH meter)
④ Oxidation-reduction potential, ORP (potable ORP meter)
⑤ Electric conductivity, EC (potable EC meter)

The arsenic concentrations were analyzed by the AAS in Jhenaidah laboratory.

2) Arsenic, EC, Fe^{2+} and Others

Figure 6.3.68 shows the arsenic concentration by AAS, EC, pH, Fe^{2+}, and Eh values at the ponds in Bara Dudpatila village. The As concentrations of both P-01 and P-02 are below 0.01 mg/l. The EC values are 27.8 mS/m and 10.7 mS/m, which are smaller than the shallow groundwater. The pH values of the ponds are higher than that of the groundwater. Iron was not detected with the iron pack test kit.

Figure 6.3.69 shows the pond water quality in Krishna Chandrapur. Among the 5 tested ponds, there are 3 ponds having As concentration above the WHO guideline value of 0.01 mg/l. The As concentrations are 0.011 mg/l in P-03, 0.013 mg/l in P-04, and 0.011 mg/l in P-05, respectively. These ponds are located in the central to southern parts of the village. The EC values of the tested ponds range from 13.2 to 42.8 mS/m. The pH values are generally higher than that of shallow groundwater, ranging from 7.60 to 8.56. Iron was not detected from the tested pond water. The Eh values are higher than the shallow groundwater, ranging from 252.5 to 308.0 mV

Figure 6.3.70 shows the results of pond water quality tests in Rajnagar Bankabarsi village. There are 9 ponds out of 20 showing arsenic concentration above 0.01 mg/l. These ponds are located in the western part, the central part and southern part of the village. The maximum As concentrations detected from the ponds are 0.02 mg/l at P-17. The EC values of pond water range from 29.2 to 99.4 mS/m, those are smaller than that of the shallow groundwater. The pH values are also higher, ranging from 7.11 to 8.58. Most of Eh values are more than 300 mV. There is only one pond having 0.2 mg/l in Fe^{2+} concentration with the pack test.

3) General Parameters

Figure 6.3.71 shows the trilinear diagram of pond water in the model rural areas. The samples of Bara Dudpatila and Krishna Chandrapur are plotted on the left marginal area of the diamond-shape graph, indicating that the water is rich in Ca +Mg in cations and rich in HCO_3 in anions. The pond water samples of Rajnagar Bankabarsi village are plotted in the central area of the diamond-shape graph. Compared with the other villages, the pond water of Rajnagar Bankabarsi is characterized by higher ratios of Na in cations and Cl in anions.

Figure 6.3.72 shows the Stiff diagram of pond water in Bara Dudpatila village. The sizes of the pond diagrams are smaller than the shallow groundwater, showing the amount of the dissolved major ions is smaller than that of the groundwater. However, the chemical composition of the pond water is similar to that of the shallow groundwater.

Figure 6.3.73 shows the Stiff diagram of Pond Water in Krishna Chandrapur. There are two types of chemical composition: one is Ca rich type in cations and the other is Na+K and Mg rich type. In anions, HCO_3 is dominant in anions.

Figure 6.3.74 shows the Stiff diagram of pond water in Rajnagar Bankabarsi. The diagrams show that the amount of dissolved major ions is much less than that of the shallow groundwater. In cations, Na is dominant in some samples. In anions, generally HCO_3 is dominant, however, some samples are rich in Ca and Na+K in anions.

From the results, it can be said that the As concentration and other major ions of the pond water are much less than those of the shallow groundwater. However, it should be noted that the pond water is very often contaminated with bacteria. Therefore, it is necessary to monitor and evaluate the quality and quantity of pond water for safe drinking water use.

Table 6.3.1 Groundwater Quality in Bara Dudpatila Village in October 2000 (1/3)

No.	Well	As by AAS (mg/l)	EC (mS/m)	pH (SU)	ORP (mV)	Fe^{2+} (mg/l)	Temp (deg-C)	Eh (mV)	As by FK (mg/l)
1	BS-CD-BD-EW-001	<0.0005	100.8	7.15	67	0	27.5	271.6	0
2	BS-CD-BD-EW-002	<0.0005	96.9	7.11	73	0	27.6	277.5	0
3	BS-CD-BD-EW-003	0.033	92.4	7.06	85	0	27.2	289.8	0
4	BS-CD-BD-EW-004	0.090	88.3	7.04	80	0.5	27.4	284.6	0.05
5	BS-CD-BD-EW-005	0.27	93.9	7.08	-48	2	27.2	156.8	0.09
6	BS-CD-BD-EW-006	0.80	88.3	7.2	-113	5	27.6	91.5	1
7	BS-CD-BD-EW-007	0.25	92.9	7.12	-86	0.5	27.2	118.8	0.9
8	BS-CD-BD-EW-008	0.27	92.6	7.14	-94	1	27.4	110.6	1
9	BS-CD-BD-EW-009	0.49	85.4	7.19	-129	10	27.9	75.3	1
10	BS-CD-BD-EW-010	0.51	92.5	7.09	-122	2	27.1	82.9	1
11	BS-CD-BD-EW-011	0.38	99.9	7.19	-110	0	27.6	94.5	0.2
12	BS-CD-BD-EW-012	0.088	63.7	7.28	-128	2	27.5	76.6	0.06
13	BS-CD-BD-EW-013	0.18	110.4	7.24	-108	0.5	27.1	96.9	0.2
14	BS-CD-BD-EW-014	0.10	107.3	7.19	-109	1	27.3	95.7	0.09
15	BS-CD-BD-EW-015	0.18	96.2	7.31	-127	2	27.2	77.8	0.5
16	BS-CD-BD-EW-016	0.21	92.6	7.08	-113	2	27.3	91.7	0.7
17	BS-CD-BD-EW-017	0.011	128.7	7.19	-116	0	27.7	88.4	0
18	BS-CD-BD-EW-018	0.0007	117.7	7.03	-89	0	27.6	115.5	0
19	BS-CD-BD-EW-019	0.012	123.5	7.19	-84	0.5	27.2	120.8	0
20	BS-CD-BD-EW-020	0.0008	129.4	7.02	-67	0	27.3	137.7	0
21	BS-CD-BD-EW-021	0.028	112.7	7.13	-70	0	27.7	134.4	0
22	BS-CD-BD-EW-022	0.0008	107.8	7.21	-74	0	27.7	130.4	0
23	BS-CD-BD-EW-023	<0.0005	111.8	7.22	-71	0	27.3	133.7	0
24	BS-CD-BD-EW-024	0.0083	72.5	7.38	-75	0	27.5	129.6	0
25	BS-CD-BD-EW-025	0.0008	78.4	7.14	-120	2	26.9	85.0	0
26	BS-CD-BD-EW-026	0.0005	49	7.36	-64	0	27.6	140.5	0
27	BS-CD-BD-EW-027	0.0017	56.2	7.38	-63	0	27.8	141.4	0
28	BS-CD-BD-EW-028	0.027	45.8	7.36	-78	1	27.4	126.6	0.05
29	BS-CD-BD-EW-029	0.0019	55.5	7.3	-90	0	27.6	114.5	0
30	BS-CD-BD-EW-030	0.00083	56.5	7.5	-103	0	27.7	101.4	0
31	BS-CD-BD-EW-031	0.00074	52.1	7.46	-90	0	27.3	114.7	0
32	BS-CD-BD-EW-032	0.00098	56.2	7.41	-86	0	27.2	118.8	0
33	BS-CD-BD-EW-033	0.0048	36.3	7.54	-97	0	28.3	107.0	0
34	BS-CD-BD-EW-034	0.034	59.1	7.32	-84	0	27.9	120.3	0
35	BS-CD-BD-EW-035	0.064	62.1	7.25	-80	0	27.3	124.7	0
36	BS-CD-BD-EW-036	0.0037	103.2	7.15	-75	0.5	27.7	129.4	0
37	BS-CD-BD-EW-037	0.22341	92.2	7.23	-80	0	27.3	124.7	0
38	BS-CD-BD-EW-038	0.0019	75.2	7.33	-92	0	27.4	112.6	0
39	BS-CD-BD-EW-039	0.0005	84.5	7.28	-89	0	27.7	115.4	0
40	BS-CD-BD-EW-040	0.0044	96.6	7.14	-79	0	27.6	125.5	0
41	BS-CD-BD-EW-041	0.0012	90.6	7.2	90	0	26.9	295.0	0
42	BS-CD-BD-EW-042	0.022779	69.8	7.27	84	1	26.8	289.1	0.01
43	BS-CD-BD-EW-043	0.11731	69	7.17	8	2	26.9	213.0	0.4
44	BS-CD-BD-EW-044	0.0018	84.3	7.19	55	0.5	26.9	260.0	0
45	BS-CD-BD-EW-045	0.0007	126.2	7.05	82	0	26.7	287.1	0
46	BS-CD-BD-EW-046	<0.0005	74.6	7.11	21	0	26.8	226.1	0
47	BS-CD-BD-EW-047	0.028	71.8	7.07	51	0	27.1	255.9	0.02
48	BS-CD-BD-EW-048	0.0011	120.5	7.04	41	0	26.9	246.0	0
49	BS-CD-BD-EW-049	0.20	68	7.33	-35	2	27.1	169.9	0
50	BS-CD-BD-EW-050	0.37	66.3	7.34	-90	10	27.1	114.9	0.02
51	BS-CD-BD-EW-051	0.29	66.4	7.18	-120	10	26.8	85.1	0.03
52	BS-CD-BD-EW-052	0.20	63.7	7.18	-135	10	26.8	70.1	0
53	BS-CD-BD-EW-053	0.21	72.5	7.2	-20	1	27.2	184.8	0.3
54	BS-CD-BD-EW-054	0.34	70.7	7.19	-145	5	27.2	59.8	0.01
55	BS-CD-BD-EW-055	0.23	71.5	7.18	-141	5	27.3	63.7	0.9
56	BS-CD-BD-EW-056	0.15	68.4	7.14	-144	5	27.1	60.9	0.07
57	BS-CD-BD-EW-057	0.56	70.2	7.12	-153	10	27.3	51.7	1
58	BS-CD-BD-EW-058	0.53	65.2	7.12	-148	10	28.3	56.0	1
59	BS-CD-BD-EW-059	0.45	67.3	7.18	-154	10	27.6	50.5	1
60	BS-CD-BD-EW-060	0.57	68.2	7.16	-153	10	27.4	51.6	0.7

Table 6.3.1 Groundwater Quality in Bara Dudpatila Village in October 2000 (2/3)

No.	Well	As by AAS (mg/l)	EC (mS/m)	pH (SU)	ORP (mV)	Fe^{2+} (mg/l)	Temp (deg-C)	Eh (mV)	As by FK (mg/l)
61	BS-CD-BD-EW-061	0.40	65.2	7.14	-150	10	27.5	54.6	0.6
62	BS-CD-BD-EW-062	0.68	63.2	7.17	-112	10	27	92.9	1
63	BS-CD-BD-EW-063	0.51	62.3	7.11	-120	10	27.1	84.9	0.8
64	BS-CD-BD-EW-064	0.81	62.2	7.19	-137	2	28.2	67.1	1
65	BS-CD-BD-EW-065	0.5243	74	7.13	-130	10	27.2	74.8	1
66	BS-CD-BD-EW-066	0.64	75.2	7.13	-149	10	26.8	56.1	1
67	BS-CD-BD-EW-067	0.57	75.2	7.1	-145	10	27	59.9	1
68	BS-CD-BD-EW-068	0.95	77.7	7.18	-133	10	26.9	72.0	1
69	BS-CD-BD-EW-069	0.46	94.2	7.04	-136	2	27	68.9	0.9
70	BS-CD-BD-EW-070	0.21	88.8	7.26	-143	1	26.7	62.1	0.5
71	BS-CD-BD-EW-071	0.19	69.6	7.24	-141	5	26.7	64.1	0.5
72	BS-CD-BD-EW-072	0.14	74.9	7.16	-121	0	26.6	84.2	0.5
73	BS-CD-BD-EW-073	0.24	66.3	7.24	-121	2	26.7	84.1	1
74	BS-CD-BD-EW-074	0.48	70.3	7.24	-136	2	26.8	69.1	0.5
75	BS-CD-BD-EW-075	0.38	67.2	7.25	-142	2	26.5	63.3	1
76	BS-CD-BD-EW-076	0.70	74.2	7.29	-151	0	26.5	54.3	0.9
77	BS-CD-BD-EW-077	1.1	66.2	7.26	-134	5	26.5	71.3	1
78	BS-CD-BD-EW-078	0.19	66.8	7.21	-86	0.5	26.6	119.2	0.3
79	BS-CD-BD-EW-079	0.13	65.3	7.18	-97	5	26.9	108.0	0.2
80	BS-CD-BD-EW-080	0.13	78.6	7.16	-102	0.5	26.4	103.4	0.1
81	BS-CD-BD-EW-081	0.083	84	7.29	-126	0.5	26.6	79.2	0.05
82	BS-CD-BD-EW-082	0.0006	96.8	7.17	-56	0	26.6	149.2	0
83	BS-CD-BD-EW-083	0.086	67.9	7.25	82	2	26.5	287.3	0.06
84	BS-CD-BD-EW-084	0.45	70.5	7.27	-69	0.5	26.7	136.1	0.6
85	BS-CD-BD-EW-085	1.0	73.5	7.2	-66	1	26.5	139.3	1
86	BS-CD-BD-EW-086	0.20	80.6	7.21	-75	0.5	26.6	130.2	0.5
87	BS-CD-BD-EW-087	0.31	73.1	7.22	-92	0.5	26.6	113.2	0.2
88	BS-CD-BD-EW-088	0.23	69.1	7.26	-108	2	26.7	97.1	0.8
89	BS-CD-BD-EW-089	0.59	68.4	7.24	-119	5	26.6	86.2	1
90	BS-CD-BD-EW-090	0.55	65.1	7.21	-134	5	26.6	71.2	0.9
91	BS-CD-BD-EW-091	0.45	63.9	7.23	-125	5	26.9	80.0	1
92	BS-CD-BD-EW-092	0.42	63.2	7.19	-130	5	26.8	75.1	1
93	BS-CD-BD-EW-093	0.63	64	7.22	-139	5	26.6	66.2	1
94	BS-CD-BD-EW-094	0.66	64.4	7.16	-137	5	26.7	68.1	1
95	BS-CD-BD-EW-095	0.59	64.9	7.12	-143	10	26.8	62.1	1
96	BS-CD-BD-EW-096	0.59	64.6	7.19	-144	5	26.7	61.1	1
97	BS-CD-BD-EW-097	0.72	62.4	7.22	-146	10	26.7	59.1	1
98	BS-CD-BD-EW-098	0.32	62.2	7.22	-143	5	26.7	62.1	0.9
99	BS-CD-BD-EW-099	0.53	64.3	7.2	-143	5	26.7	62.1	1
100	BS-CD-BD-EW-100	0.14	76.8	7.4	-4	2	27	200.9	0.3
101	BS-CD-BD-EW-101	0.22	67.7	7.36	-68	2	27.1	136.9	0.6
102	BS-CD-BD-EW-102	0.45	62.2	7.35	-93	2	27.1	111.9	0.9
103	BS-CD-BD-EW-103	0.31	76.4	7.27	-136	5	27.3	68.7	1
104	BS-CD-BD-EW-104	0.070	68.5	7.29	-108	1	27.2	96.8	0.03
105	BS-CD-BD-EW-105	0.045	71.5	7.31	-138	2	27.2	66.8	0.05
106	BS-CD-BD-EW-106	0.16	71.9	7.28	-120	10	27.2	84.8	0.7
107	BS-CD-BD-EW-107	0.38	58.2	7.27	-138	2	27.5	66.6	1
108	BS-CD-BD-EW-108	0.22	78.9	7.25	-134	0.5	26.9	71.0	0.6
109	BS-CD-BD-EW-109	0.093	84.1	7.32	-134	1	26.6	71.2	0.04
110	BS-CD-BD-EW-110	0.18	81.9	7.23	-125	0.5	26.6	80.2	0.5
111	BS-CD-BD-EW-111	0.11	87.3	7.27	-129	2	26.6	76.2	0.5
112	BS-CD-BD-EW-112	0.0057	124	7.24	-93	0	26.4	112.4	0
113	BS-CD-BD-EW-113	<0.0005	134.4	7.43	-123	0	26.9	82.0	0
114	BS-CD-BD-EW-114	0.019	75.7	7.38	-137	2	26.3	68.4	0.01
115	BS-CD-BD-EW-115	0.065	70.2	7.35	-136	2	26.6	69.2	0.03
116	BS-CD-BD-EW-116	0.052	80.3	7.37	-130	0.5	26.3	75.4	0.01
117	BS-CD-BD-EW-117	0.054	69.8	7.39	-127	0.5	26.7	78.1	0.03
118	BS-CD-BD-EW-118	0.023	93.5	7.18	-116	2	26.6	89.2	0.02
119	BS-CD-BD-EW-119	0.029	75	7.3	-122	0.5	26.7	83.1	0
120	BS-CD-BD-EW-120	0.030	65.7	7.36	-100	2	26.5	105.3	0.01

Table 6.3.1 Groundwater Quality in Bara Dudpatila Village in October 2000 (3/3)

No.	Well	As by AAS (mg/l)	EC (mS/m)	pH (SU)	ORP (mV)	Fe^{2+} (mg/l)	Temp (deg-C)	Eh (mV)	As by FK (mg/l)
121	BS-CD-BD-EW-121	0.068	78.6	7.28	-97	2	26.5	108.3	0.02
122	BS-CD-BD-EW-122	0.088	74	7.3	-40	2	26.4	165.4	0.02
123	BS-CD-BD-EW-123	0.092	95	7.02	-98	0.3	26.7	107.1	0.04
124	BS-CD-BD-EW-124	0.064	76.6	7.31	-118	0.5	26.6	87.2	0
125	BS-CD-BD-EW-125	0.070	67.8	7.3	-119	0.5	26.7	86.1	0.04
126	BS-CD-BD-EW-126	0.061	64.1	7.32	-119	0.5	26.9	86.0	0.01
127	BS-CD-BD-EW-127	0.10	52.3	7.32	-124	0	28.8	79.6	0.04
128	BS-CD-BD-EW-128	0.11	74.3	7.31	-87	0.2	27.3	117.7	0.04
129	BS-CD-BD-EW-129	0.25	84.3	7.29	-96	0.2	27.7	108.4	0.05
130	BS-CD-BD-EW-130	0.20	71.6	7.32	-87	0	27.1	117.9	0.06
131	BS-CD-BD-EW-131	0.15	81.3	7.31	-94	0	27.1	110.9	0.02
132	BS-CD-BD-EW-132	0.10	79.9	7.25	-83	0	27.3	121.7	0
133	BS-CD-BD-EW-133	0.074	91.5	7.33	-118	0.2	27.7	86.4	0.01
134	BS-CD-BD-EW-134	0.17	77.8	7.28	-107	0	27.1	97.9	0.05
135	BS-CD-BD-EW-135	0.055	77	7.37	-123	1	27.2	81.8	0.04
136	BS-CD-BD-EW-136	0.026	99.3	7.24	-82	0.2	28	122.2	0
137	BS-CD-BD-EW-137	0.023	93.9	7.19	-82	0	27.6	122.5	0
138	BS-CD-BD-EW-138	0.0010	102.3	7.19	-85	0	27.6	119.5	0
139	BS-CD-BD-EW-139	0.0070	101.4	7.3	-90	0	27.4	114.6	0
140	BS-CD-BD-EW-140	0.0082	125.9	7.14	-79	0	27.4	125.6	0
141	BS-CD-BD-EW-141	0.0054	99.8	7.27	-83	0	27.4	121.6	0
142	BS-CD-BD-EW-142	0.0092	103.2	7.24	-58	0	27.6	146.5	0
143	BS-CD-BD-EW-143	0.015	91.2	7.2	-49	0	27.6	155.5	0
144	BS-CD-BD-EW-144	0.053	83.1	7.17	-52	0	28.2	152.1	0
145	BS-CD-BD-EW-145	0.050	101.1	7.31	-61	0	28	143.2	0.03
146	BS-CD-BD-EW-146	0.041	58.9	7.56	-75	0	28	129.2	0
147	BS-CD-BD-EW-147	0.018	139.1	7.23	-50	0	27.7	154.4	0
148	BS-CD-BD-EW-148	0.14	80.6	7.43	-70	0	27.6	134.5	0.09
149	BS-CD-BD-EW-149	0.043	67.3	7.32	68	0	26.9	273.0	0
150	BS-CD-BD-EW-150	0.049	83.6	7.26	-68	0	27.6	136.5	0
151	BS-CD-BD-EW-151	0.037	66.5	7.2	8	0	26.8	213.1	0
152	BS-CD-BD-EW-152	0.050	65.7	7.4	-55	2	27.4	149.6	0.01
153	BS-CD-BD-EW-153	0.091	103.2	7.17	-74	0	27.5	130.6	0.04
154	BS-CD-BD-EW-154	0.64	63.1	7.51	-95	2	27.2	109.8	1
155	BS-CD-BD-EW-155	0.23	62.9	7.24	-123	5	26.8	82.1	0.4
156	BS-CD-BD-EW-156	0.33	66.6	7.2	-136	5	26.7	69.1	0.8
157	BS-CD-BD-EW-157	0.19	59.2	7.34	-97	2	26.1	108.6	0.4
158	BS-CD-BD-EW-158	0.089	64.3	7.35	-95	2	26.1	110.6	0.05
159	BS-CD-BD-EW-159	0.091	69.9	7.33	-111	2	26	94.6	0.1
160	BS-CD-BD-EW-160	0.17	67.1	7.42	-122	0.5	26.2	83.5	0.7
161	BS-CD-BD-EW-161	0.18	65.9	7.4	-108	2	25.9	97.7	0.3
162	BS-CD-BD-EW-162	0.16	61.8	7.38	-128	1	26.4	77.4	0.4
163	BS-CD-BD-EW-163	0.022	68.4	7.43	-60	2	25.8	145.8	0.02
164	BS-CD-BD-EW-164	0.046	70.2	7.3	-94	1	25.9	111.7	0
165	BS-CD-BD-EW-165	0.051	65.1	7.29	-99	0	25.9	106.7	0
166	BS-CD-BD-EW-166	0.14	86.6	7.18	-106	5	26.9	99.0	0.1
167	BS-CD-BD-EW-167	0.054	69.6	7.18	-8	0.5	27.1	196.9	0.02
168	BS-CD-BD-EW-168	0.19	91.8	7.08	-96	5	27.1	108.9	0.2
169	BS-CD-BD-EW-169	0.0098	68.2	7.31	80	0	26.8	285.1	0
170	BS-CD-BD-EW-170	0.034	70.2	7.07	68	1	27.2	272.8	0.01
171	BS-CD-BD-EW-171	0.044	66.6	7.17	42	1	27.1	246.9	0.02
172	BS-CD-BD-EW-172	<0.0005	68.5	7.32	84	0	26.8	289.1	0

Table 6.3.2 Groundwater Quality in Krishna Chandrapur Village in October 2000 (1/2)

No.	Well	As by AAS (mg/l)	EC (mS/m)	pH (SU)	ORP (mV)	Fe^{2+} (mg/l)	Temp (deg-C)	Eh (mV)	As by FK (mg/l)
1	BS-JD-CC-EW-001	0.077	103.5	7.05	-60	0	26.5	145.3	0
2	BS-JD-CC-EW-002	0.024	102.5	7.07	-56	0	26.7	149.1	0.01
3	BS-JD-CC-EW-003	0.020	81.8	7.06	-91	2	27.2	113.8	0.03
4	BS-JD-CC-EW-004	0.033	93.8	7.11	-130	5	27.3	74.7	0.02
5	BS-JD-CC-EW-005	0.037	85.8	7.17	-122	5	27.2	82.8	0
6	BS-JD-CC-EW-006	0.091	89.0	7.13	-132	5	27.0	72.9	0.01
7	BS-JD-CC-EW-007	0.042	91.0	7.12	-125	5	27.7	79.4	0
8	BS-JD-CC-EW-008	<0.0005	101.2	7.17	-93	0	27.5	111.6	0
9	BS-JD-CC-EW-009	0.0030	113.5	7.04	-91	0.2	27.4	113.6	0
10	BS-JD-CC-EW-010	<0.0005	101.7	7.04	-70	0	27.4	134.6	0
11	BS-JD-CC-EW-011	0.049	77.8	7.21	-134	2	27.5	70.6	0.01
12	BS-JD-CC-EW-012	0.015	95.3	7.14	-64	0	27.0	140.9	0
13	BS-JD-CC-EW-013	0.083	87.2	7.26	-134	2	27.4	70.6	0.03
14	BS-JD-CC-EW-014	0.087	75.6	7.19	-129	10	27.4	75.6	0.01
15	BS-JD-CC-EW-015	0.025	107.3	7.05	-103	0.2	26.8	102.1	0
16	BS-JD-CC-EW-016	0.0072	71.6	7.13	-114	1	26.9	91.0	0
17	BS-JD-CC-EW-017	0.060	95.7	7.15	-138	5	26.8	67.1	0.04
18	BS-JD-CC-EW-018	0.0087	101.0	7.11	-118	2	28.1	86.1	0
19	BS-JD-CC-EW-019	0.014	108.5	7.01	-118	5	27.2	86.8	0
20	BS-JD-CC-EW-020	0.090	80.0	7.14	-83	5	27.6	121.5	0.01
21	BS-JD-CC-EW-021	0.0078	78.6	7.15	-72	0	27.3	132.7	0
22	BS-JD-CC-EW-022	0.0007	107.1	6.91	-60	0	27.2	144.8	0
23	BS-JD-CC-EW-023	0.24	87.0	7.11	-52	2	27.0	152.9	0.05
24	BS-JD-CC-EW-024	0.0019	89.4	7.20	-78	0	27.5	126.6	0
25	BS-JD-CC-EW-025	0.025	91.7	7.18	-86	2	27.5	118.6	0
26	BS-JD-CC-EW-026	0.34	110.0	7.13	-113	2	27.4	91.6	0.09
27	BS-JD-CC-EW-027	0.11	87.1	7.18	-126	2	27.3	78.7	0.01
28	BS-JD-CC-EW-028	0.095	93.3	7.11	-80	2	27.2	124.8	0.03
29	BS-JD-CC-EW-029	0.017	108.8	7.09	42	1	27.1	246.9	0
30	BS-JD-CC-EW-030	<0.0005	106.5	7.16	-57	0	27.5	147.6	0
31	BS-JD-CC-EW-031	0.0006	105.8	7.16	-46	0	27.3	158.7	0
32	BS-JD-CC-EW-032	0.055	70.0	7.07	-98	0.5	27.9	106.3	0
33	BS-JD-CC-EW-033	0.029	87.0	7.13	-99	0.2	27.4	105.6	0
34	BS-JD-CC-EW-034	0.035	68.4	7.08	-99	0.2	27.4	105.6	0
35	BS-JD-CC-EW-035	0.14	79.5	7.05	-72	5	27.2	132.8	0.01
36	BS-JD-CC-EW-036	0.16	42.6	7.15	-120	10	27.5	84.6	0.06
37	BS-JD-CC-EW-037	0.27	90.8	7.23	-147	10	27.3	57.7	0.05
38	BS-JD-CC-EW-038	0.20	71.4	7.11	-139	5	27.3	65.7	0.2
39	BS-JD-CC-EW-039	0.14	70.2	7.23	-142	5	27.4	62.6	0.02
40	BS-JD-CC-EW-040	0.023	73.1	7.18	-84	0.5	27.3	120.7	0.01
41	BS-JD-CC-EW-041	0.14	64.5	7.23	-127	2	27.1	77.9	0.05
42	BS-JD-CC-EW-042	0.19	68.0	7.21	-112	1	27.2	92.8	0.07
43	BS-JD-CC-EW-043	0.15	65.0	7.15	-133	5	27.4	71.6	0.6
44	BS-JD-CC-EW-044	0.33	83.1	7.11	-132	5	27.1	72.9	0.6
45	BS-JD-CC-EW-045	0.28	81.9	7.14	-139	5	27.3	65.7	0.6
46	BS-JD-CC-EW-046	0.19	79.9	7.16	-147	5	27.2	57.8	0.3
47	BS-JD-CC-EW-047	0.19	81.1	7.16	-148	5	27.2	56.8	0.3
48	BS-JD-CC-EW-048	0.17	67.7	7.26	-146	2	27.1	58.9	0.5
49	BS-JD-CC-EW-049	0.046	142.0	7.27	-117	0.2	27.3	87.7	0
50	BS-JD-CC-EW-050	0.10	99.8	7.15	-41	1	27.2	163.8	0.02
51	BS-JD-CC-EW-051	0.52	80.9	7.20	-68	5	26.7	137.1	0.8
52	BS-JD-CC-EW-052	0.16	78.2	7.16	-128	5	27.0	76.9	0.3
53	BS-JD-CC-EW-053	0.52	85.2	7.06	-142	10	27.1	62.9	1
54	BS-JD-CC-EW-054	0.88	82.3	7.12	-135	10	27.2	69.8	1
55	BS-JD-CC-EW-055	0.27	73.3	7.23	-126	10	26.9	79.0	0.09
56	BS-JD-CC-EW-056	0.34	81.8	7.13	-50	10	26.8	155.1	0.9
57	BS-JD-CC-EW-057	0.45	80.0	7.12	-114	10	26.9	91.0	1
58	BS-JD-CC-EW-058	0.88	91.5	7.12	-130	10	26.7	75.1	0.8
59	BS-JD-CC-EW-059	0.63	89.5	7.06	-144	10	27.5	60.6	1
60	BS-JD-CC-EW-060	0.84	78.9	7.10	-144	10	26.7	61.1	1

Table 6.3.2 Groundwater Quality in Krishna Chandrapur Village in October 2000 (2/2)

No.	Well	As by AAS (mg/l)	EC (mS/m)	pH (SU)	ORP (mV)	Fe^{2+} (mg/l)	Temp (deg-C)	Eh (mV)	As by FK (mg/l)
61	BS-JD-CC-EW-061	0.10	83.9	7.19	-136	2	26.5	69.3	0.3
62	BS-JD-CC-EW-062	0.13	80.0	7.17	-132	20	26.9	73.0	0.3
63	BS-JD-CC-EW-063	0.19	83.9	7.14	-130	2	26.8	75.1	0.1
64	BS-JD-CC-EW-064	0.19	61.5	7.21	-148	5	26.5	57.3	0.1
65	BS-JD-CC-EW-065	0.50	81.2	7.18	-126	2	27.0	78.9	1
66	BS-JD-CC-EW-066	0.94	85.5	7.08	-143	10	27.0	61.9	1
67	BS-JD-CC-EW-067	0.69	77.6	7.16	-150	2	26.9	55.0	1
68	BS-JD-CC-EW-068	0.56	64.3	7.22	-128	0.5	27.3	76.7	1
69	BS-JD-CC-EW-069	0.95	78.5	7.09	-143	10	27.0	61.9	1
70	BS-JD-CC-EW-070	0.74	80.2	7.16	-145	10	27.1	59.9	1
71	BS-JD-CC-EW-071	0.50	89.0	7.02	-130	10	27.0	74.9	0.5
72	BS-JD-CC-EW-072	0.044	77.7	7.10	-110	10	27.1	94.9	0.04
73	BS-JD-CC-EW-073	<0.0005	159.6	7.02	-118	0	26.9	87.0	0
74	BS-JD-CC-EW-074	1.2	71.1	7.22	-126	10	27.0	78.9	0.5
75	BS-JD-CC-EW-075	0.47	72.6	7.18	-110	10	27.4	94.6	0.5
76	BS-JD-CC-EW-076	0.58	73.8	7.21	-130	5	27.5	74.6	0.6
77	BS-JD-CC-EW-077	0.84	92.4	7.06	-130	10	27.1	74.9	0.7
78	BS-JD-CC-EW-078	0.60	81.4	7.10	-120	1	27.1	84.9	1
79	BS-JD-CC-EW-079	0.52	87.3	7.20	-120	5	27.1	84.9	0.5
80	BS-JD-CC-EW-080	0.57	92.0	7.11	-110	5	27.2	94.8	1
81	BS-JD-CC-EW-081	0.63	94.1	7.08	-130	10	27.1	74.9	0.7
82	BS-JD-CC-EW-082	0.64	84.3	7.10	48	2	27.1	252.9	1
83	BS-JD-CC-EW-083	0.46	84.1	7.10	12	10	27.3	216.7	0.5
84	BS-JD-CC-EW-084	0.16	97.1	7.12	3	10	27.1	207.9	0.06
85	BS-JD-CC-EW-085	0.034	108.7	7.17	-3	10	27.2	201.8	0.03
86	BS-JD-CC-EW-086	0.049	87.0	7.20	-8	10	27.2	196.8	0.02
87	BS-JD-CC-EW-087	0.72	72.8	7.16	-110	10	27.4	94.6	1
88	BS-JD-CC-EW-088	0.85	68.8	7.22	-119	2	27.2	85.8	1
89	BS-JD-CC-EW-089	0.82	75.6	7.12	-113	10	27.4	91.6	1
90	BS-JD-CC-EW-090	0.86	73.7	7.14	-118	10	27.3	86.7	1
91	BS-JD-CC-EW-091	0.73	78.1	7.09	-123	10	27.2	81.8	1
92	BS-JD-CC-EW-092	0.12	67.7	7.20	-127	5	27.1	77.9	0.04
93	BS-JD-CC-EW-093	0.15	77.2	7.13	-110	10	27.6	94.5	0.09
94	BS-JD-CC-EW-094	0.74	75.6	7.15	-115	10	27.6	89.5	1
95	BS-JD-CC-EW-095	0.29	72.2	7.19	-115	10	27.4	89.6	0.05
96	BS-JD-CC-EW-096	0.74	73.2	7.15	-135	1	27.2	69.8	1
97	BS-JD-CC-EW-097	0.84	73.4	7.14	-127	5	27.4	77.6	1
98	BS-JD-CC-EW-098	0.53	69.8	7.19	-134	2	27.1	70.9	1
99	BS-JD-CC-EW-099	0.91	80.2	7.10	-142	10	27.5	62.6	1
100	BS-JD-CC-EW-100	0.65	88.8	7.05	-140	10	27.9	64.3	1
101	BS-JD-CC-EW-101	0.61	78.6	7.12	-138	10	27.6	66.5	1
102	BS-JD-CC-EW-102	0.39	79.9	7.12	-140	10	27.4	64.6	1
103	BS-JD-CC-EW-103	0.065	60.6	7.19	-142	5	27.4	62.6	0.03
104	BS-JD-CC-EW-104	0.14	83.9	7.03	-80	5	26.8	125.1	0.3
105	BS-JD-CC-EW-105	0.33	58.8	7.13	-52	2	26.7	153.1	0.6
106	BS-JD-CC-EW-106	0.29	58.4	7.15	-90	5	26.6	115.2	0.7
107	BS-JD-CC-EW-107	0.26	57.7	7.13	-101	1	26.4	104.4	1
108	BS-JD-CC-EW-108	0.17	53.0	7.15	-113	5	26.7	92.1	0.3
109	BS-JD-CC-EW-109	0.19	55.9	7.19	-126	5	26.7	79.1	0.2
110	BS-JD-CC-EW-110	0.09	57.4	7.49	-137	0	26.5	68.3	0.02
111	BS-JD-CC-EW-111	0.12	68.3	7.16	-121	5	26.8	84.1	0.07
112	BS-JD-CC-EW-112	0.18	60.6	7.15	-131	5	26.7	74.1	0.1
113	BS-JD-CC-EW-113	0.15	72.6	7.11	-132	5	26.5	73.3	0.06
114	BS-JD-CC-EW-114	0.20	55.0	7.15	-134	5	26.5	71.3	0.3
115	BS-JD-CC-EW-115	0.17	59.5	7.16	-138	5	26.6	67.2	0.1

Table 6.3.3 Groundwater Quality in Rajnagar Banlabarsi Village in October 2000 (1/2)

No.	Well	As by AAS (mg/l)	EC * (mS/m)	pH (SU)	ORP (mV)	Fe^{2+} (mg/l)	Temp (deg-C)	Eh (mV)	As by FK (mg/l)
1	BS-JS-RB-EW-001	0.33	266	7.09	-163	10	26.4	42.4	0.3
2	BS-JS-RB-EW-002	0.32	270	7.08	-129	5	26.3	76.4	0.3
3	BS-JS-RB-EW-003	0.26	268	7.00	-115	2	26.4	90.4	0.4
4	BS-JS-RB-EW-004	0.36	271	7.07	-140	5	26.4	65.4	0.2
5	BS-JS-RB-EW-005	0.16	266	7.16	-146	2	26.3	59.4	0.4
6	BS-JS-RB-EW-006	0.30	251	6.84	-134	10	26.4	71.4	0.03
7	BS-JS-RB-EW-007	0.44	140	7.12	-156	5	27.1	48.9	0.4
8	BS-JS-RB-EW-008	0.38	-	7.14	-166	10	27.2	38.8	0.3
9	BS-JS-RB-EW-009	0.42	259	7.16	-152	2	27.2	52.8	0.4
10	BS-JS-RB-EW-010	0.38	-	7.16	-136	2	27.2	68.8	0.3
11	BS-JS-RB-EW-011	0.15	-	7.12	-135	5	27.0	69.9	0.06
12	BS-JS-RB-EW-012	0.12	262	7.05	-131	5	27.1	73.9	0
13	BS-JS-RB-EW-013	0.097	208	6.97	-118	5	26.9	87.0	0.04
14	BS-JS-RB-EW-014	0.10	223	6.95	-120	5	26.9	85.0	0.01
15	BS-JS-RB-EW-015	0.12	257	7.06	-134	5	27.0	70.9	0.06
16	BS-JS-RB-EW-016	0.15	269	7.11	-137	5	26.9	68.0	0.07
17	BS-JS-RB-EW-017	0.012	62	7.82	40	0	29.1	243.4	0
18	BS-JS-RB-EW-018	0.33	258	7.17	-144	2	27.2	60.8	1
19	BS-JS-RB-EW-019	0.73	268	7.14	-137	2	26.6	68.2	0.8
20	BS-JS-RB-EW-020	0.71	262	7.12	-141	2	27.1	63.9	0.8
21	BS-JS-RB-EW-021	0.91	265	7.15	-136	5	26.5	69.3	0.9
22	BS-JS-RB-EW-022	0.46	264	7.09	-147	2	27.1	57.9	0.9
23	BS-JS-RB-EW-023	0.50	-	7.13	-149	5	27.0	55.9	0.9
24	BS-JS-RB-EW-024	0.37	-	7.05	-125	2	26.9	80.0	0.5
25	BS-JS-RB-EW-025	0.38	256	7.08	-145	2	27.0	59.9	0.8
26	BS-JS-RB-EW-026	0.38	-	7.18	-167	5	26.9	38.0	1
27	BS-JS-RB-EW-027	0.51	-	7.17	-142	2	26.8	63.1	0.8
28	BS-JS-RB-EW-028	0.52	271	7.07	-137	5	27.1	67.9	0.8
29	BS-JS-RB-EW-029	0.68	268	7.19	-143	2	27.2	61.8	0.8
30	BS-JS-RB-EW-030	0.61	264	7.20	-146	2	27.1	58.9	0.7
31	BS-JS-RB-EW-031	0.40	216	6.90	-130	5	26.6	75.2	0.9
32	BS-JS-RB-EW-032	0.89	200	6.89	-133	5	26.5	72.3	1
33	BS-JS-RB-EW-033	0.58	240	6.95	-146	10	26.6	59.2	0.8
34	BS-JS-RB-EW-034	0.82	245	6.95	-122	5	26.6	83.2	0.9
35	BS-JS-RB-EW-035	0.48	-	6.89	-119	5	26.5	86.3	0.8
36	BS-JS-RB-EW-036	0.54	-	6.83	-124	5	26.9	81.0	0.9
37	BS-JS-RB-EW-037	0.62	222	6.86	-125	5	26.8	80.1	0.7
38	BS-JS-RB-EW-038	0.69	292	7.07	-150	5	27.0	54.9	0.8
39	BS-JS-RB-EW-039	0.52	228	6.87	-134	5	27.4	70.6	0.6
40	BS-JS-RB-EW-040	0.41	-	6.87	-122	5	26.5	83.3	0.7
41	BS-JS-RB-EW-041	0.27	-	7.07	-134	10	27.0	70.9	0.9
42	BS-JS-RB-EW-042	0.59	239	6.95	-134	10	26.3	71.4	0.8
43	BS-JS-RB-EW-043	0.52	287	7.03	-143	5	26.9	62.0	1
44	BS-JS-RB-EW-044	0.53	297	7.24	-122	5	26.1	83.6	0.9
45	BS-JS-RB-EW-045	0.60	244	6.87	-98	5	27.7	106.4	1
46	BS-JS-RB-EW-046	0.71	250	6.99	-149	10	26.3	56.4	1
47	BS-JS-RB-EW-047	0.70	-	7.01	-135	10	26.8	70.1	1
48	BS-JS-RB-EW-048	0.59	-	7.09	-135	10	26.6	70.2	1
49	BS-JS-RB-EW-049	0.54	238	7.00	-135	5	26.4	70.4	0.9
50	BS-JS-RB-EW-050	0.60	273	7.03	-128	5	26.5	77.3	0.7
51	BS-JS-RB-EW-051	0.60	250	7.22	-128	5	26.6	77.2	0.3
52	BS-JS-RB-EW-052	0.52	281	7.24	-135	2	26.8	70.1	0.5
53	BS-JS-RB-EW-053	0.061	-	6.93	-125	2	26.7	80.1	0.02
54	BS-JS-RB-EW-054	0.57	281	7.25	-135	2	26.5	70.3	0.4
55	BS-JS-RB-EW-055	0.76	279	7.27	-128	10	27.6	76.5	0.09
56	BS-JS-RB-EW-056	0.57	276	7.13	50	10	26.8	255.1	0.1
57	BS-JS-RB-EW-057	0.47	270	7.12	-114	10	26.9	91.0	0.8
58	BS-JS-RB-EW-058	0.55	284	7.12	-130	10	26.7	75.1	0.6
59	BS-JS-RB-EW-059	0.33	241	7.06	-144	10	26.7	61.1	0.5
60	BS-JS-RB-EW-060	0.24	266	7.10	-144	10	26.9	61.0	1

Table 6.3.3 Groundwater Quality in Rajnagar Banlabarsi Village in October 2000 (1/2)

No.	Well	As by AAS (mg/l)	EC * (mS/m)	pH (SU)	ORP (mV)	Fe^{2+} (mg/l)	Temp (deg-C)	Eh (mV)	As by FK (mg/l)

Table 6.3.3 Groundwater Quality in Rajnagar Banlabarsi Village in October 2000 (2/2)

No.	Well	As by AAS (mg/l)	EC * (mS/m)	pH (SU)	ORP (mV)	Fe^{2+} (mg/l)	Temp (deg-C)	Eh (mV)	As by FK (mg/l)
61	BS-JS-RB-EW-061	0.40	280	7.19	-144	10	26.7	61.1	1
62	BS-JS-RB-EW-062	0.39	-	7.17	-132	2	26.9	73.0	0.1
63	BS-JS-RB-EW-063	0.70	280	7.14	-130	2	26.7	75.1	0.8
64	BS-JS-RB-EW-064	0.59	272	7.21	-148	5	26.6	57.2	0.6
65	BS-JS-RB-EW-065	0.66	276	7.21	-119	5	27.2	85.8	0.09
66	BS-JS-RB-EW-066	0.54	240	7.12	-110	5	27.7	94.4	0.03
67	BS-JS-RB-EW-067	0.74	277	7.19	-125	5	27.6	79.5	0.7
68	BS-JS-RB-EW-068	0.59	-	7.14	-132	5	27.8	72.4	0.07
69	BS-JS-RB-EW-069	0.50	285	7.09	-143	10	26.4	62.4	0.1
70	BS-JS-RB-EW-070	0.29	225	7.13	-133	5	26.4	72.4	0.4
71	BS-JS-RB-EW-071	0.47	271	7.21	-137	10	30.0	65.8	0.7
72	BS-JS-RB-EW-072	0.69	256	7.22	-126	5	26.9	79.0	0.5
73	BS-JS-RB-EW-073	0.81	274	7.13	-142	5	27.5	62.6	1
74	BS-JS-RB-EW-074		275						

*EC: EC values were re-measured in February 2001.

Table 6.3.4 Groundwater Quality in Bara Dudpatila Village in December 2000 (1/2)

No.	Well	As by AAS (mg/l)	EC (mS/m)	pH (SU)	ORP (mV)	Fe^{2+} (mg/l)	Temp (deg-C)	Eh (mV)	As by FK (mg/l)
1	BS-CD-BD-EW-001	0.0007	103.4	7.16	-40	0	25.8	165.8	0
2	BS-CD-BD-EW-002	<0.0005	102.6	7.22	-52	0	25.5	154.0	0
3	BS-CD-BD-EW-004	0.11	93.5	7.16	-55	1	25.9	150.7	0.02
4	BS-CD-BD-EW-005	0.12	99.3	7.15	-66	2	25.5	140.0	1
5	BS-CD-BD-EW-007	0.20	98.2	7.12	-210	0.5	25.7	-4.1	0.9
6	BS-CD-BD-EW-009	0.52	89.8	7.19	-248	2	25.5	-42.0	1
7	BS-CD-BD-EW-010	0.66	97.6	7.10	-103	2	25.7	102.9	1
8	BS-CD-BD-EW-011	0.099	117.3	7.19	-127	0	26.0	78.6	0.04
9	BS-CD-BD-EW-013	0.17	118.6	7.20	-148	0.5	25.8	57.8	0.2
10	BS-CD-BD-EW-014	0.12	111.5	7.22	-126	2	26.0	79.6	0.3
11	BS-CD-BD-EW-016	0.20	105.0	7.20	-126	1	25.7	79.9	0.5
12	BS-CD-BD-EW-017	0.014	129.4	7.15	-264	0	24.9	-57.6	0
13	BS-CD-BD-EW-019	0.012	119.8	7.18	56	0.5	22.3	264.3	0
14	BS-CD-BD-EW-020	<0.0005	128.2	7.00	-18	0	22.0	190.5	0
15	BS-CD-BD-EW-022	0.0007	108.3	7.18	-8	0	23.0	199.8	0
16	BS-CD-BD-EW-023	<0.0005	110.7	7.18	-52	0	22.4	156.2	0
17	BS-CD-BD-EW-025	<0.0005	72.8	7.12	24	2	22.4	232.2	0
18	BS-CD-BD-EW-026	<0.0005	49.0	7.28	-38	0	21.9	170.6	0
19	BS-CD-BD-EW-028	0.020	46.2	7.32	56	1	22.3	264.3	0
20	BS-CD-BD-EW-029	0.0030	54.5	7.31	12	0	22.6	220.1	0
21	BS-CD-BD-EW-031	0.0009	53.2	7.42	46	0	22.2	254.4	0
22	BS-CD-BD-EW-032	0.0007	58.2	7.36	48	0	22.1	256.5	0
23	BS-CD-BD-EW-034	0.042	58.1	7.31	32	0	22.3	240.3	0
24	BS-CD-BD-EW-035	0.016	62.4	7.25	-80	0	22.3	128.3	0
25	BS-CD-BD-EW-038	0.0009	74.6	7.31	-12	0	22.1	196.5	0
26	BS-CD-BD-EW-040	0.0005	95.1	7.17	-34	0	22.6	174.1	0
27	BS-CD-BD-EW-041	0.0007	89.7	7.16	63	0	22.9	270.9	0
28	BS-CD-BD-EW-043	0.14	71.2	7.18	-83	2	22.8	125.0	0.3
29	BS-CD-BD-EW-044	0.0010	88.2	7.09	86	0.5	23.0	293.8	0
30	BS-CD-BD-EW-046	0.0007	76.2	7.16	77	0	23.1	284.7	0
31	BS-CD-BD-EW-047	0.023	70.9	7.08	13	0	23.2	220.7	0.03
32	BS-CD-BD-EW-049	0.23	76.0	7.29	-47	5	25.2	159.2	0.5
33	BS-CD-BD-EW-050	0.33	70.7	7.22	-130	10	25.5	76.0	1
34	BS-CD-BD-EW-052	0.18	65.6	7.24	-135	10	24.8	71.5	0.05
35	BS-CD-BD-EW-053	0.23	75.3	7.15	-134	2	23.9	73.2	0.03
36	BS-CD-BD-EW-055	0.36	74.4	7.02	-123	2	24.4	83.8	1
37	BS-CD-BD-EW-056	0.13	69.7	7.23	-142	2	24.7	64.6	0.05
38	BS-CD-BD-EW-059	0.40	75.0	7.09	-128	10	25.5	78.0	1
39	BS-CD-BD-EW-060		70.7	7.20	-149	10	25.1	57.3	0.6
40	BS-CD-BD-EW-061	0.18	68.3	7.20	-115	10	24.0	92.1	0.4
41	BS-CD-BD-EW-062	0.63	66.5	7.22	-146	10	25.5	60.0	1
42	BS-CD-BD-EW-064	0.40	55.7	6.96	-53	5	19.8	157.1	1
43	BS-CD-BD-EW-065	0.35	78.8	7.17	-137	5	25.0	69.4	1
44	BS-CD-BD-EW-067	0.29	82.7	7.43	-128	10	25.5	78.0	1
45	BS-CD-BD-EW-068	0.72	84.6	7.24	-143	10	25.8	62.8	1
46	BS-CD-BD-EW-070	0.14	90.9	7.26	-132	0.5	24.5	74.7	0.3
47	BS-CD-BD-EW-071	0.12	70.1	7.32	-137	2	25.1	69.3	0.5
48	BS-CD-BD-EW-073	0.18	68.4	7.50	-149	1	24.9	57.4	1
49	BS-CD-BD-EW-074	0.44	73.4	7.29	-147	10	25.7	58.9	0.4
50	BS-CD-BD-EW-076	0.95	75.4	7.55	-137	0.5	24.8	69.5	1
51	BS-CD-BD-EW-077	0.40	70.7	7.46	-128	5	24.0	79.1	1
52	BS-CD-BD-EW-079	0.23	69.7	7.40	-111	2	25.0	95.4	0.06
53	BS-CD-BD-EW-080	0.090	78.4	7.20	-54	0.5	22.2	154.4	0.08
54	BS-CD-BD-EW-082	<0.0005	97.2	7.18	-64	0	22.4	144.2	0
55	BS-CD-BD-EW-083	0.30	68.3	7.23	-64	2	22.2	144.4	0.04
56	BS-CD-BD-EW-085	0.75	70.0	7.20	-50	1	22.4	158.2	1
57	BS-CD-BD-EW-086	0.25	83.8	7.54	-119	0.5	26.3	86.4	0.9
58	BS-CD-BD-EW-088	0.25	68.0	7.20	-90	2	22.4	118.2	0.9
59	BS-CD-BD-EW-089	0.33	70.3	7.30	-121	10	25.6	84.9	1
60	BS-CD-BD-EW-091	0.45	55.4	7.29	-138	10	25.6	67.9	1

Table 6.3.4 Groundwater Quality in Bara Dudpatila Village in December 2000 (2/2)

No.	Well	As by AAS (mg/l)	EC (mS/m)	pH (SU)	ORP (mV)	Fe^{2+} (mg/l)	Temp (deg-C)	Eh (mV)	As by FK (mg/l)
61	BS-CD-BD-EW-092	0.38	65.5	7.29	-98	10	25.9	107.7	0.7
62	BS-CD-BD-EW-094	0.30	55.3	7.29	-138	2	25.5	68.0	1
63	BS-CD-BD-EW-095	0.45	55.4	7.25	-131	5	26.0	74.6	1
64	BS-CD-BD-EW-097	0.53	53.8	7.07	-57	5	20.7	152.5	1
65	BS-CD-BD-EW-098	0.23	52.6	7.01	-52	5	20.3	157.8	0.09
66	BS-CD-BD-EW-100	0.16	76.7	7.34	-115	5	26.2	90.5	0.06
67	BS-CD-BD-EW-101	0.16	69.8	7.34	-133	2	25.7	72.9	0.2
68	BS-CD-BD-EW-103	0.36	80.8	7.26	-125	10	25.2	81.2	1
69	BS-CD-BD-EW-104	0.031	76.0	7.36	-136	0.5	26.2	69.5	0.03
70	BS-CD-BD-EW-106	0.18	72.6	7.00	-64	2	20.6	145.5	0.2
71	BS-CD-BD-EW-107	0.19	53.1	6.98	-54	5	20.4	155.7	1
72	BS-CD-BD-EW-109	0.13	80.0	7.30	-125	1	22.3	83.3	0.05
73	BS-CD-BD-EW-110	0.22	80.3	7.24	-119	0.5	22.6	89.1	0.6
74	BS-CD-BD-EW-112	0.0050	122.3	7.18	-58	0	22.2	150.4	0
75	BS-CD-BD-EW-113	0.0006	136.8	7.41	-119	0	22.3	89.3	0
76	BS-CD-BD-EW-115	0.060	70.6	7.31	-139	2	22.5	69.2	0.01
77	BS-CD-BD-EW-116	0.054	80.4	7.21	-120	2	22.4	88.2	0.02
78	BS-CD-BD-EW-118	0.017	92.6	7.15	-110	2	22.4	98.2	0
79	BS-CD-BD-EW-119	0.027	76.1	7.26	-118	1	25.6	87.9	0
80	BS-CD-BD-EW-121	0.065	76.4	7.26	-90	2	22.1	118.5	0.01
81	BS-CD-BD-EW-122	0.063	72.2	7.21	-36	2	22.4	172.2	0
82	BS-CD-BD-EW-124	0.022	75.8	7.29	-116	0.5	22.3	92.3	0
83	BS-CD-BD-EW-125	0.011	65.0	7.21	-100	1	25.0	106.4	0.06
84	BS-CD-BD-EW-127	0.11	52.1	7.31	-116	0	22.4	92.2	0
85	BS-CD-BD-EW-130	0.11	70.1	7.28	-42	0	24.1	165.0	0.04
86	BS-CD-BD-EW-131	0.15	80.6	7.34	-56	0	24.3	150.9	0
87	BS-CD-BD-EW-133	0.020	90.7	7.32	-117	0.5	22.3	91.3	0.01
88	BS-CD-BD-EW-134	0.21	76.5	7.23	-105	0	22.3	103.3	0
89	BS-CD-BD-EW-136	0.028	96.7	7.23	-52	0.2	23.6	155.4	0
90	BS-CD-BD-EW-137	<0.0005	94.5	7.16	-63	0	22.3	145.3	0
91	BS-CD-BD-EW-139	0.0033	98.0	7.21	-70	0	22.0	138.5	0
92	BS-CD-BD-EW-140	0.0007	120.0	7.10	-50	0	22.4	158.2	0
93	BS-CD-BD-EW-142	0.0060	105.1	7.26	-18	0	22.3	190.3	0
94	BS-CD-BD-EW-143	0.0072	44.0	7.11	-30	0	22.5	178.2	0
95	BS-CD-BD-EW-144	0.085	81.3	7.13	-50	0	23.2	157.7	0
96	BS-CD-BD-EW-145	0.062	98.4	7.25	-48	0	22.9	159.9	0.03
97	BS-CD-BD-EW-146	0.061	61.1	7.47	-30	0	24.6	176.7	0
98	BS-CD-BD-EW-148	0.26	60.1	7.32	-63	0	22.6	145.1	0.8
99	BS-CD-BD-EW-149	0.052	65.7	7.36	15	0	22.4	223.2	0
100	BS-CD-BD-EW-151	0.060	68.3	7.24	-15	0	23.9	192.2	0
101	BS-CD-BD-EW-152	0.072	63.6	7.32	-26	2	24.0	181.1	0.01
102	BS-CD-BD-EW-155	0.24	55.8	7.22	-139	10	25.8	66.8	0.3
103	BS-CD-BD-EW-156	0.26	64.3	7.37	-146	10	26.0	59.6	0.7
104	BS-CD-BD-EW-157	0.23	62.7	7.31	-138	10	25.4	68.1	0.7
105	BS-CD-BD-EW-161	0.25	57.3	7.03	-54	2	20.2	155.8	0.5
106	BS-CD-BD-EW-162	0.25	52.0	7.12	-60	5	19.8	150.1	0.6
107	BS-CD-BD-EW-163	0.033	68.4	7.41	-33	2	22.4	175.2	0
108	BS-CD-BD-EW-164	0.049	70.3	7.28	-63	0.5	22.4	145.2	0
109	BS-CD-BD-EW-166	0.25	38.6	7.34	-116	2	24.3	90.9	0.07
110	BS-CD-BD-EW-167	0.060	70.7	7.27	-147	2	25.0	59.4	0.05
111	BS-CD-BD-EW-169	0.013	77.2	7.22	-137	0	25.0	69.4	0
112	BS-CD-BD-EW-170	0.042	54.5	7.25	-129	0	23.6	78.4	0
113	BS-CD-BD-EW-172	0.0019	69.2	7.49	-122	0	23.7	85.3	0

Table 6.3.5 Groundwater Quality in Krishna Chandrapur Village in December 2000 (1/2)

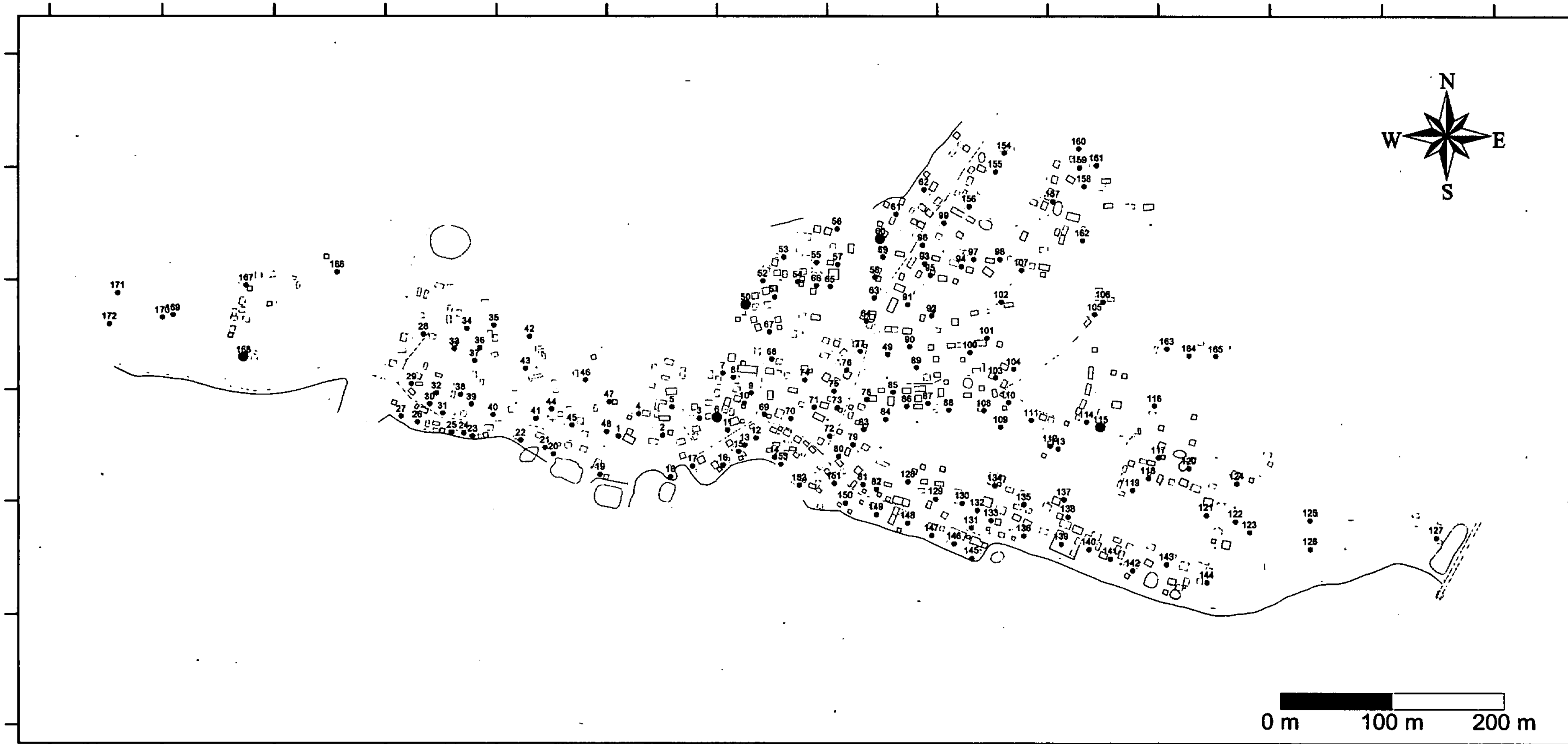
No.	Well	As by AAS (mg/l)	EC (mS/m)	pH (SU)	ORP (mV)	Fe^{2+} (mg/l)	Temp (deg-C)	Eh (mV)	As by FK (mg/l)
1	BS-JD-CC-EW-001	0.034	135.5	7.10	-110	2	22.8	98.0	0
2	BS-JD-CC-EW-002	0.013	90.6	7.13	-112	0	22.7	96.0	0
3	BS-JD-CC-EW-004	0.072	72.4	7.19	-90	2	22.6	118.1	0
4	BS-JD-CC-EW-005	0.041	80.0	7.14	-141	5	24.8	65.5	0
5	BS-JD-CC-EW-007	0.081	98.2	6.86	-101	5	24.7	105.6	0
6	BS-JD-CC-EW-008	0.0011	102.5	7.11	-90	0	22.8	118.0	0
7	BS-JD-CC-EW-010	<0.0005	108.6	7.04	41	0	24.5	247.7	0
8	BS-JD-CC-EW-011	0.053	75.6	7.16	-136	2	24.8	70.5	0
9	BS-JD-CC-EW-013	0.088	78.8	7.17	-120	1	22.8	88.0	0
10	BS-JD-CC-EW-015	0.0085	109.6	7.02	-123	0.5	24.6	83.7	0
11	BS-JD-CC-EW-016	0.010	78.3	7.19	-102	0.5	24.7	104.6	0
12	BS-JD-CC-EW-017	0.097	103.5	7.06	-96	5	23.2	111.7	0
13	BS-JD-CC-EW-019	0.016	92.2	7.09	57	2	24.6	263.7	0
14	BS-JD-CC-EW-020	0.071	75.3	7.15	-136	5	24.7	70.6	0.03
15	BS-JD-CC-EW-022	<0.0005	115.0	6.98	-30	0	25.5	176.0	0
16	BS-JD-CC-EW-023	0.24	91.5	7.06	-103	5	24.3	103.9	0.1
17	BS-JD-CC-EW-025	0.031	100.5	7.07	-80	5	25.3	126.2	0.01
18	BS-JD-CC-EW-026	0.26	117.2	7.06	-100	5	25.2	106.2	0.05
19	BS-JD-CC-EW-028	0.27	103.7	7.08	-82	5	25.4	124.1	0.07
20	BS-JD-CC-EW-029	0.012	120.6	7.14	-8	1	25.2	198.2	0
21	BS-JD-CC-EW-031	0.0011	127.6	7.10	80	0	25.3	286.2	0
22	BS-JD-CC-EW-032	0.048	72.2	7.05	-17	2	23.9	190.2	0.4
23	BS-JD-CC-EW-034	0.044	71.0	7.11	-67	0.5	24.5	139.7	0.01
24	BS-JD-CC-EW-035	0.21	77.2	7.17	-115	5	24.6	91.7	0.01
25	BS-JD-CC-EW-037	0.31	87.6	7.19	-111	5	23.9	96.2	0.01
26	BS-JD-CC-EW-038	0.38	76.0	7.08	-118	10	25.9	87.7	0.07
27	BS-JD-CC-EW-040	0.083	77.3	7.18	-127	0	24.8	79.5	0
28	BS-JD-CC-EW-041	0.15	68.0	7.17	-94	2	25.6	111.9	0.02
29	BS-JD-CC-EW-043	0.21	67.9	7.15	-109	5	25.7	96.9	0.5
30	BS-JD-CC-EW-044	0.18	81.5	7.08	-133	5	25.7	72.9	0.06
31	BS-JD-CC-EW-046	0.17	79.1	7.15	-140	10	25.9	65.7	0.01
32	BS-JD-CC-EW-047	0.17	72.6	7.14	-128	10	25.6	77.9	0
33	BS-JD-CC-EW-049	0.061	110.0	7.22	-121	0.5	25.6	84.9	0
34	BS-JD-CC-EW-050	0.091	94.9	7.24	-135	0.5	25.6	70.9	0
35	BS-JD-CC-EW-052	0.17	67.0	7.14	-104	5	25.3	102.2	0
36	BS-JD-CC-EW-053	0.69	76.7	7.06	-132	10	25.3	74.2	1
37	BS-JD-CC-EW-056	0.38	78.6	7.10	-130	10	24.8	76.5	0.6
38	BS-JD-CC-EW-058	0.38	87.0	7.07	-143	5	24.6	63.7	0.09
39	BS-JD-CC-EW-059	0.48	97.5	7.02	-80	5	24.6	126.7	0.06
40	BS-JD-CC-EW-061	0.15	81.1	7.10	-107	5	24.6	99.7	0
41	BS-JD-CC-EW-062	0.14	75.8	7.18	-128	2	22.9	79.9	0.02
42	BS-JD-CC-EW-064	0.22	62.3	7.15	-140	5	24.9	66.4	0.02
43	BS-JD-CC-EW-065	0.63	72.8	7.05	-132	10	24.8	74.5	0.4
44	BS-JD-CC-EW-067	0.80	84.6	7.13	-104	10	24.6	102.7	0.6
45	BS-JD-CC-EW-068	0.71	87.4	6.99	-131	10	25.4	75.1	0.7
46	BS-JD-CC-EW-070	0.81	71.9	7.12	-141	10	25.0	65.4	0.09
47	BS-JD-CC-EW-071	0.21	103.4	7.08	-104	5	22.7	104.0	0
48	BS-JD-CC-EW-073	<0.0005	154.6	6.95	-125	0	24.5	81.7	0
49	BS-JD-CC-EW-074	0.44	59.7	7.20	-102	2	22.9	105.9	0.01
50	BS-JD-CC-EW-076	0.25	75.0	7.27	-127	0	23.7	80.3	0.02
51	BS-JD-CC-EW-077	0.77	87.6	7.03	-109	10	24.2	97.9	1
52	BS-JD-CC-EW-079	0.39	66.2	7.18	-149	5	25.3	57.2	1
53	BS-JD-CC-EW-080	0.38	90.9	7.04	-127	5	25.0	79.4	0.07
54	BS-JD-CC-EW-082	0.35	82.5	7.06	-130	2	24.9	76.4	0.06
55	BS-JD-CC-EW-083	0.29	83.2	7.08	-131	10	24.6	75.7	0.04
56	BS-JD-CC-EW-085	0.051	102.2	7.18	-135	2	24.0	72.1	0
57	BS-JD-CC-EW-086	0.071	88.8	7.21	-135	2	23.9	72.2	0.01
58	BS-JD-CC-EW-088	0.56	65.5	7.21	-121	0.5	23.5	86.4	1
59	BS-JD-CC-EW-089	0.52	72.6	7.10	-141	10	24.8	65.5	1
60	BS-JD-CC-EW-091	0.52	76.9	7.05	-136	10	25.5	70.0	1

Table 6.3.5 Groundwater Quality in Krishna Chandrapur Village in December 2000 (2/2)

No.	Well	As by AAS (mg/l)	EC (mS/m)	pH (SU)	ORP (mV)	Fe^{2+} (mg/l)	Temp (deg-C)	Eh (mV)	As by FK (mg/l)
61	BS-JD-CC-EW-092	0.12	66.3	7.16	-141	0	25.6	64.9	0.01
62	BS-JD-CC-EW-094	0.74	76.3	7.10	-133	10	25.6	72.9	1
63	BS-JD-CC-EW-095	0.12	72.5	7.24	-140	5	25.6	65.9	0
64	BS-JD-CC-EW-097	0.60	73.5	7.12	-128	5	25.9	77.7	1
65	BS-JD-CC-EW-098	0.55	71.3	7.23	-146	5	26.8	59.1	1
66	BS-JD-CC-EW-100	0.54	86.8	7.07	-128	10	25.2	78.2	0.7
67	BS-JD-CC-EW-101	0.69	78.1	7.12	-122	5	25.7	83.9	1
68	BS-JD-CC-EW-103	0.063	61.8	7.20	-120	5	27.3	84.7	0
69	BS-JD-CC-EW-104	0.18	82.6	7.06	-104	5	25.6	101.9	0.05
70	BS-JD-CC-EW-106	0.27	58.1	7.12	-94	5	25.1	112.3	0.02
71	BS-JD-CC-EW-107	0.49	58.1	6.96	105	2	24.8	311.5	0.03
72	BS-JD-CC-EW-109	0.30	59.9	7.20	-139	5	26.2	66.5	0.03
73	BS-JD-CC-EW-110	0.10	61.0	7.08	-110	5	24.7	96.6	0.06
74	BS-JD-CC-EW-112	0.27	61.3	7.12	-52	5	26.0	153.6	0.1
75	BS-JD-CC-EW-113	0.24	72.9	7.11	-99	5	25.6	106.9	0.3
76	BS-JD-CC-EW-115	0.21	61.1	7.71	-125	5	25.6	80.9	0.01

Table 6.3.6 Groundwater Quality in Rajnagar Banlabarsi Village in December 2000

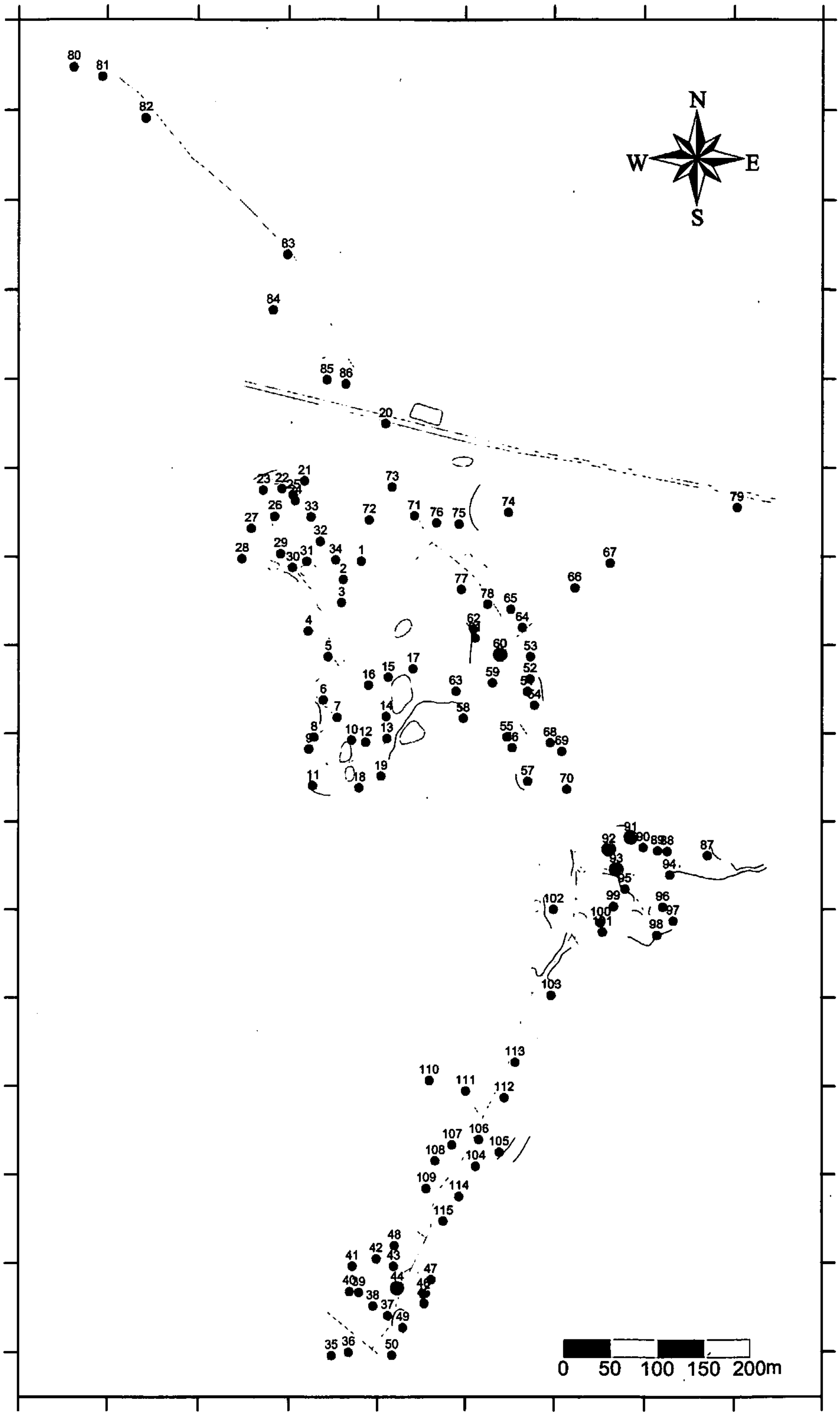
No.	Well	As by AAS (mg/l)	EC (mS/m)	pH (SU)	ORP (mV)	Fe^{2+} (mg/l)	Temp (deg-C)	Eh (mV)	As by FK (mg/l)
1	BS-JS-RB-EW-001	0.38	265	7.14	-90	2	25.1	116.3	0.8
2	BS-JS-RB-EW-002	0.44	266	7.15	-88	2	22.9	119.9	0.1
3	BS-JS-RB-EW-003	0.34	268	7.07	-93	2	23.4	114.5	0.2
4	BS-JS-RB-EW-004	0.44	269	7.15	-89	2	24.5	117.7	0.05
5	BS-JS-RB-EW-005	0.45	264	7.30	-107	2	24.6	99.7	0.5
6	BS-JS-RB-EW-007	0.46	267	7.27	-101	1	24.3	105.9	0.04
7	BS-JS-RB-EW-008	0.37	269	7.13	-94	5	25.1	112.3	0.03
8	BS-JS-RB-EW-010	0.57	270	7.16	-106	5	24.9	100.4	0.02
9	BS-JS-RB-EW-011	0.12	148	6.91	-5	5	24.0	202.1	0.02
10	BS-JS-RB-EW-012	0.17	255	7.06	-44	2	23.6	163.4	0.02
11	BS-JS-RB-EW-013	0.17	210	7.00	-47	5	23.4	160.5	0.02
12	BS-JS-RB-EW-014	0.14	219	7.02	-50	5	23.3	157.6	0.01
13	BS-JS-RB-EW-017	0.0014	74.1	7.74	-1	0	24.2	205.9	0
14	BS-JS-RB-EW-019	0.80	271	7.09	-100	5	25.3	106.2	0.4
15	BS-JS-RB-EW-020	0.76	271	7.01	-79	2	24.1	128.0	0.3
16	BS-JS-RB-EW-023	0.66	270	7.15	-133	5	24.8	73.5	1
17	BS-JS-RB-EW-025	0.41	258	7.14	-124	5	25.6	81.9	0.9
18	BS-JS-RB-EW-026	0.92	258	7.16	-112	5	25.0	94.4	1
19	BS-JS-RB-EW-028	0.59	268	7.07	-125	5	25.3	81.2	0.8
20	BS-JS-RB-EW-030	1.2	263	7.11	-132	5	25.7	73.9	1
21	BS-JS-RB-EW-031	0.84	216	6.96	-121	10	25.0	85.4	1
22	BS-JS-RB-EW-032	0.82	217	6.93	-117	10	24.7	89.6	1
23	BS-JS-RB-EW-034	0.98	249	6.96	-122	10	25.0	84.4	1
24	BS-JS-RB-EW-035	0.63	228	6.90	-115	10	24.9	91.4	1
25	BS-JS-RB-EW-037	0.79	248	6.99	-118	5	24.9	88.4	0.5
26	BS-JS-RB-EW-038	0.72	288	7.05	-129	10	25.2	77.2	1
27	BS-JS-RB-EW-041	0.75	275	7.06	-117	10	25.2	89.2	1
28	BS-JS-RB-EW-043	0.86	285	6.99	-90	5	23.9	117.2	0.7
29	BS-JS-RB-EW-044	0.55	297	7.12	-118	5	25.3	88.2	0.5
30	BS-JS-RB-EW-045	0.61	255	6.89	-115	10	24.2	91.9	0.9
31	BS-JS-RB-EW-046	0.19	274	7.02	-127	5	24.6	79.7	0.5
32	BS-JS-RB-EW-047	0.19	235	7.09	-135	5	24.5	71.7	0.8
33	BS-JS-RB-EW-049	0.32	235	7.12	-41	5	25.0	165.4	0.4
34	BS-JS-RB-EW-050	0.39	268	7.17	-120	5	25.2	86.2	0.1
35	BS-JS-RB-EW-051	0.38	247	7.29	-90	2	21.6	118.8	0.2
36	BS-JS-RB-EW-052	0.34	278	7.22	-103	2	24.8	103.5	0.5
37	BS-JS-RB-EW-055	0.44	275	7.19	-90	5	24.8	116.5	0.09
38	BS-JS-RB-EW-056	0.20	268	7.16	24	5	25.1	230.3	0.09
39	BS-JS-RB-EW-058	0.28	139.5	7.15	-28	2	22.9	179.9	0.6
40	BS-JS-RB-EW-059	0.34	240	7.11	-14	10	22.7	194.0	0.3
41	BS-JS-RB-EW-061	0.53	278	7.20	-68	5	22.3	140.3	1
42	BS-JS-RB-EW-062	0.13	178.9	7.30	-120	5	22.1	88.5	0.7
43	BS-JS-RB-EW-064	0.13	249	7.25	44	2	22.8	252.0	0.6
44	BS-JS-RB-EW-065	0.16	275	7.36	48	2	23.3	255.6	0.09
45	BS-JS-RB-EW-067	0.31	272	7.18	-63	2	23.0	144.8	0.6
46	BS-JS-RB-EW-068	0.15	243	7.19	-53	2	22.4	155.2	0.07
47	BS-JS-RB-EW-070	0.19	231	7.11	-109	5	24.4	97.8	0.6
48	BS-JS-RB-EW-071	0.49	268	7.15	-77	5	22.2	131.4	0.5
49	BS-JS-RB-EW-072	0.48	255	7.20	-76	5	22.6	132.1	0.4
50	BS-JS-RB-EW-073	0.46	265	7.18	-101	2	24.5	105.7	1



172 ● Existing Well with TW No.

● Existing Well where General Water Quality Sample Collected

Figure 6.3.1	Location Map of Existing Tubewells in Bara Dudpatila Village
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	



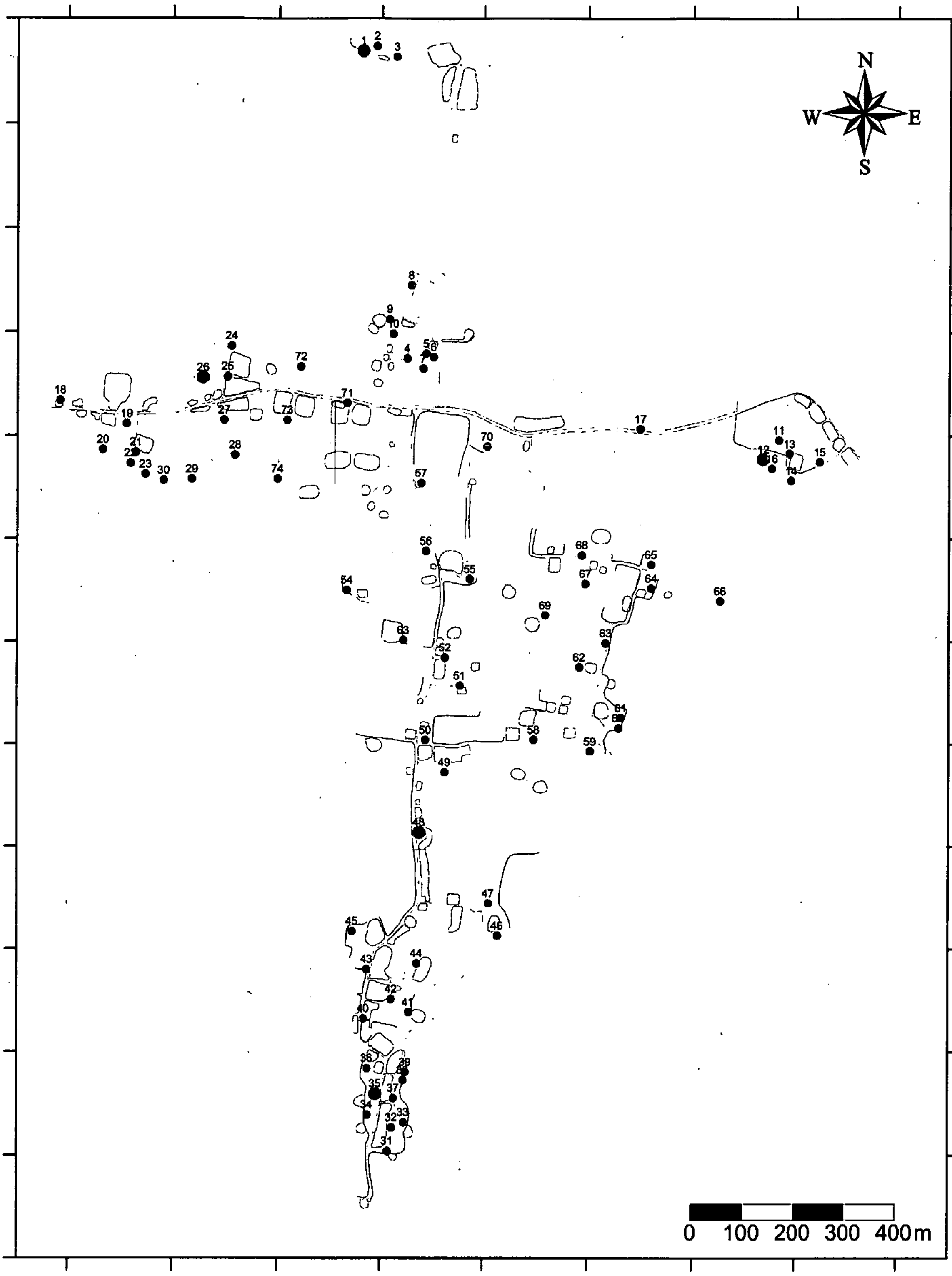
115 ● Existing Well with TW No.

● Existing Well where General Water Quality Sample Collected

Figure 6.3.2	Location Map of Existing Tubewells in Krishna Chandrapur Village

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



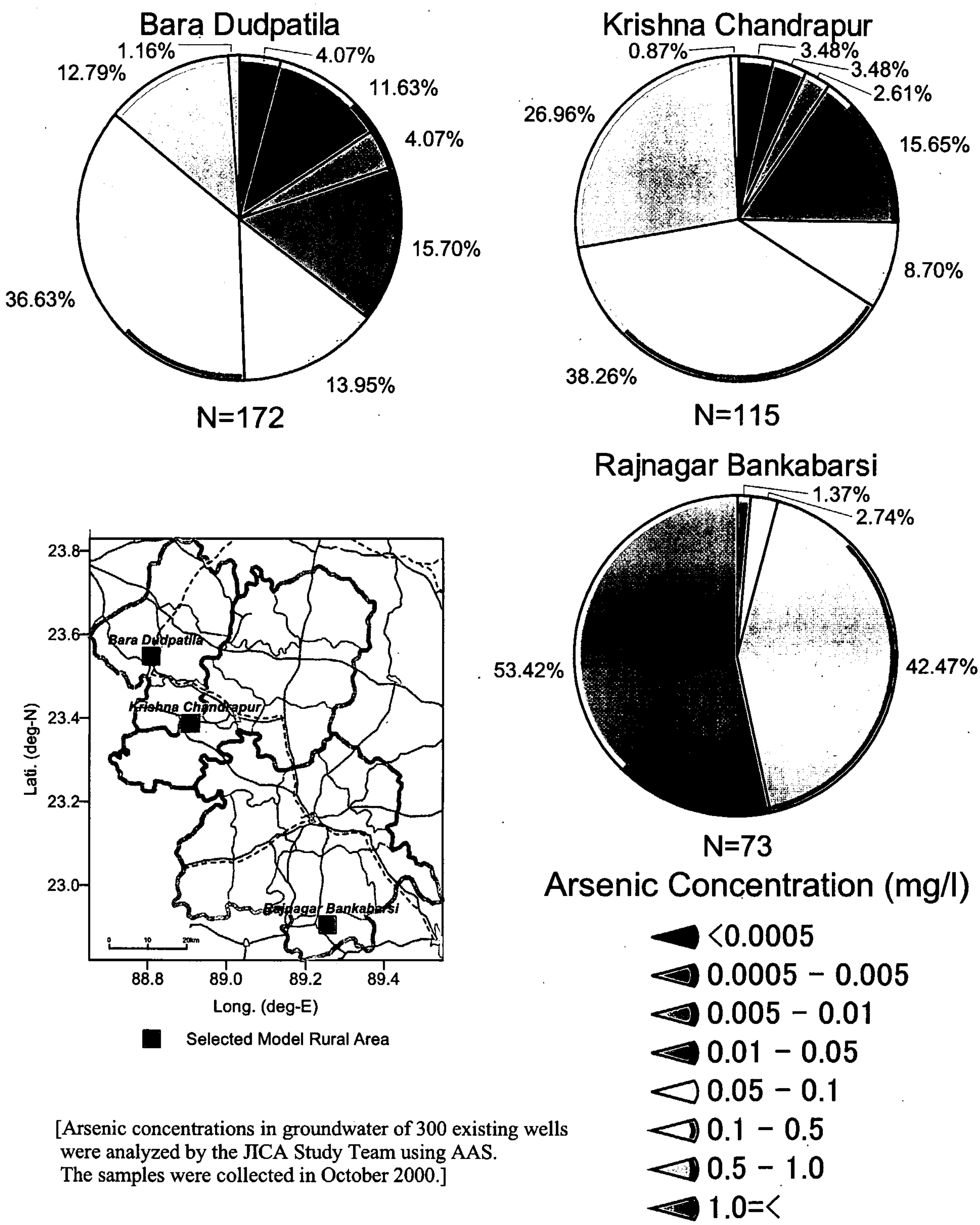
74 ● Existing Well with TW No.

● Existing Well where General Water Quality Sample Collected

Figure 6.3.3 **Location Map of Existing Tubewells in Rajnagar Bankabarsi Village**

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

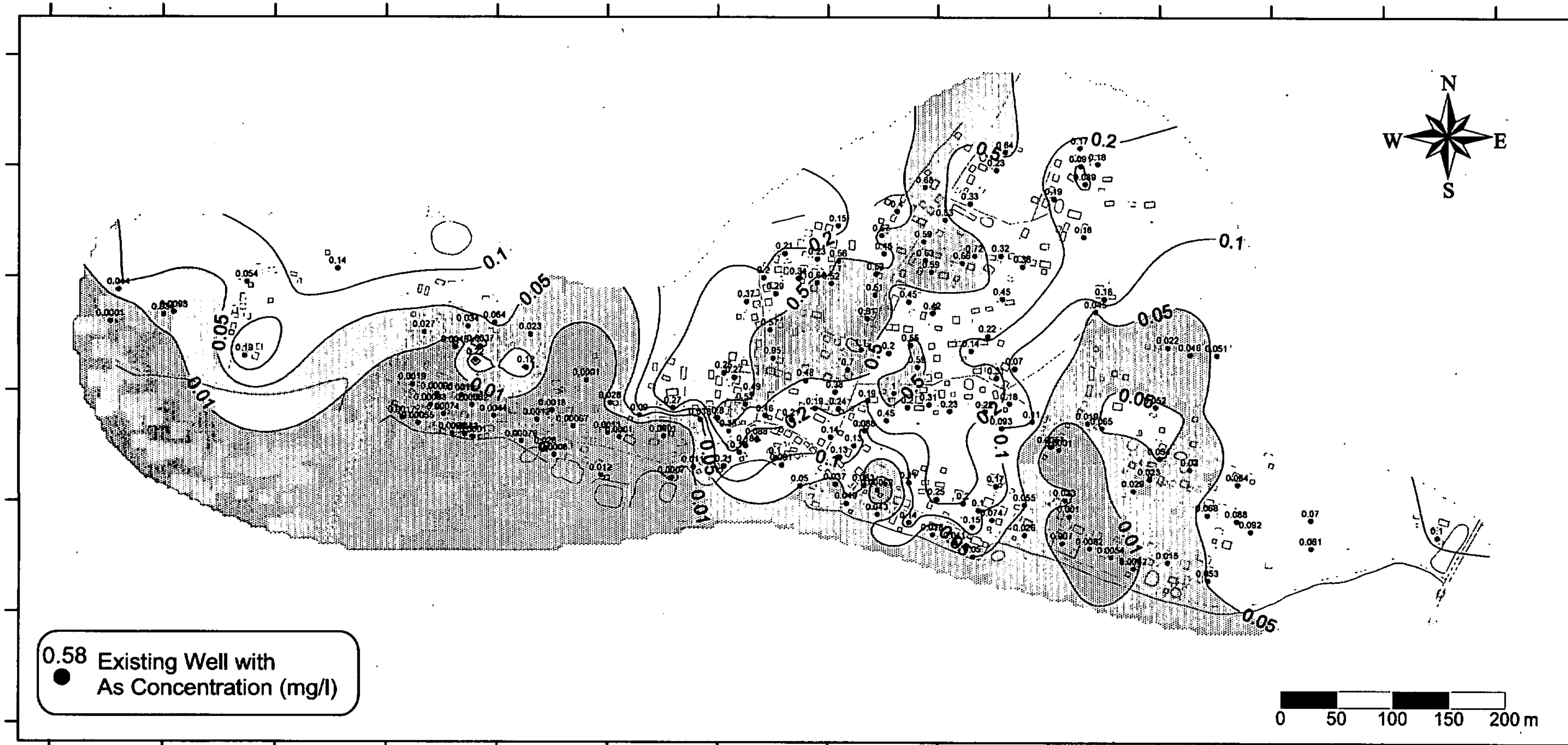


[Arsenic concentrations in groundwater of 300 existing wells were analyzed by the JICA Study Team using AAS. The samples were collected in October 2000.]

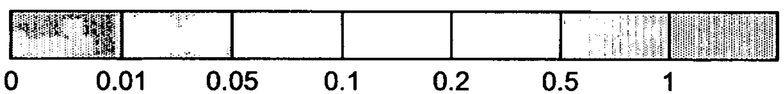
Figure 6.3.4	Arsenic Concentrations of Exsiting Wells in Model Rural Areas Analyzed by AAS

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

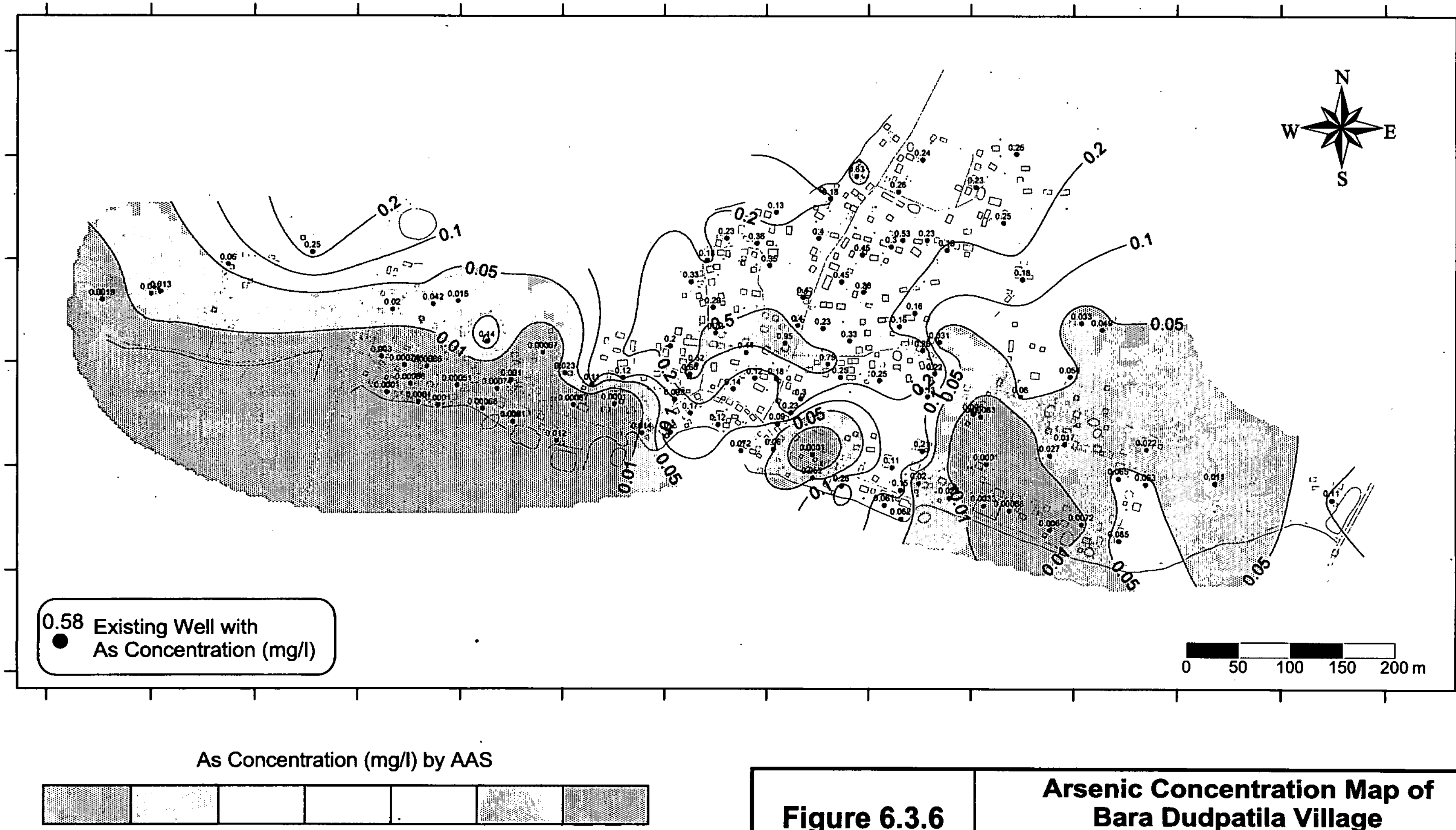


As Concentration (mg/l) by AAS



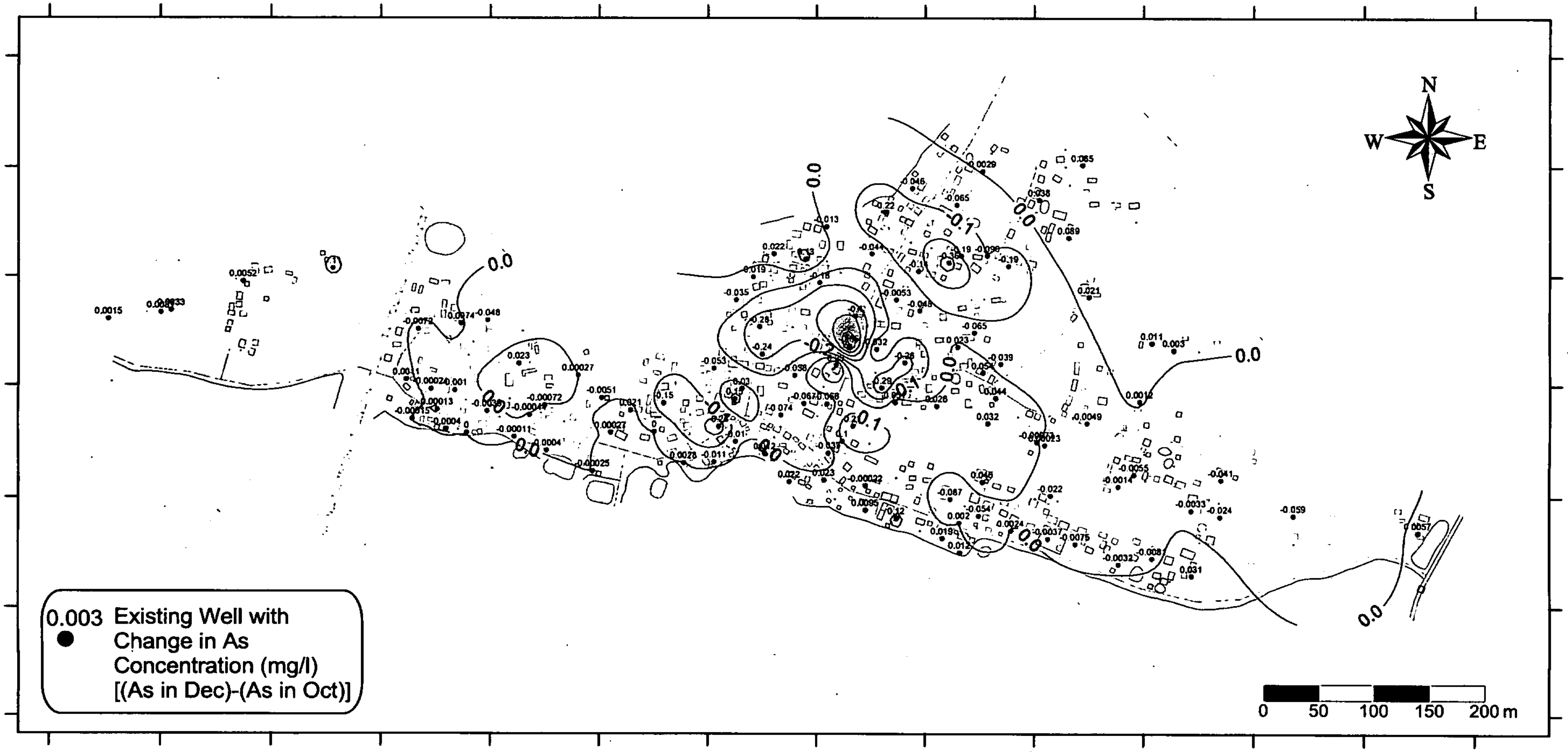
[The groundwater samples were collected from 172 existing wells in October 2000. The arsenic concentrations were analyzed by AAS in Jhenaidah Laboratory.]

Figure 6.3.5	Arsenic Concentration Map of Bara Dudpatila Village (October 2000)
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	



[The groundwater samples were collected from 112 existing wells in December 2000. The arsenic concentrations were analyzed by AAS in Jhenaidah Laboratory.]

Figure 6.3.6	Arsenic Concentration Map of Bara Dudpatila Village (December 2000)
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	



Changes in As Concentration (mg/l)
between October and December 2000 by AAS

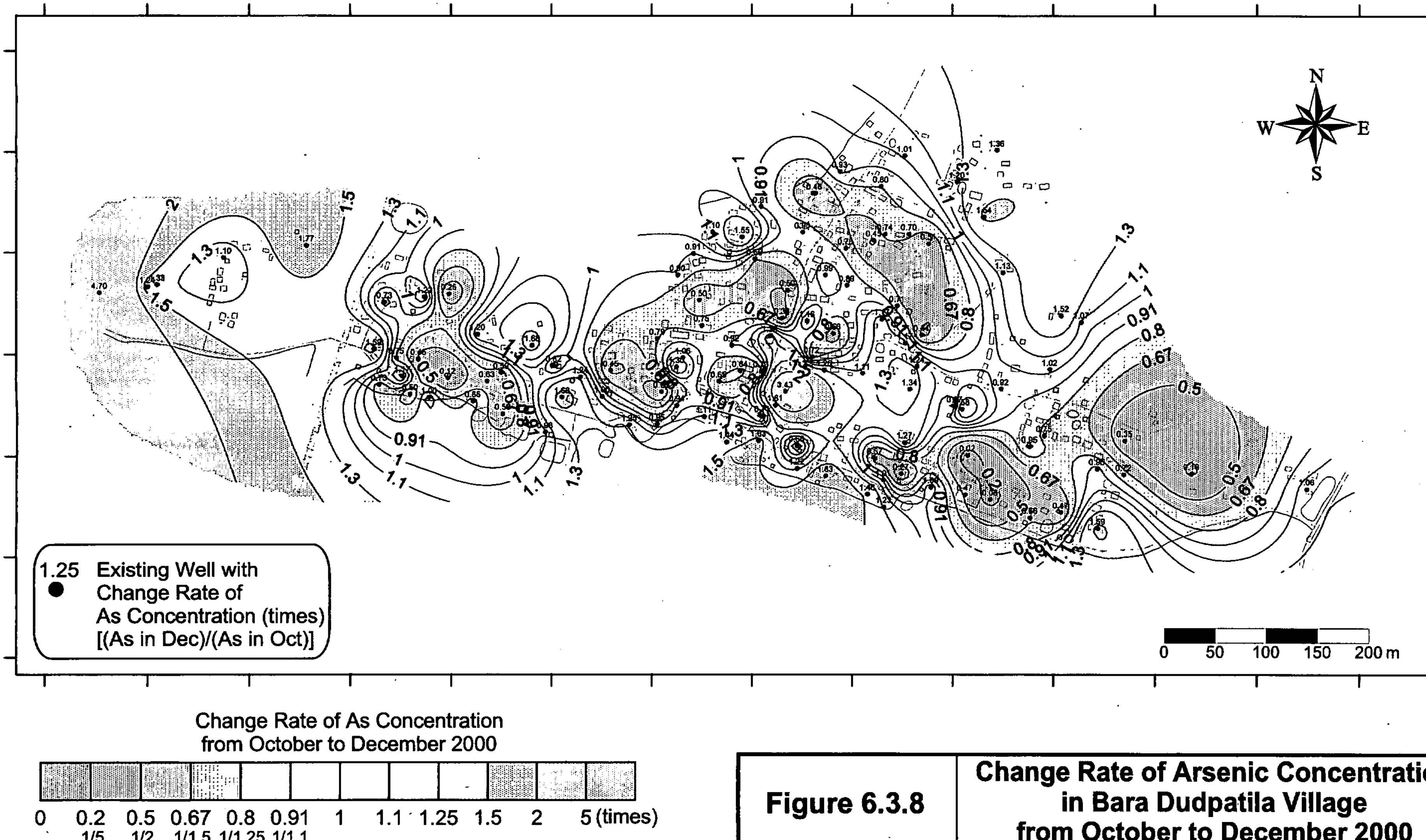
-0.70 -0.60 -0.50 -0.40 -0.30 -0.20 -0.10 0.00 0.10 0.20 0.30

[A total of 112 existing wells' samples were used for the comparison between October and December 2000.
The arsenic concentrations were analyzed by AAS in Jhenaidah Laboratory.]

Figure 6.3.7 | **Changes in Arsenic Concentration in Bara Dudpatila Village between October and December 2000**

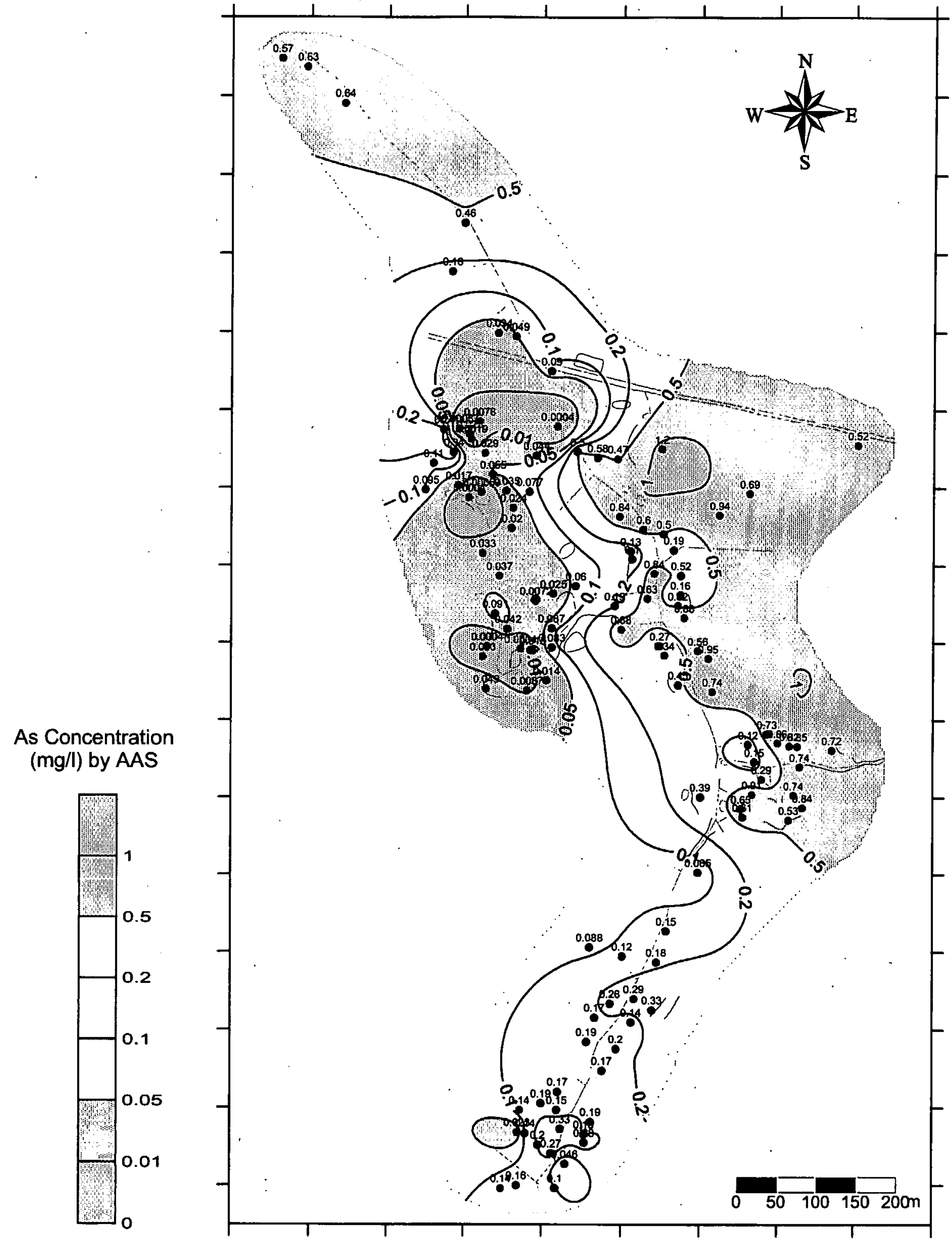
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



[A total of 112 existing wells' samples were used for the comparison between October and December 2000.
The arsenic concentrations were analyzed by AAS in Jhenaidah Laboratory.]

Figure 6.3.8	Change Rate of Arsenic Concentration in Bara Dudpatila Village from October to December 2000
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	



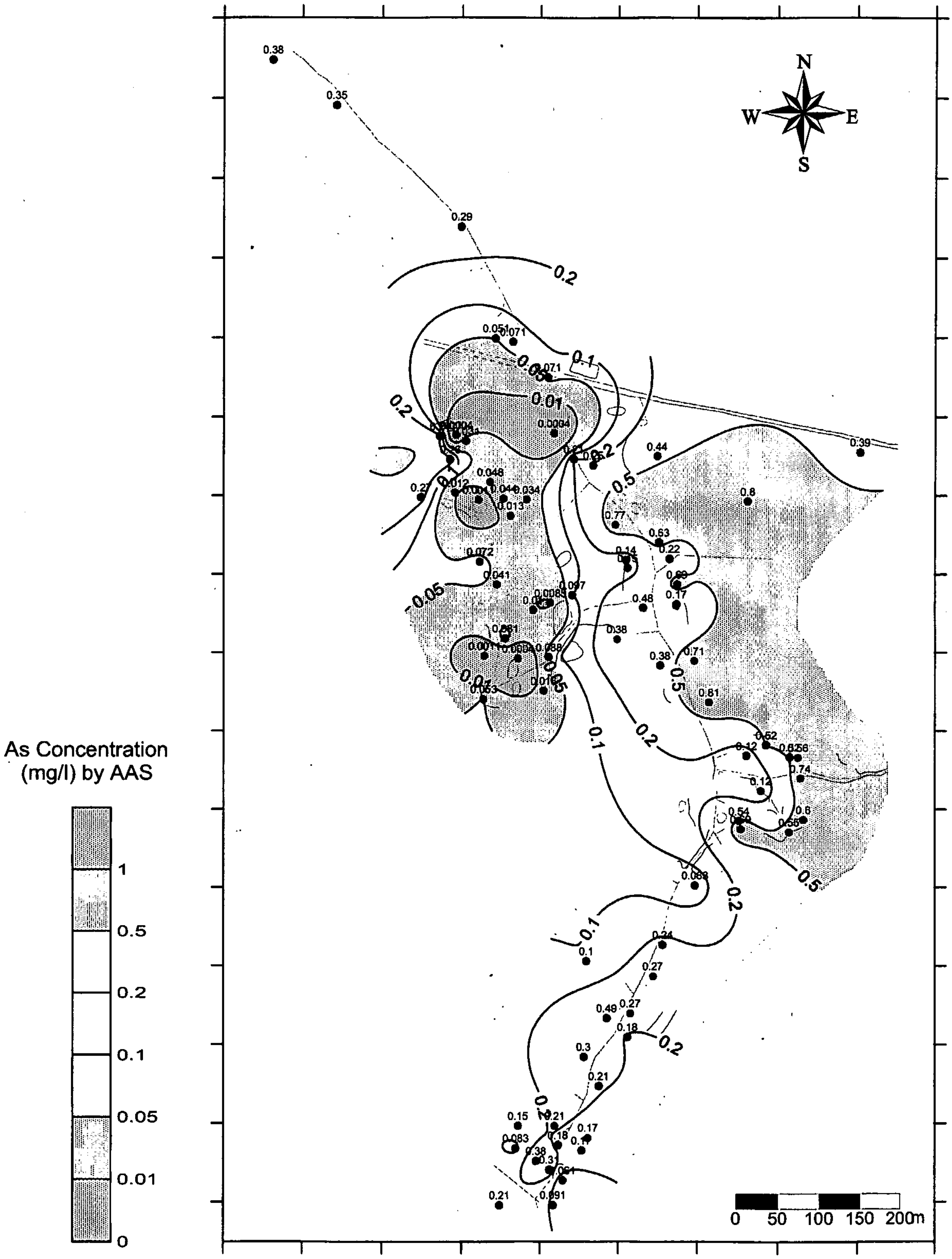
[The groundwater samples were collected from 115 existing wells in October 2000.
The arsenic concentrations were analyzed by AAS in Jhenaidah Laboratory.]

0.05 ● Existing Well with As Concentration (mg/l)

Figure 6.3.9	**Arsenic Concentration Map of Krishna Chandrapur Village (October 2000)**

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



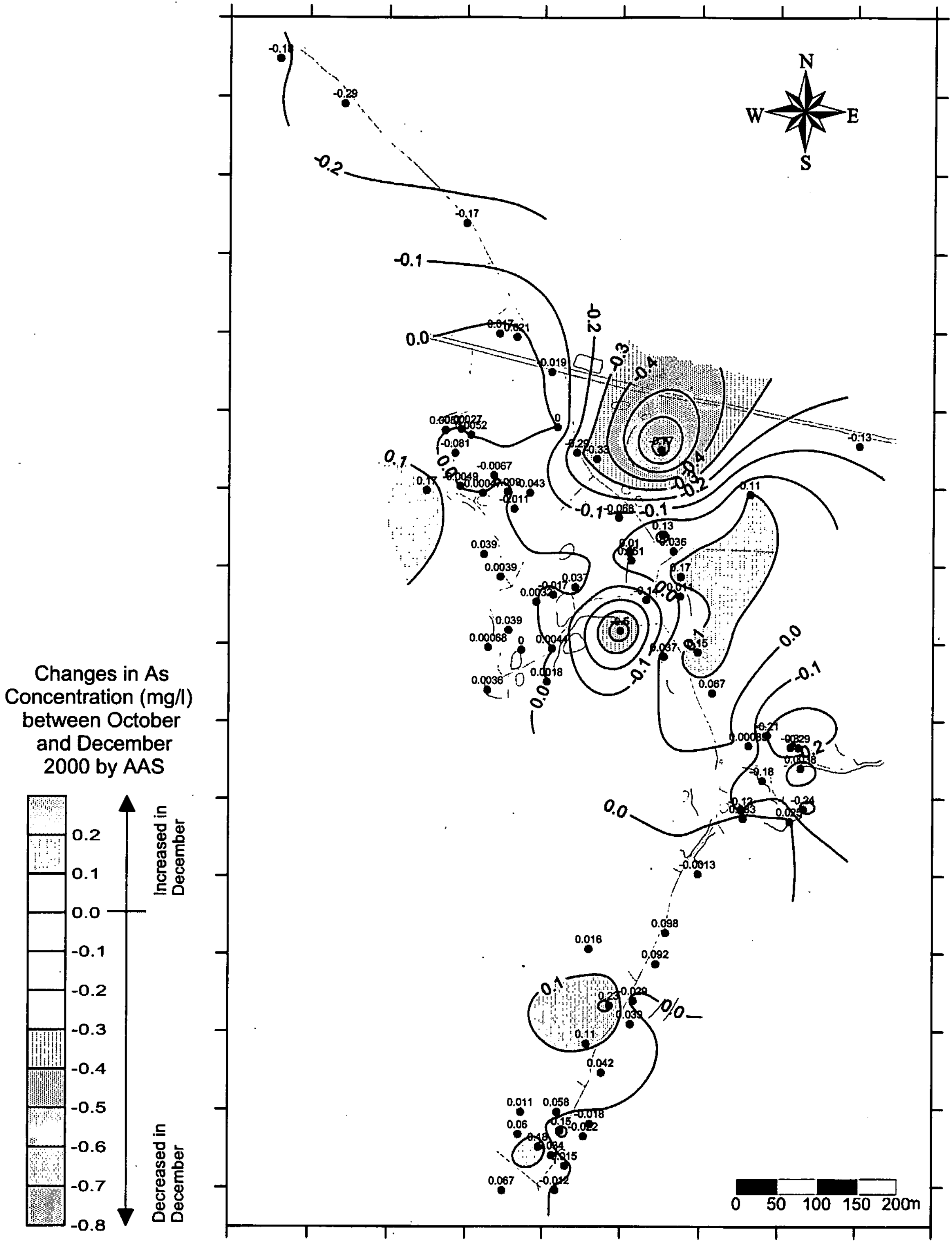
[The groundwater samples were collected from 76 existing wells in December 2000.
The arsenic concentrations were analyzed by AAS in Jhenaidah Laboratory.]

0.05 ● Existing Well with As Concentration (mg/l)

Figure 6.3.10	**Arsenic Concentration Map of Krishna Chandrapur Village (December 2000)**

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

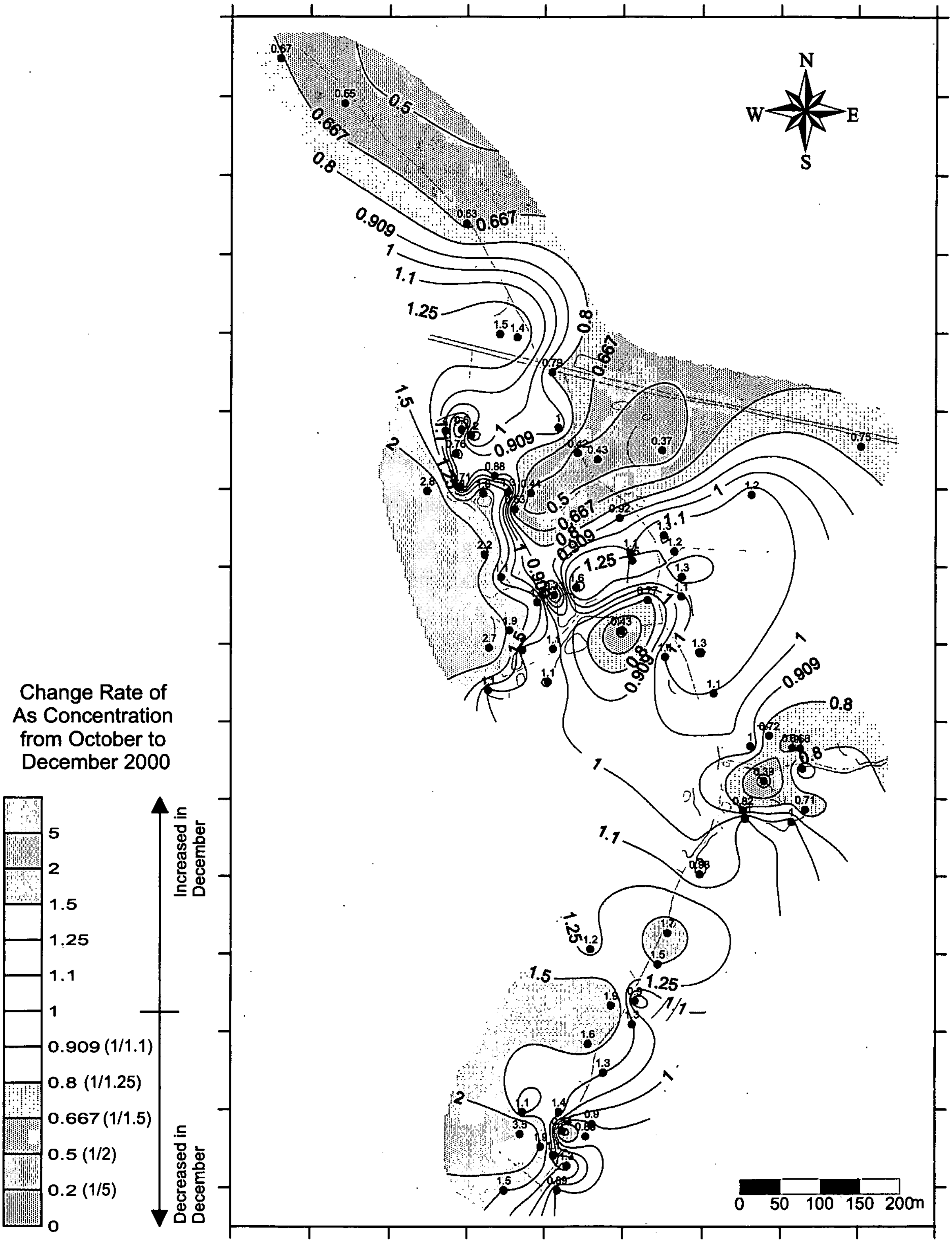
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



[A total of 76 existing wells' samples were used for the comparison between October and December 2000. The arsenic concentrations were analyzed by AAS in Jhenaidah Laboratory.]

0.003 ● Existing Well with Change in As Concentration (mg/l) [(As in Dec)-(As in Oct)]

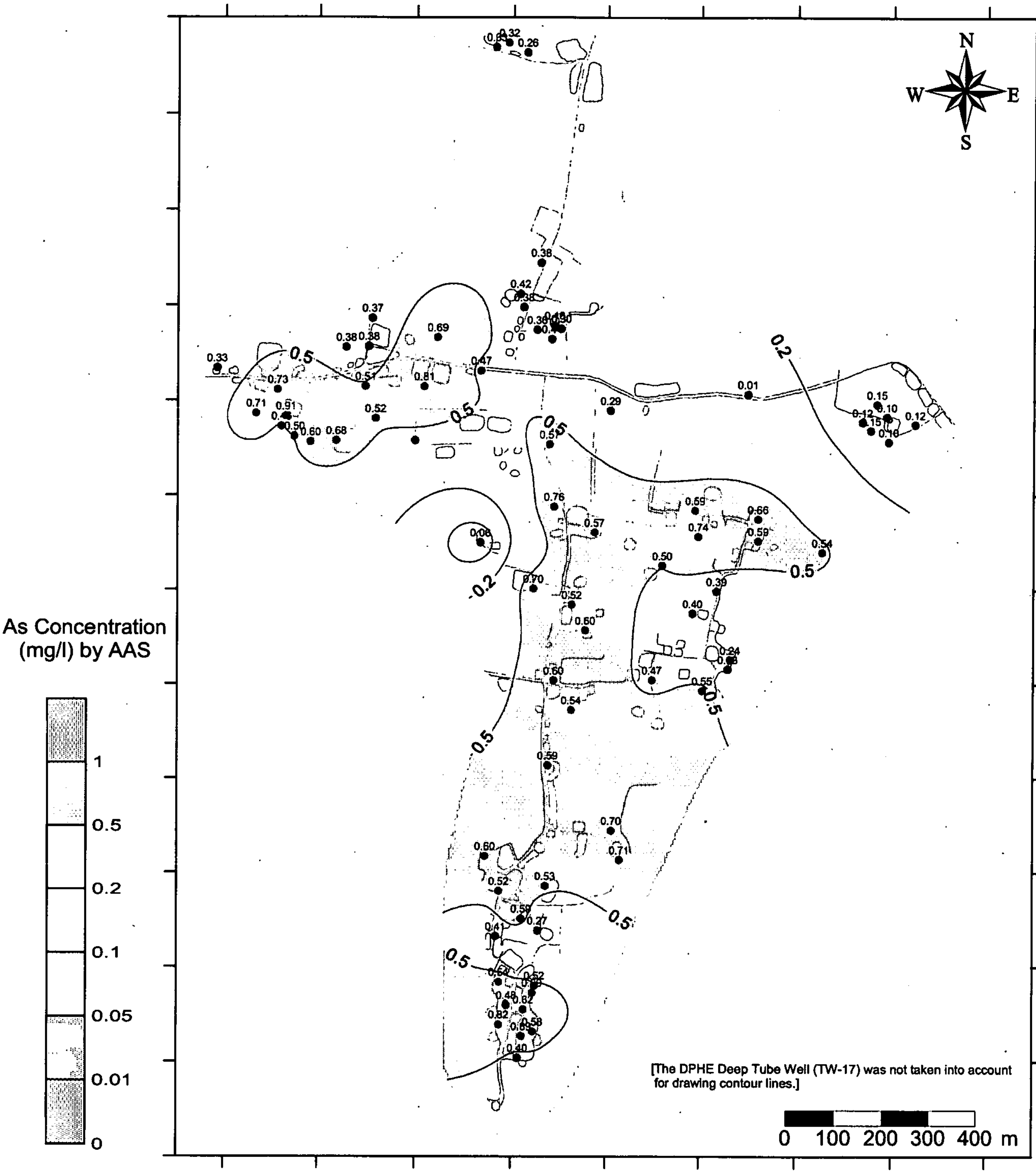
Figure 6.3.11	Changes in Arsenic Concentration in Krishna Chandrapur Village between October and December 2000
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	



[A total of 76 existing wells' samples were used for the comparison between October and December 2000. The arsenic concentrations were analyzed by AAS in Jhenaidah Laboratory.]

0.003 ● Existing Well with Change Rate of As Concentration (times) [(As in Dec)/(As in Oct)]

Figure 6.3.12	Change Rate of Arsenic Concentration in Krishna Chandrapur Village from October to December 2000
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	



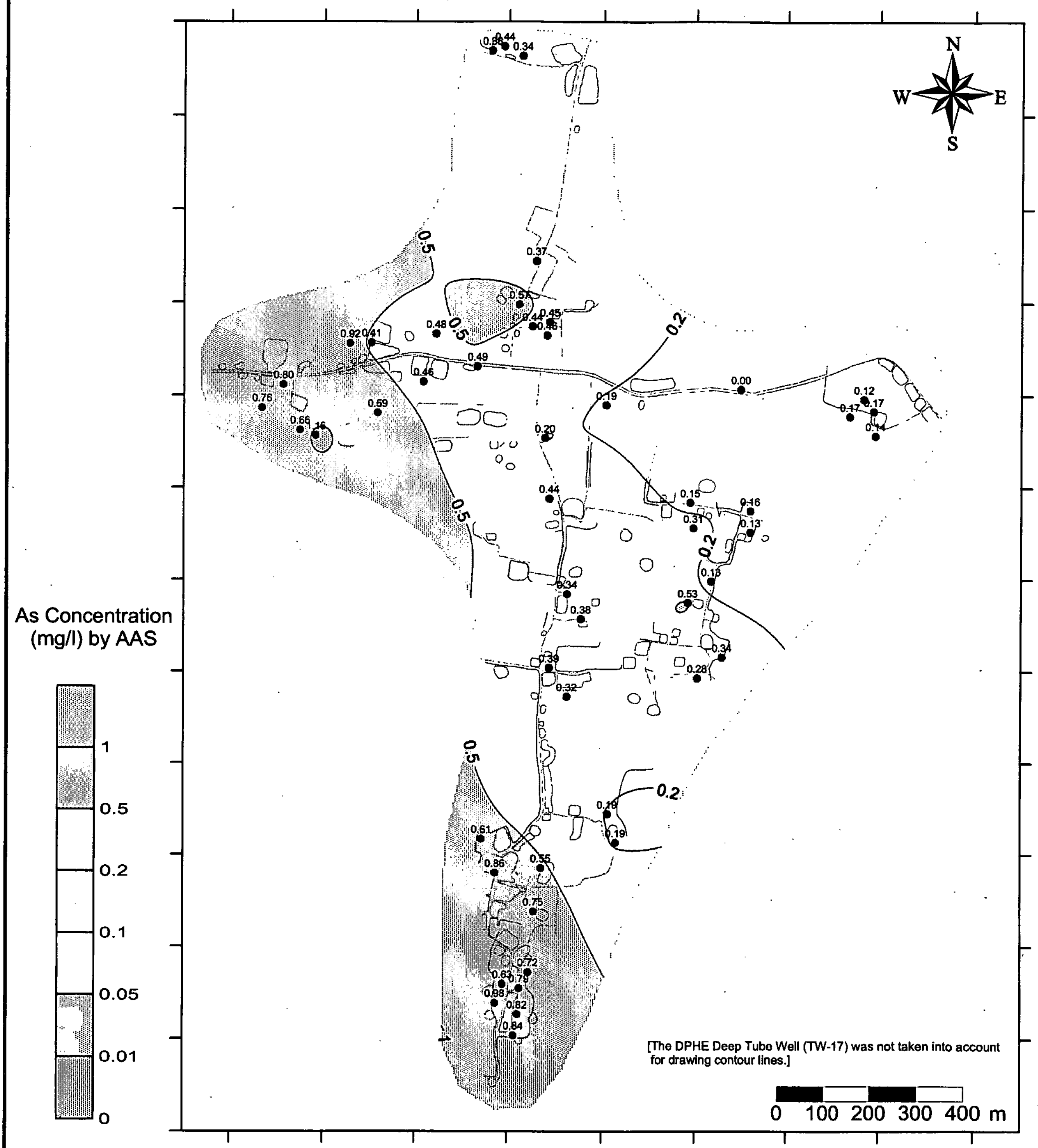
[The groundwater samples were collected from 74 existing wells in October 2000. The arsenic concentrations were analyzed by AAS in Jhenaidah Laboratory.]

0.58 ● Existing Well with As Concentration (mg/l)

Figure 6.3.13	Arsenic Concentration Map of Rajnagar Bankabarsi Village (October 2000)

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



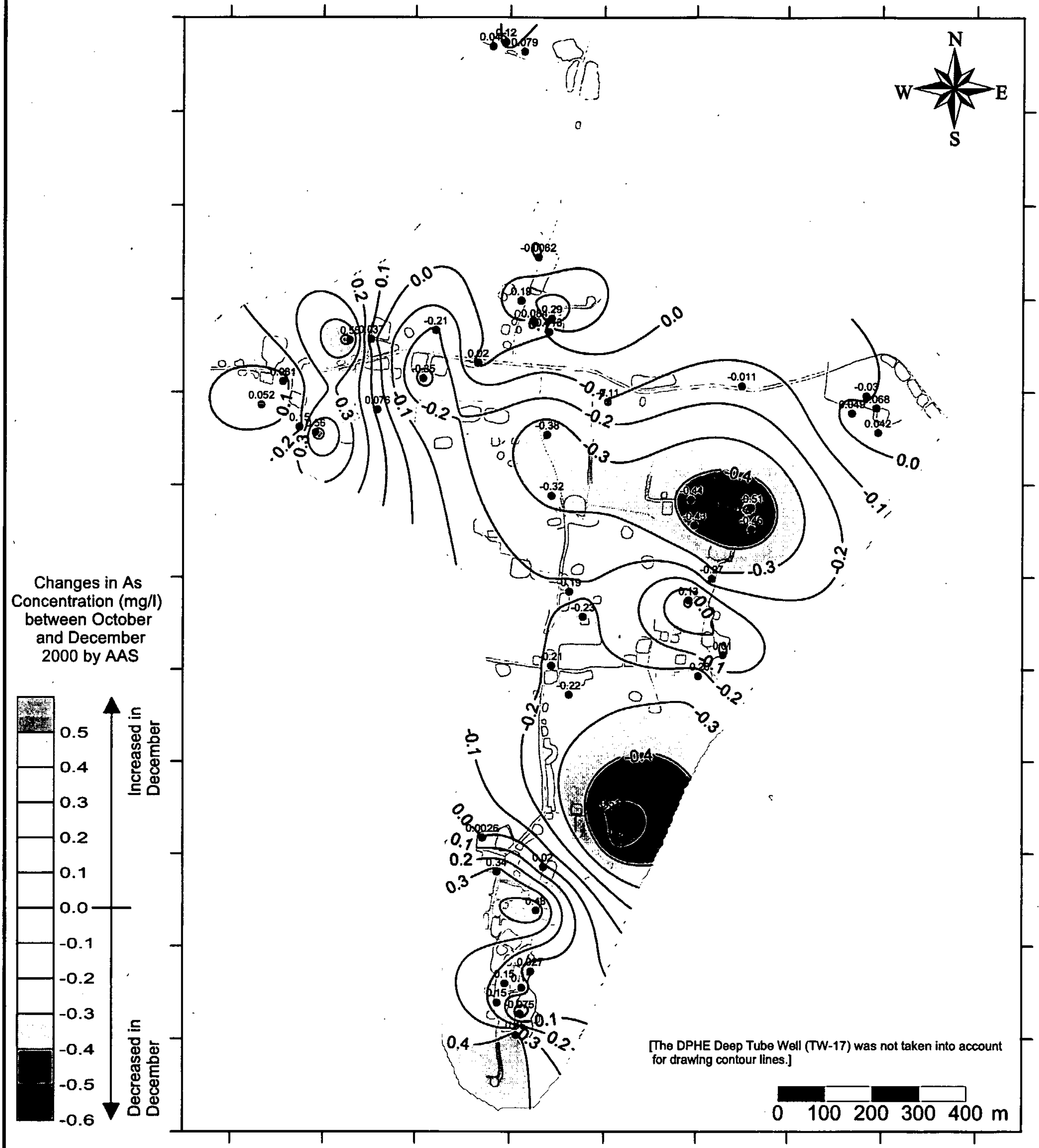
[The groundwater samples were collected from 50 existing wells in December 2000. The arsenic concentrations were analyzed by AAS in Jhenaidah Laboratory.]

0.58 ● Existing Well with As Concentration (mg/l)

Figure 6.3.14	Arsenic Concentration Map of Rajnagar Bankabarsi Village (December 2000)

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



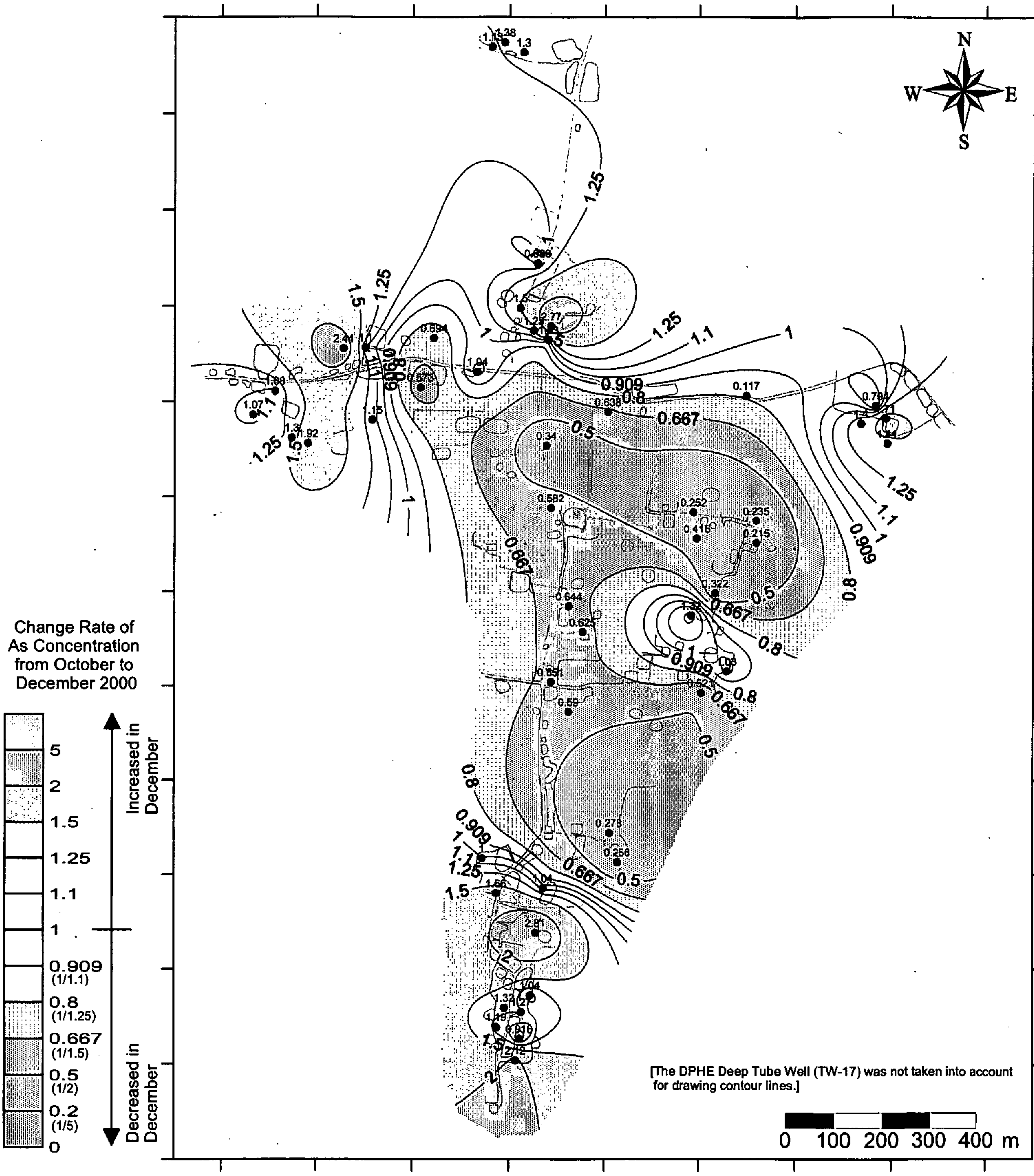
[A total of 50 existing wells' samples were used for the comparison between October and December 2000. The arsenic concentrations were analyzed by AAS in Jhenaidah Laboratory.]

0.003 ● Existing Well with Change in As Concentration (mg/l) [(As in Dec)-(As in Oct)]

Figure 6.3.15	Changes in Arsenic Concentration in Rajnagar Bankabarsi Village between October and December 2000

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



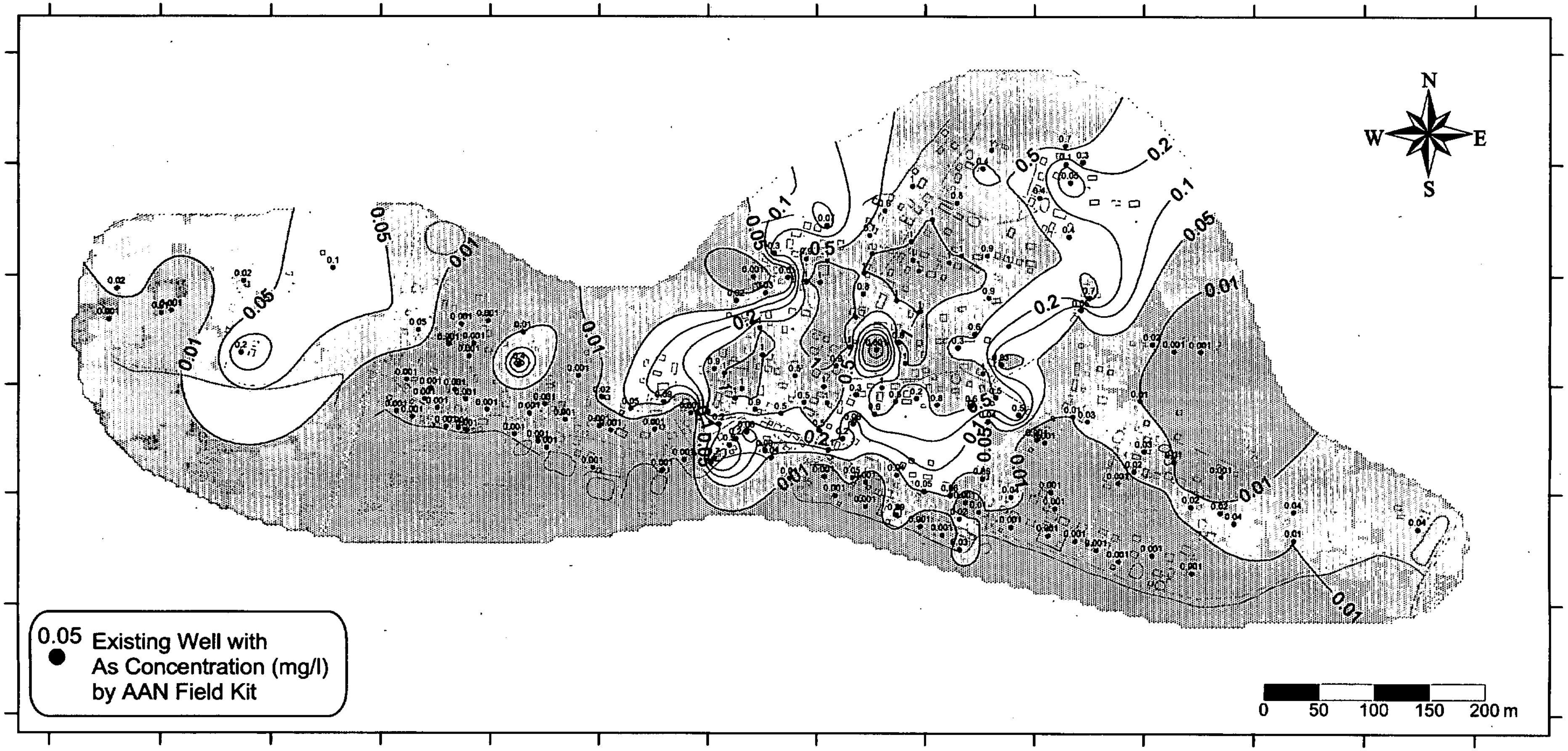
[A total of 50 existing wells' samples were used for the comparison between October and December 2000. The arsenic concentrations were analyzed by AAS in Jhenaidah Laboratory.]

1.25 ● Existing Well with Change Rate of As Concentration (times) [(As in Dec)/(As in Oct)]

Figure 6.3.16	Change Rate of Arsenic Concentration in Rajnagar Bankabarsi Village from October to December 2000

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

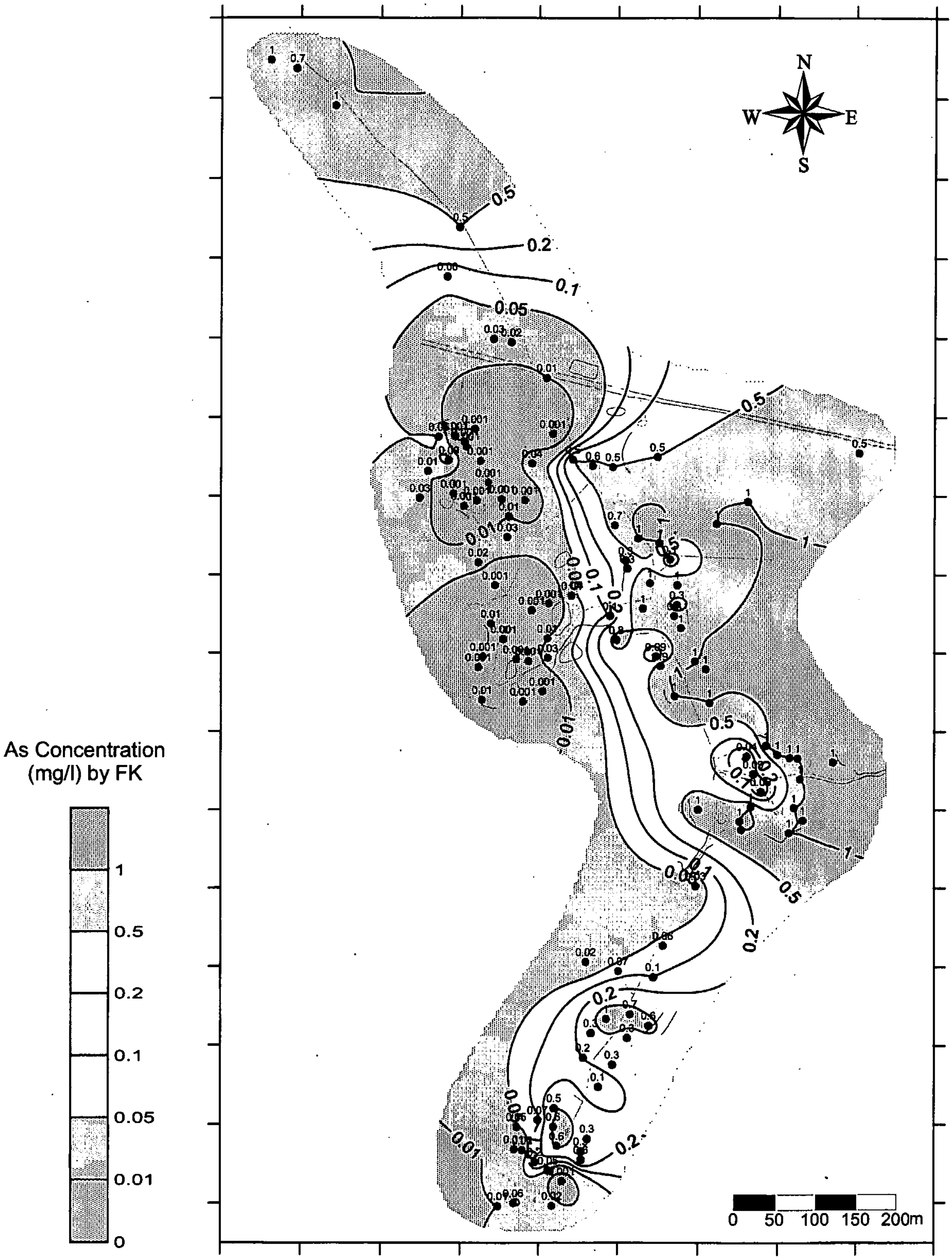


As Concentration (mg/l) by AAN Field Kit

0	0.01	0.05	0.1	0.2	0.5	1

[The arsenic concentrations of groundwater were measured at 172 existing tubewells by the AAN Field Kit at the time of water sampling in October 2000.]

Figure 6.3.17	Arsenic Concentration Map of Bara Dudpatila Village by Field Kit (October 2000)
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	



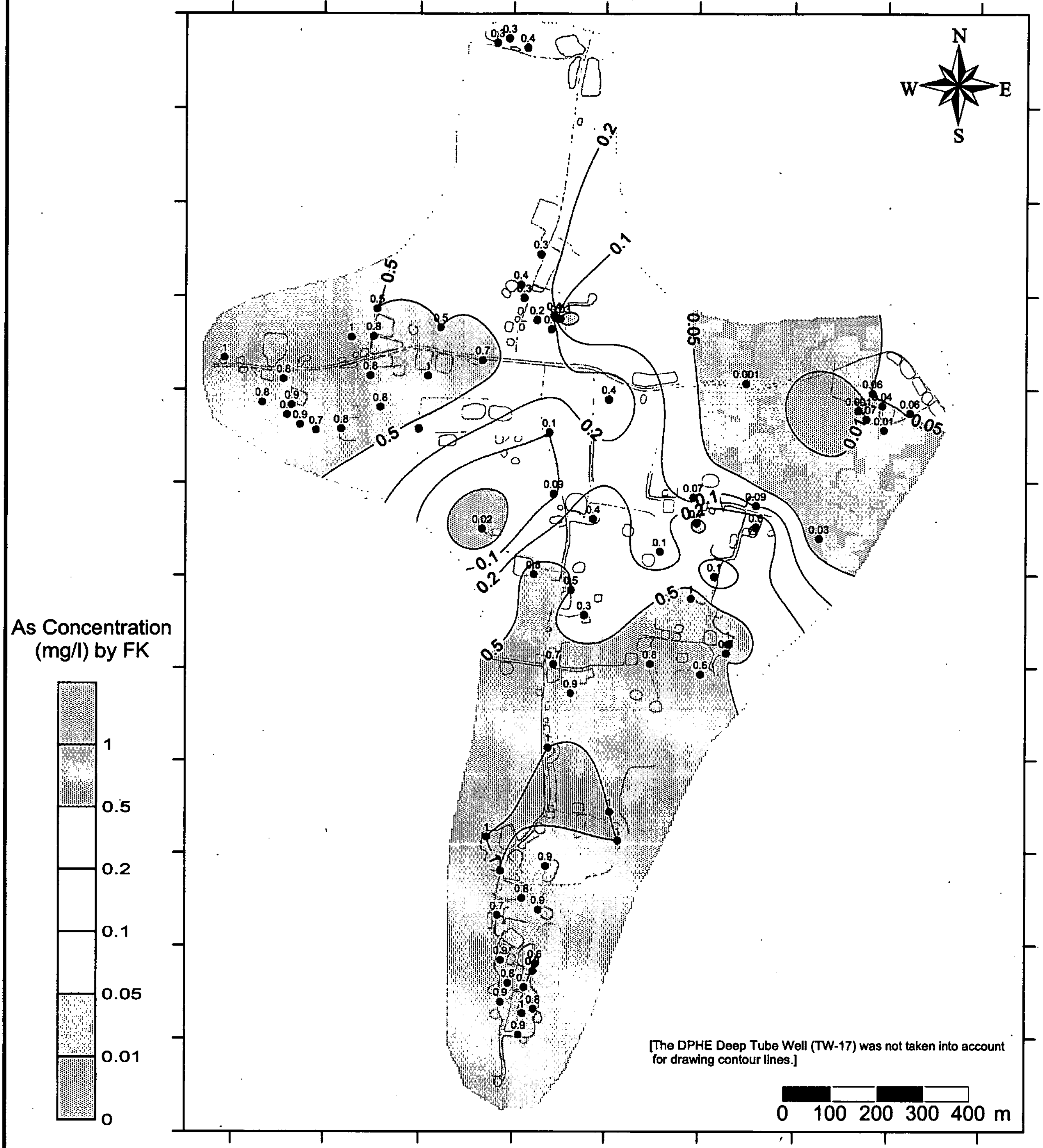
[The arsenic concentrations of groundwater were measured at 115 existing tubewells by the AAN Field Kit at the time of water sampling in October 2000.]

0.05 Existing Well with As Concentration (mg/l) by AAN Field Kit

Figure 6.3.18	**Arsenic Concentration Map of Krishna Chandrapur Village by Field Kit (October 2000)**

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



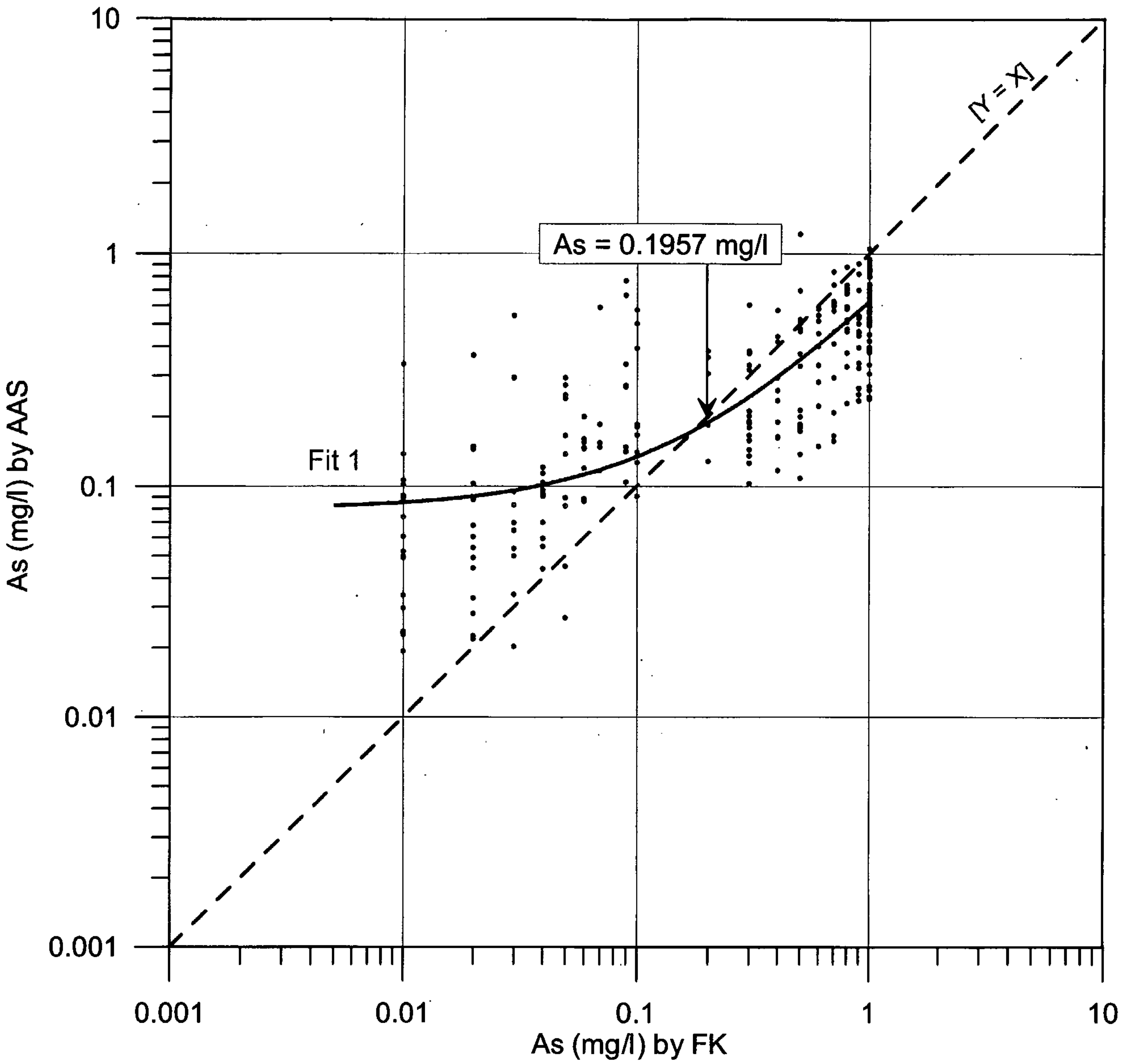
[The arsenic concentrations of groundwater were measured at 74 existing tubewells by the AAN Field Kit at the time of water sampling in October 2000.]

0.05 ● Existing Well with As Concentration (mg/l) by AAN Field Kit

Figure 6.3.19	Arsenic Concentration Map of Rajnagar Bankabarsi Village by Field Kit (October 2000)

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



Fit Results

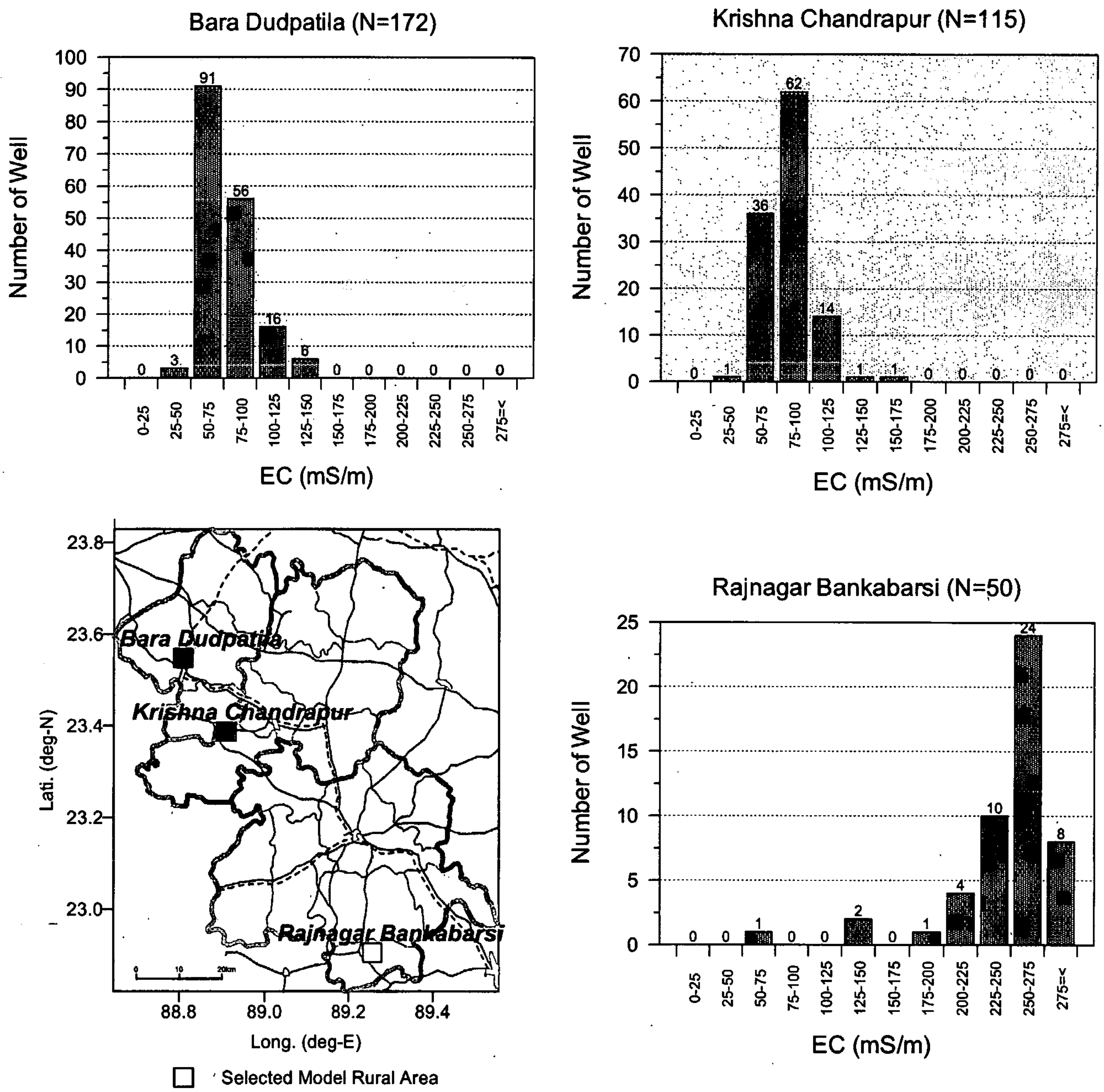
Fit 1: Linear
Equation Y = 0.5009593586 * X + 0.0969041654
Number of data points used = 600
Coef of determination, R-squared = 0.597232

[The data of 600 samples in the model rural areas were used for the comparison.
AAS : Atmoic Absorption Spectrometer installed in Jhenaidah Laboratory
FK : Asia Arsenic Network (AAN) Field Kit]

Figure 6.3.20	Comparison of As Concentrations Measured by FK and AAS in the Model Rural Areas

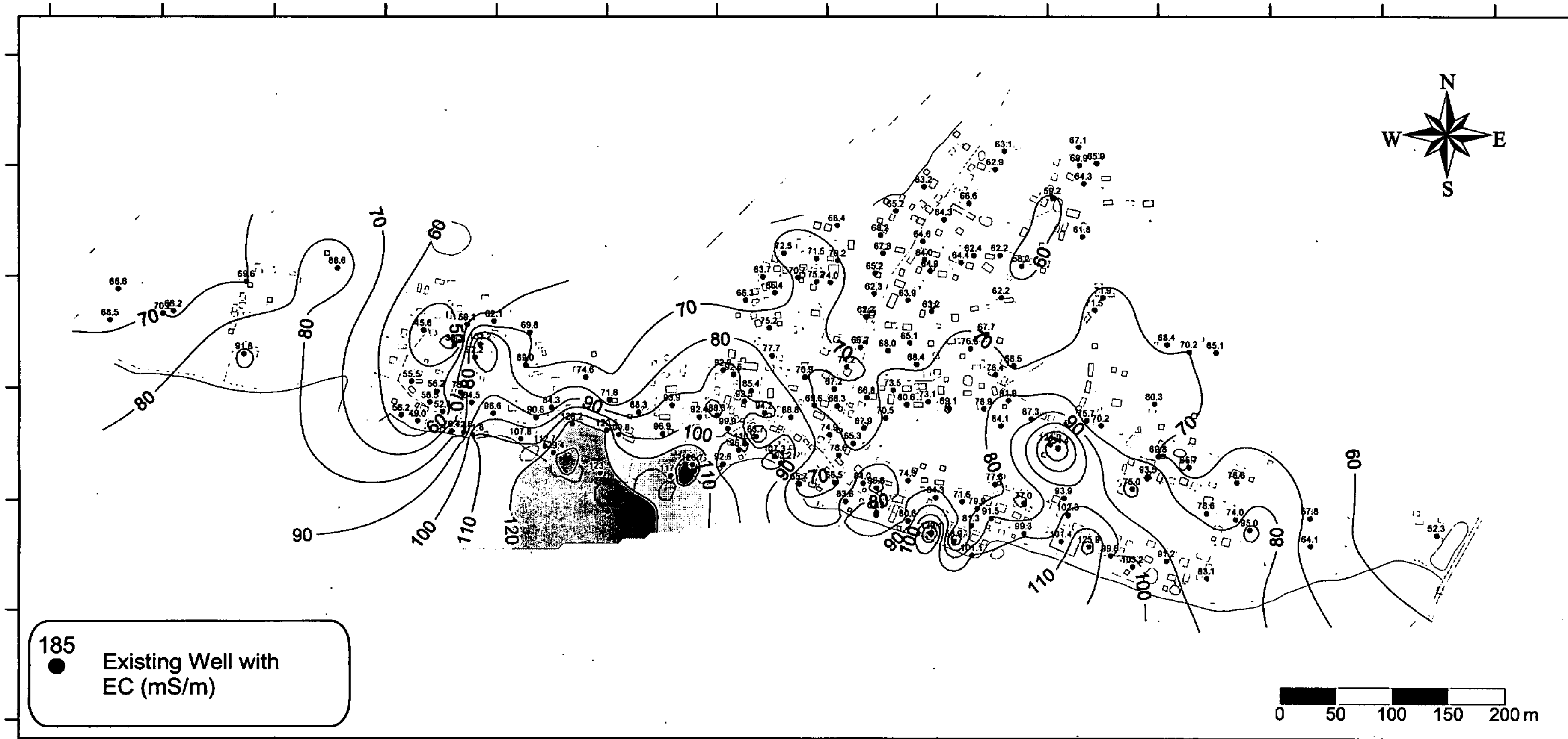
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



[The EC values of existing wells in the model rural areas were measured by Potable EC Meter in October 2000.]

Figure 6.3.21	**Electric Conductivity of Existing Wells in the Model Rural Areas**
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	



Electric Conductivity, EC (mS/m)

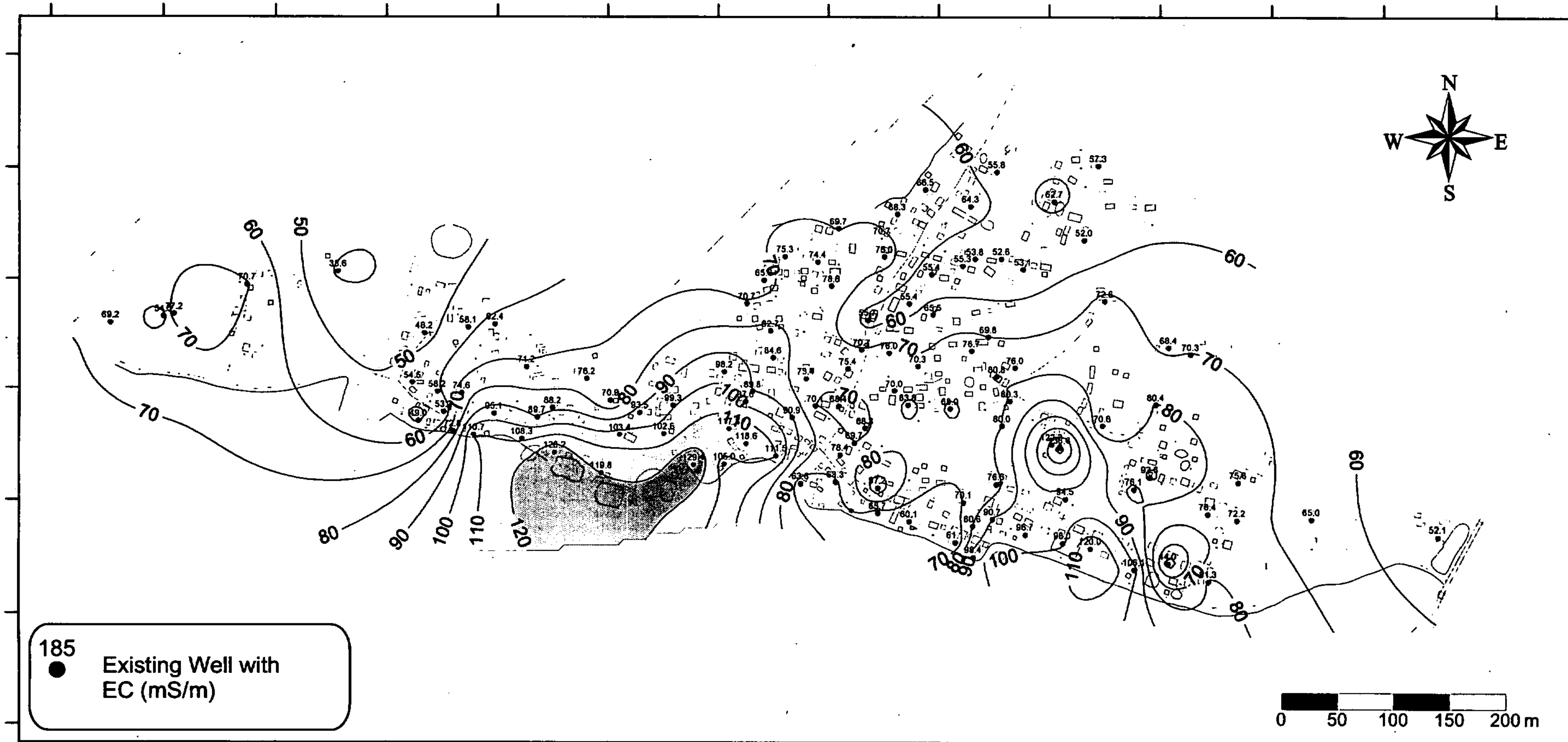
30 40 50 60 70 80 90 100 110 120 130 140

[The groundwater samples were collected from 172 existing wells in October 2000. The EC values were measured at the site by potable EC meter.]

Figure 6.3.22	EC Map of Bara Dudpatila Village (October 2000)

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



Electric Conductivity, EC (mS/m)

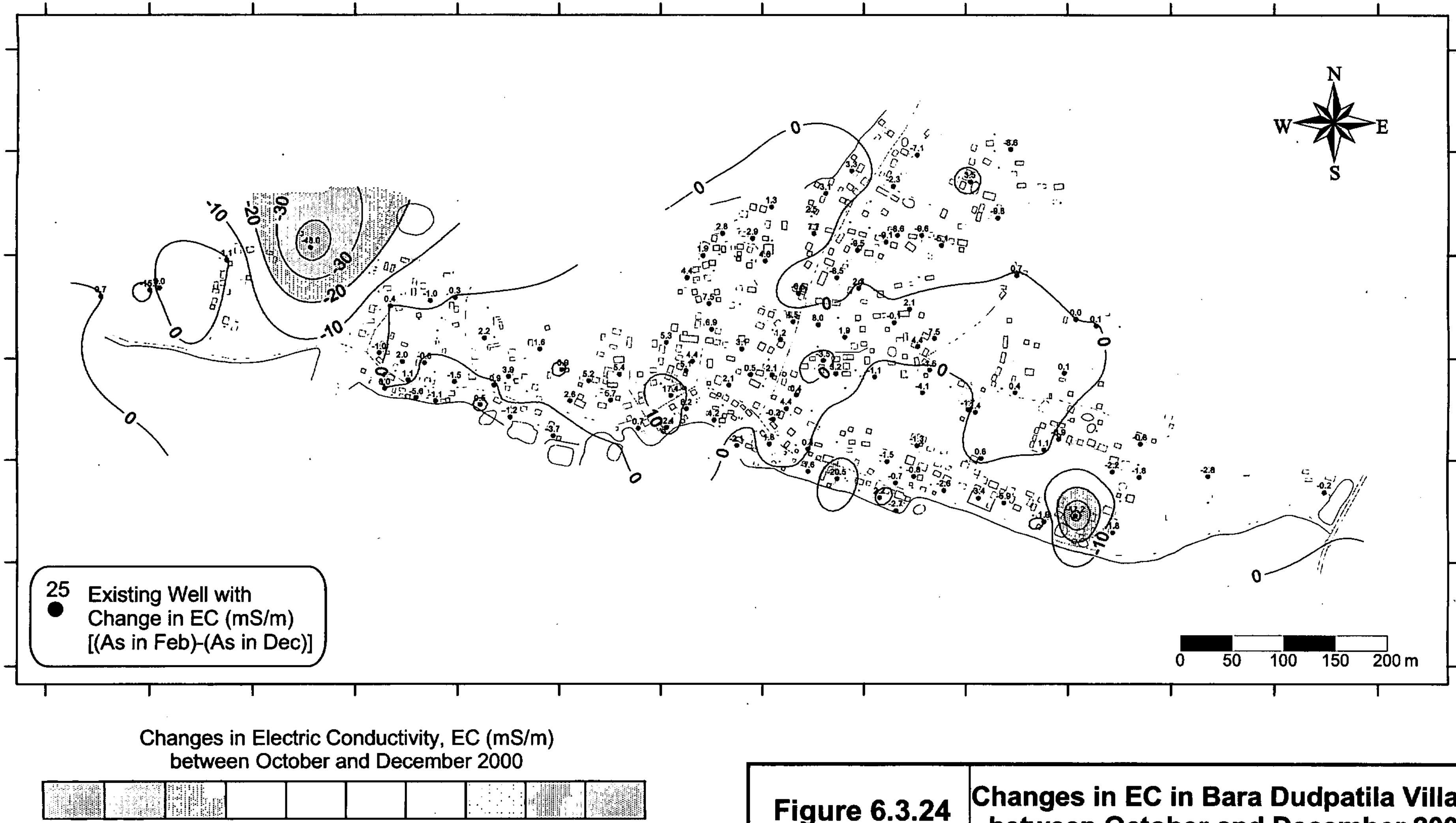
30	40	50	60	70	80	90	100	110	120	130	140

[The groundwater samples were collected from 112 existing wells in December 2000. The EC values were measured at the site by potable EC meter.]

Figure 6.3.23 **EC Map of Bara Dudpatila Village (December 2000)**

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

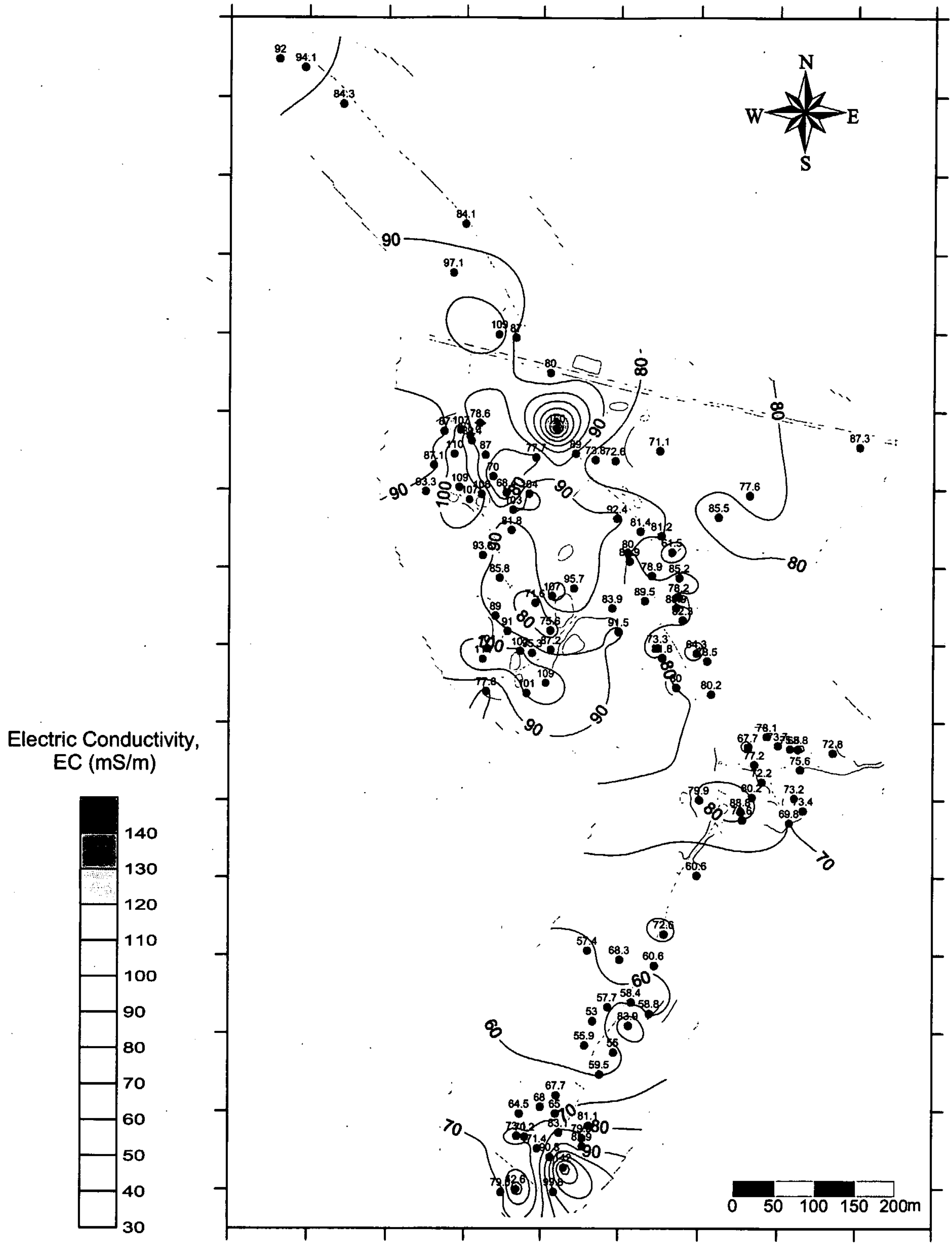


[A total of 112 existing wells' samples were used for the comparison between October and December 2000.
The EC values were measured at the site by Potable EC Meter.]

Figure 6.3.24	**Changes in EC in Bara Dudpatila Village between October and December 2000**

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

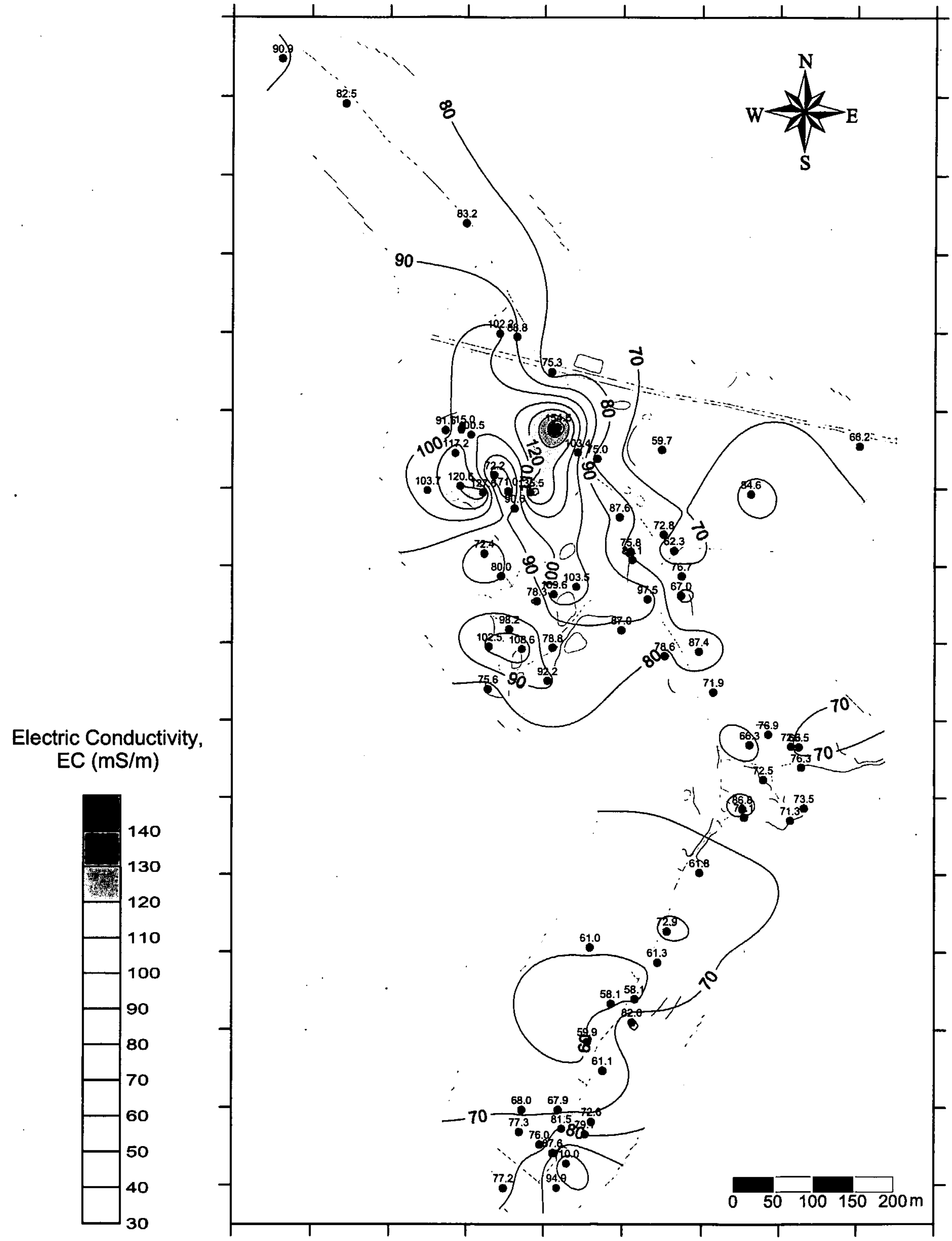
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



[The groundwater samples were collected from 115 existing wells in October 2000. The EC values were measured at the site by potable EC meter.]

53.8
● Existing Well with EC (mS/m)

Figure 6.3.25	EC Map of Krishna Chandrapur Village (October 2000)
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	



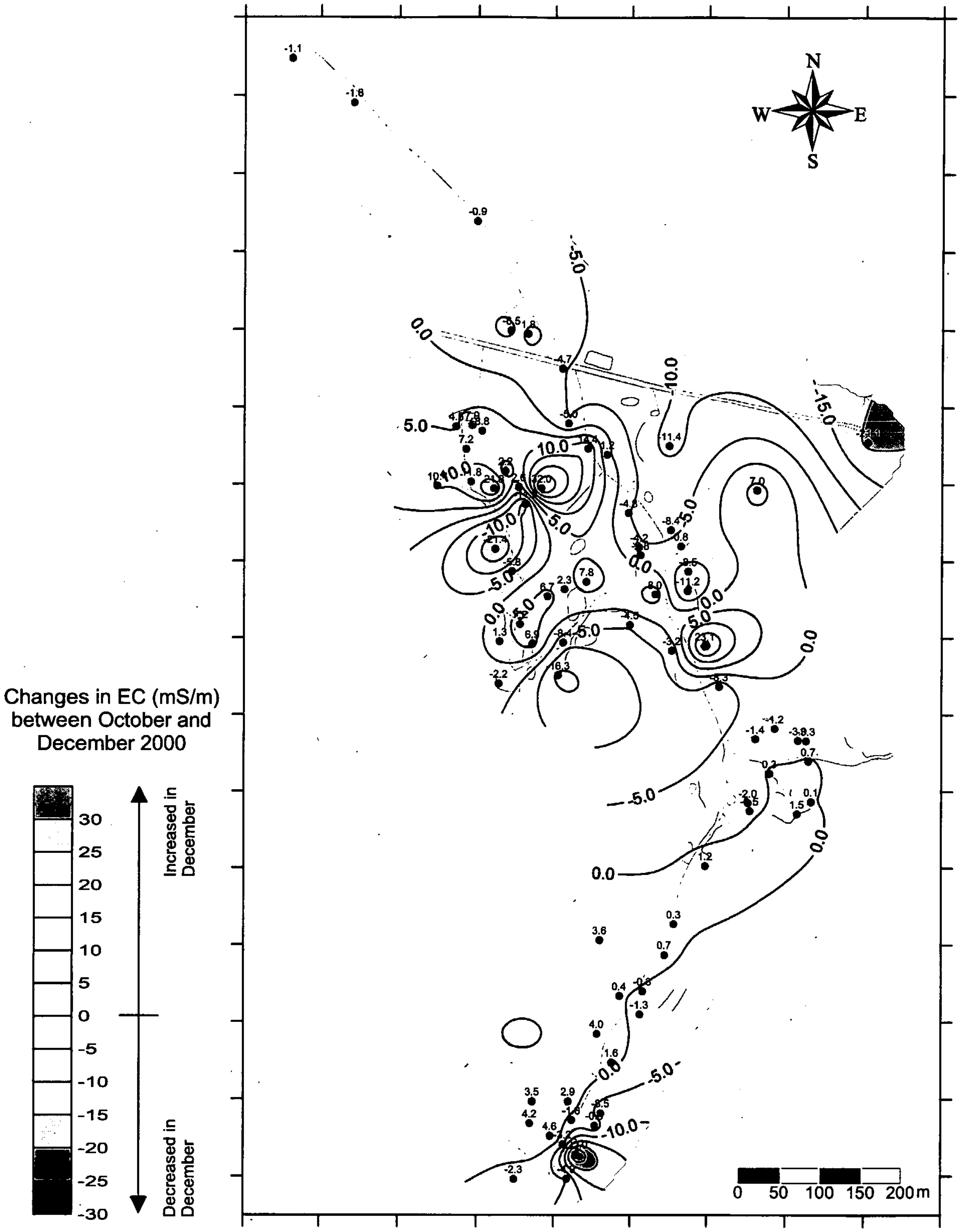
[The groundwater samples were collected from 76 existing wells in December 2000.
The EC values were measured at the site by potable EC meter.]

53.8
● Existing Well with EC (mS/m)

Figure 6.3.26	EC Map of Krishna Chandrapur Village (December 2000)

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



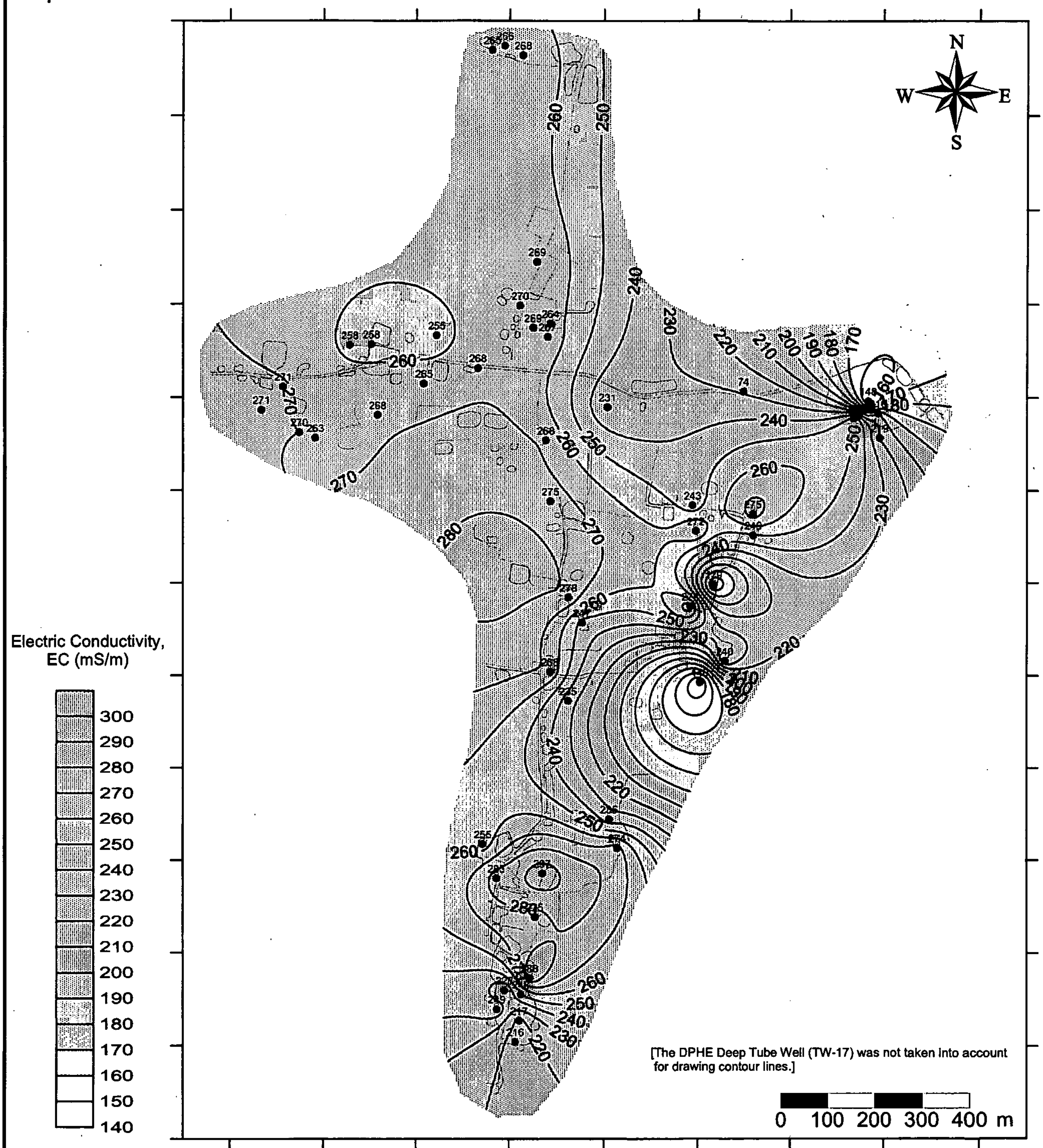
[A total of 76 existing wells' samples were used for the comparison between October and December 2000. The EC values were measured at the site by Potable EC Meter.]

12.5 ● Existing Well with Change in EC (mS/m) [(As in Dec)-(As in Oct)]

Figure 6.3.27	**Changes in EC in Krishna Chandrapur Village between October and December 2000**

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



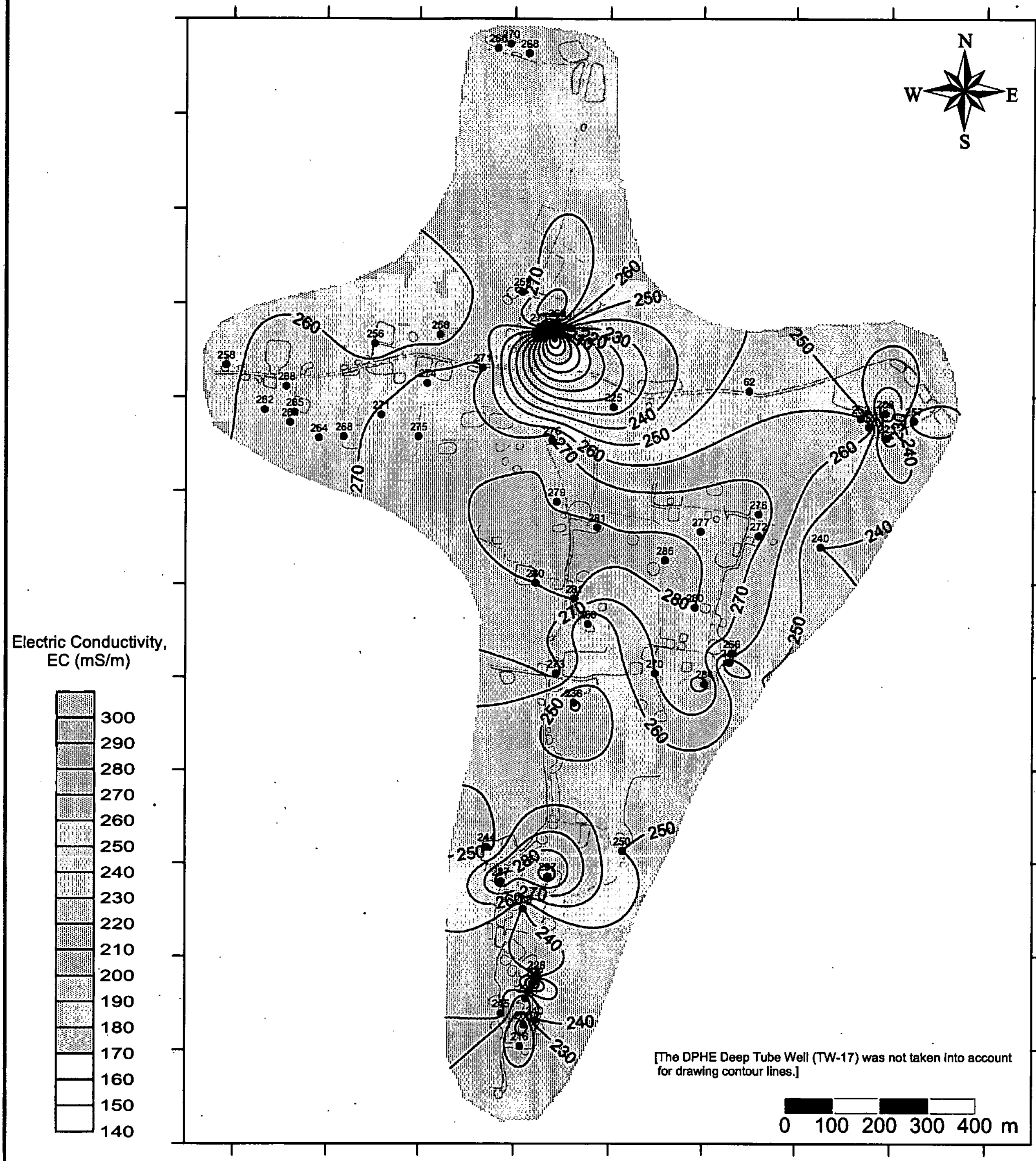
[The groundwater samples were collected from 50 existing wells in December 2000. The EC values were measured at the site by potable EC meter.]

185 ● Existing Well with EC (mS/m)

Figure 6.3.28	**EC Map of Rajnagar Bankabarsi Village (December 2000)**

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



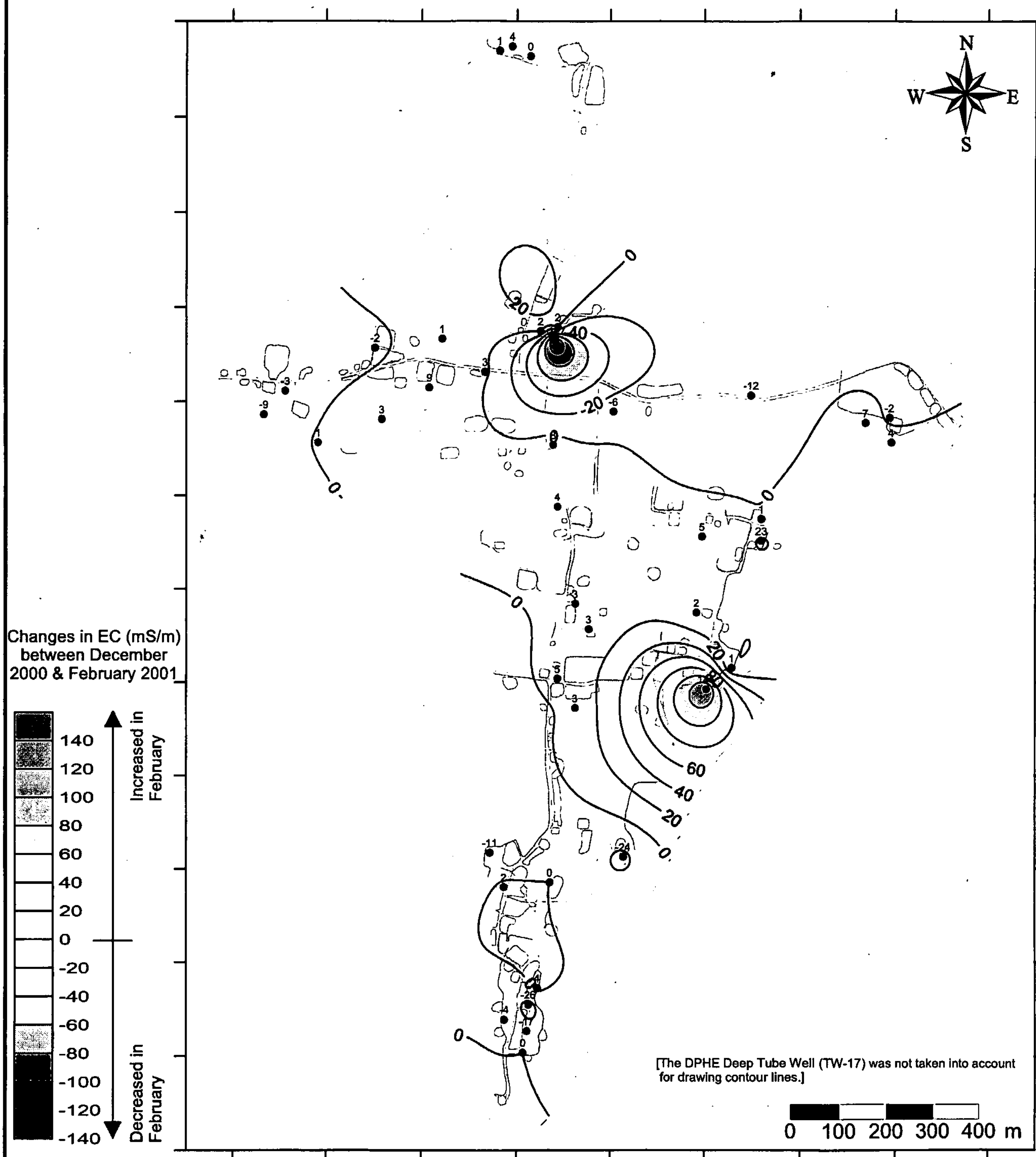
185 ● Existing Well with EC (mS/m)

[The groundwater samples were collected from 58 existing wells in February 2001. The EC values were measured at the site by potable EC meter.]

Figure 6.3.29	EC Map of Rajnagar Bankabarsi Village (February 2001)

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

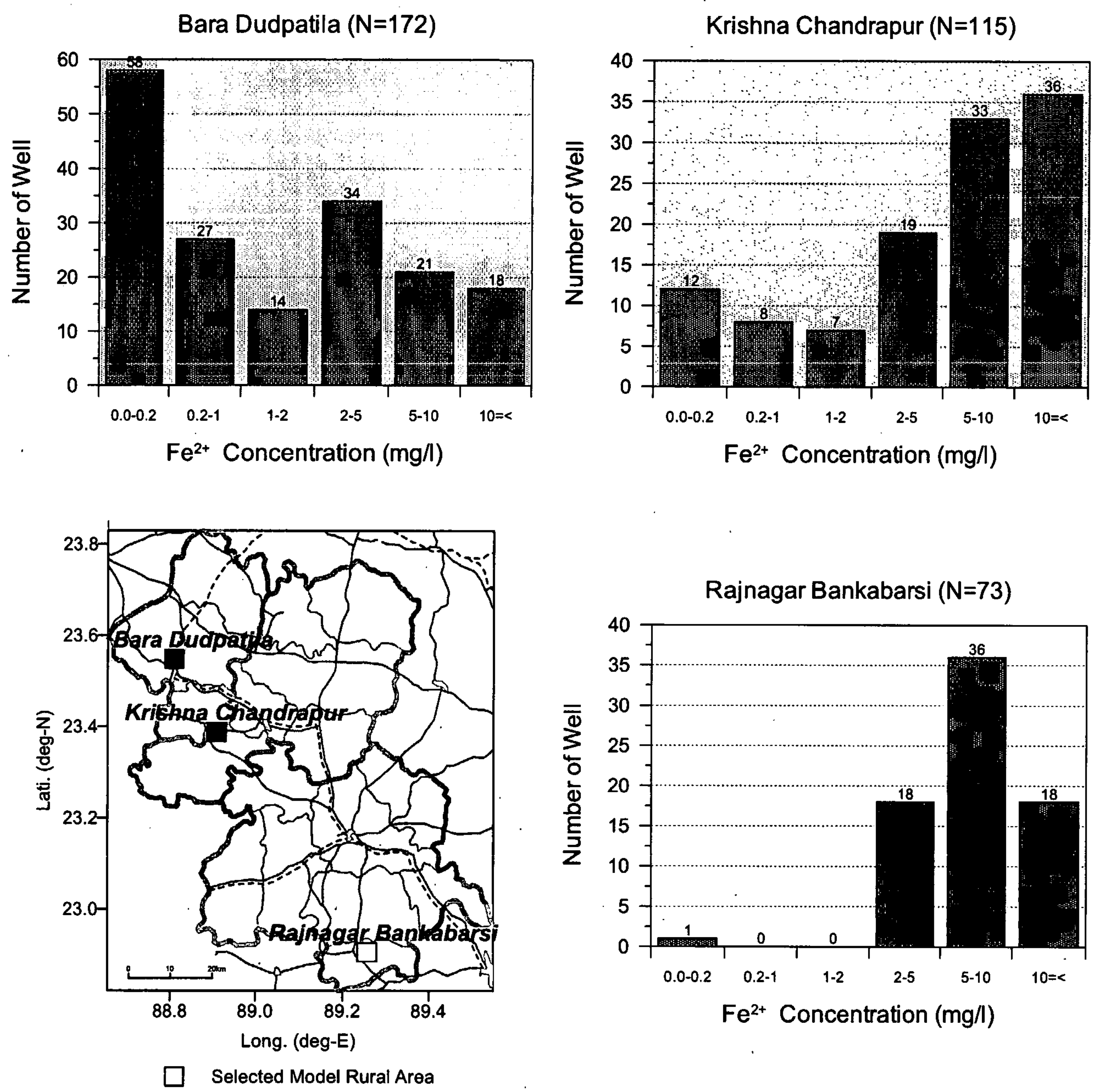
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



[A total of 41 existing wells' samples were used for the comparison between December 2000 and February 2001. The EC values were measured at the site by Potable EC Meter.]

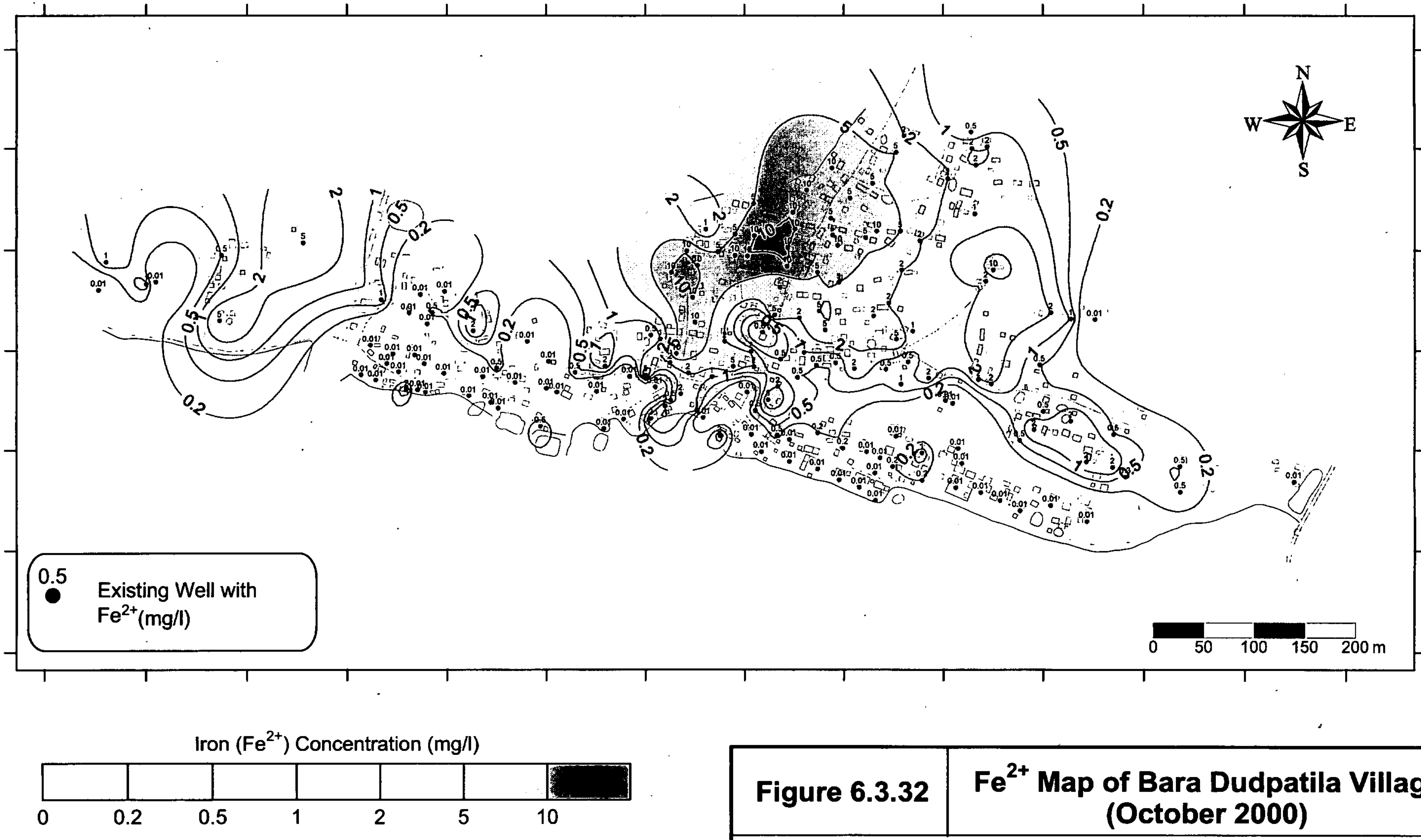
25 ● Existing Well with Change in EC (mS/m) [(As in Feb)-(As in Dec)]

Figure 6.3.30	Changes in EC in Rajnagar Bankabarsi Village between December 2000 and February 2001
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	



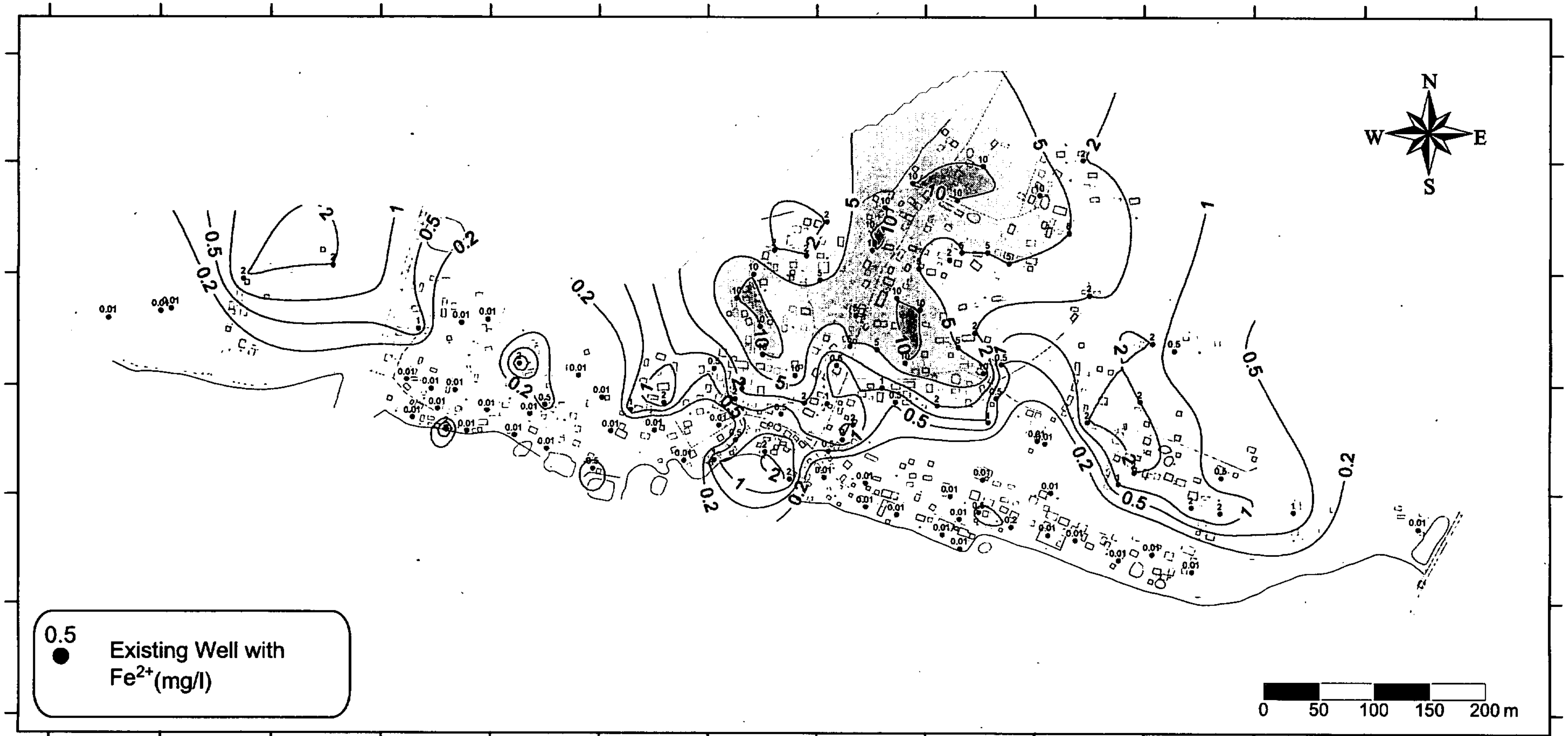
[The Fe^{2+} values of existing wells in the model rural areas were measured by Iron Pack Test Kit in October 2000.]

Figure 6.3.31	Fe^{2+} Concentration of Existing Wells in the Model Rural Areas
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	



[The groundwater samples were collected from 172 existing wells in October 2000. The Fe^{2+} concentrations were measured at the site by Iron Pack Test Kit.]

Figure 6.3.32	Fe^{2+} Map of Bara Dudpatila Village (October 2000)
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	

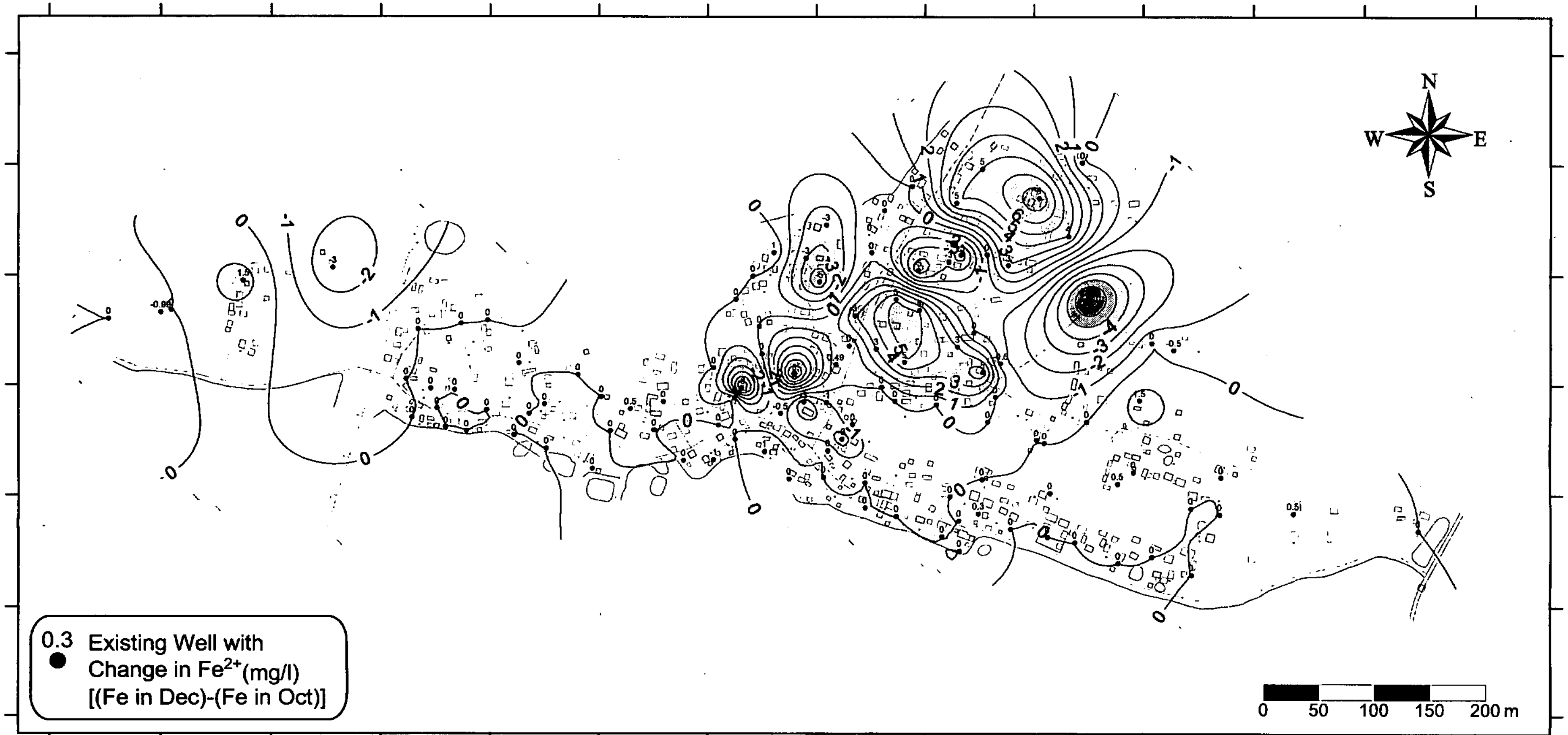


Iron (Fe^{2+}) Concentration (mg/l)

0	0.2	0.5	1	2	5	10

[The groundwater samples were collected from 112 existing wells in December 2000. The Fe^{2+} concentrations were measured at the site by Iron Pack Test Kit.]

Figure 6.3.33	Fe^{2+} Map of Bara Dudpatila Village (December 2000)
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	

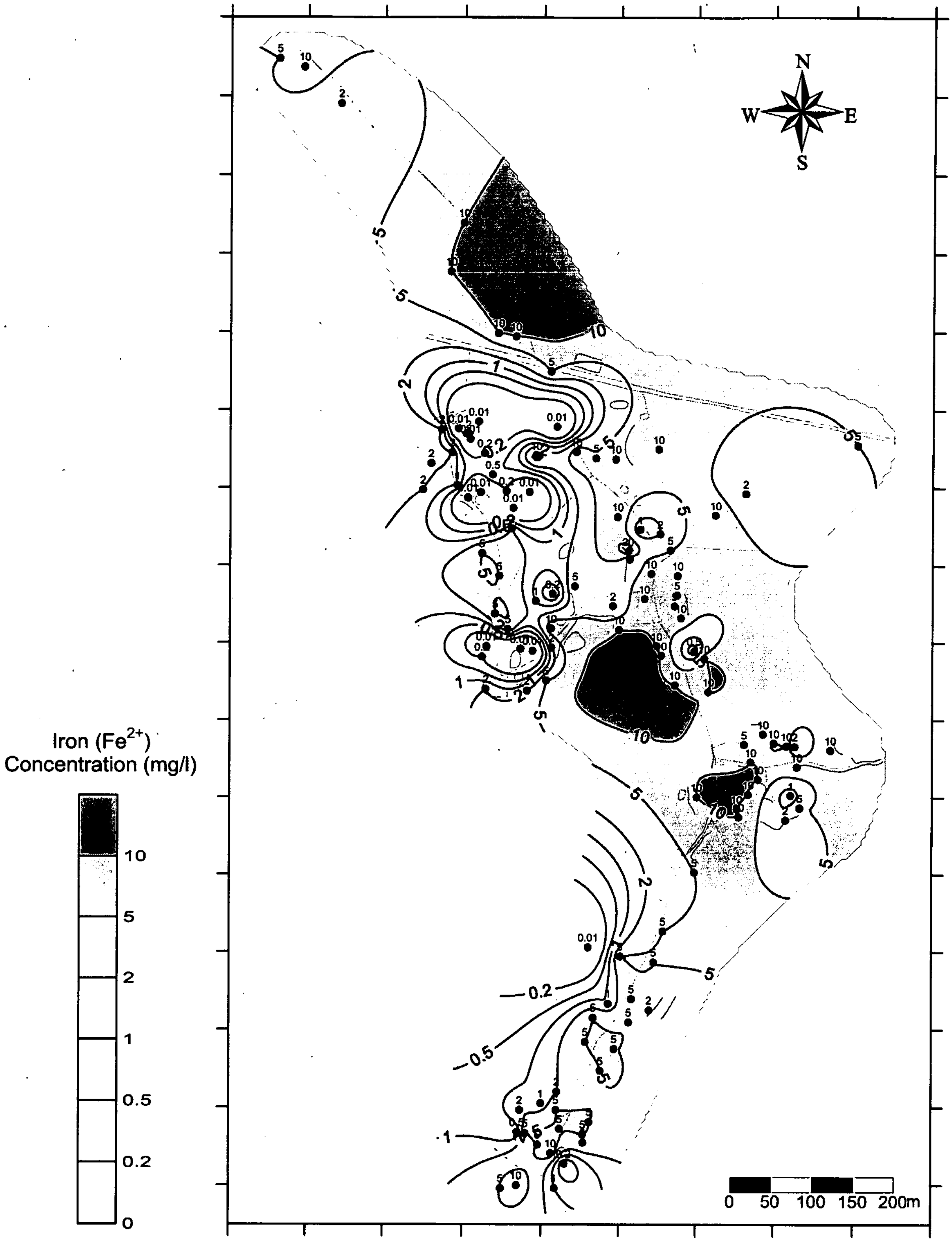


Changes in Iron (Fe^{2+}) Concentration (mg/l)
between October and December 2000

-8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7

[A total of 112 existing wells' samples were used for the comparison between October and December 2000.
The Fe^{2+} concentrations were measured at the site by Iron Pack Test Kit.]

Figure 6.3.34	Changes in Fe^{2+} in Bara Dudpatila Village between October and December 2000
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	



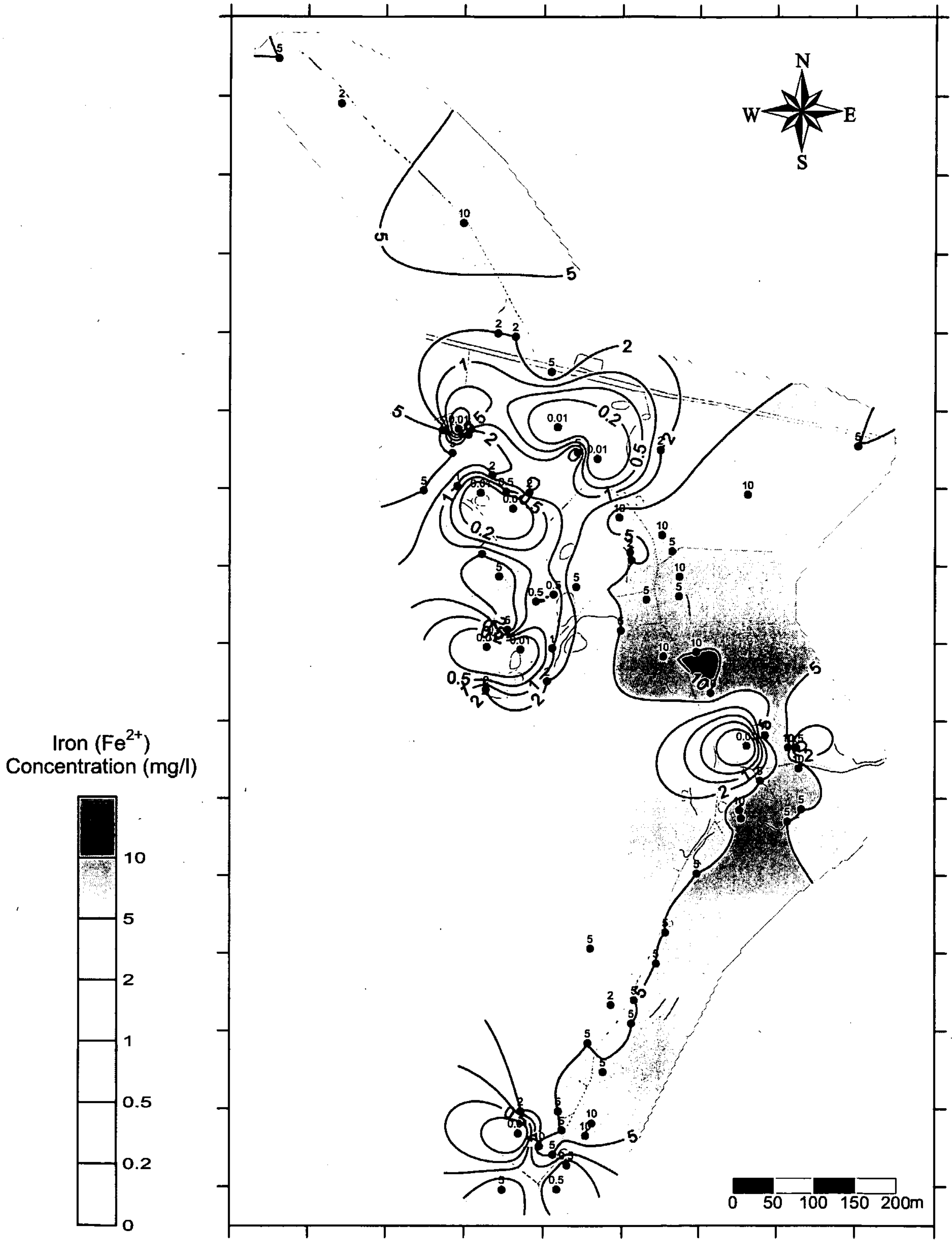
[The groundwater samples were collected from 115 existing wells in October 2000. The Fe^{2+} concentrations were measured at the site by Iron Pack Test Kit.]

5.0 ● Existing Well with Fe^{2+}(mg/l)

Figure 6.3.35	Fe^{2+} Map of Krishna Chandrapur Village (October 2000)

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



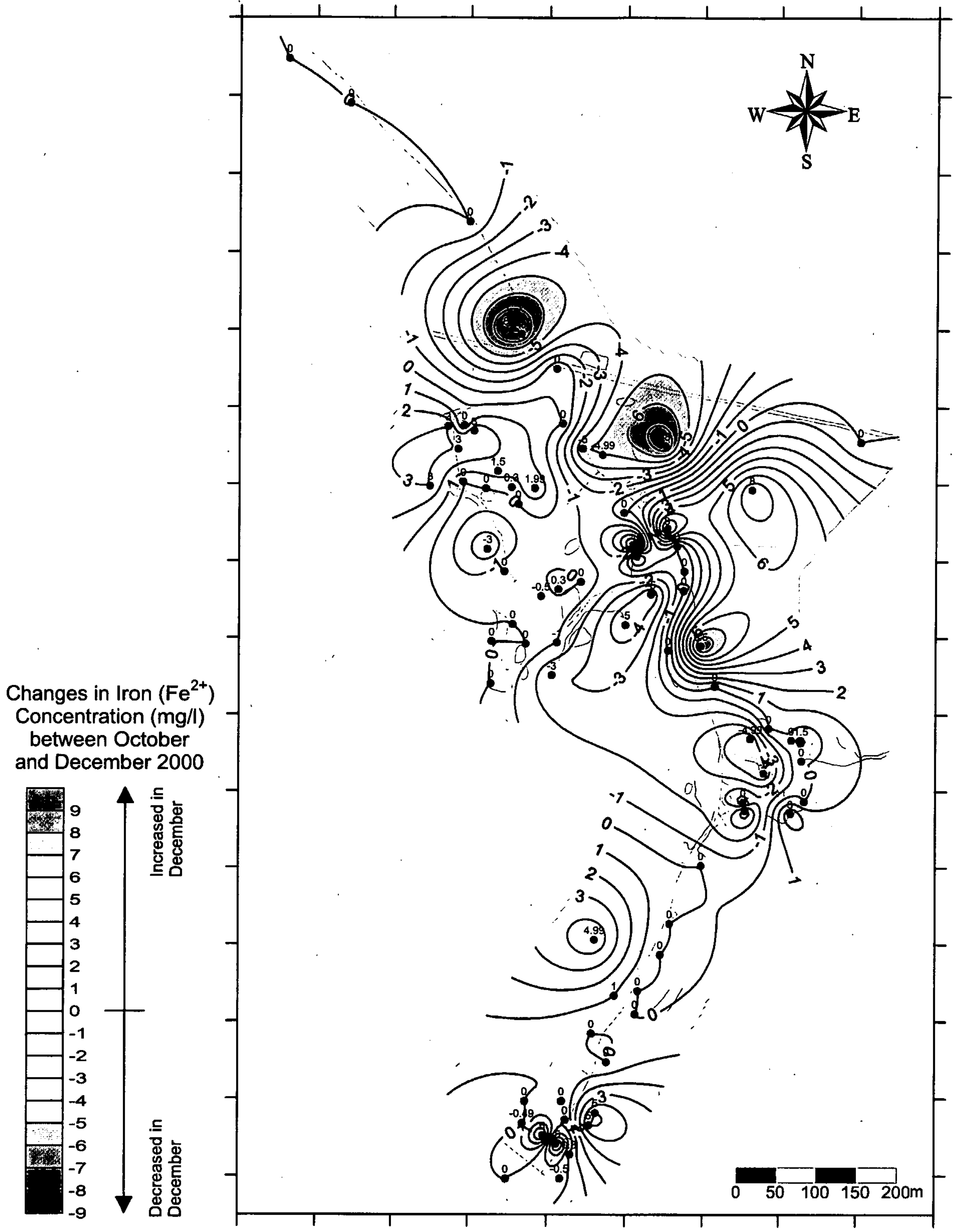
[The groundwater samples were collected from 76 existing wells in December 2000. The Fe^{2+} concentrations were measured at the site by Iron Pack Test Kit.]

0.5
● Existing Well with Fe^{2+}(mg/l)

Figure 6.3.36	Fe^{2+} Map of Krishna Chandrapur Village (December 2000)

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

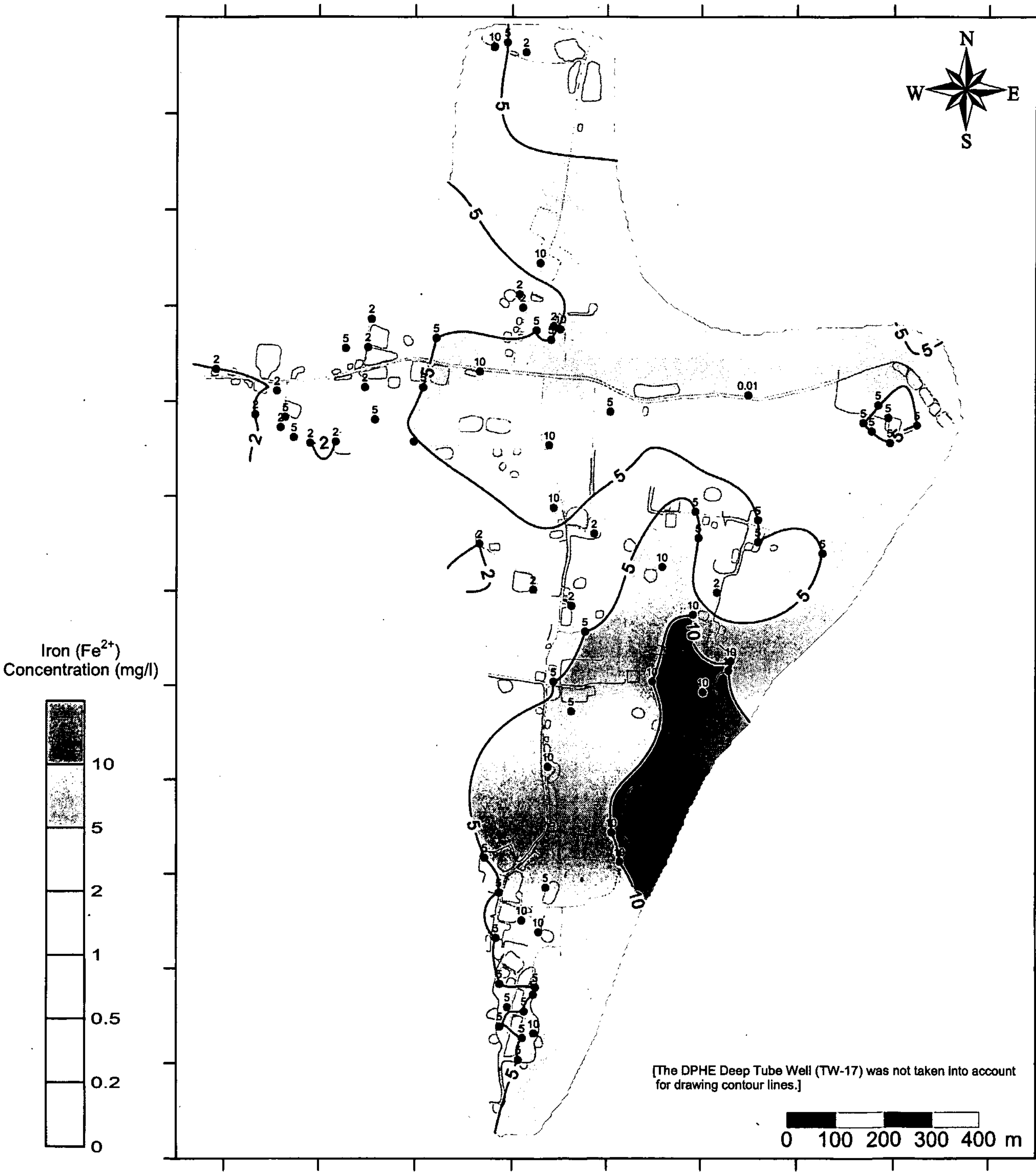
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



[A total of 76 existing wells' samples were used for the comparison between October and December 2000. The Fe^{2+} concentrations were measured at the site by Iron Pack Test Kit.]

0.3 ● Existing Well with Change in Fe^{2+}(mg/l) [(Fe in Dec)-(Fe in Oct)]

Figure 6.3.37	Changes in Fe^{2+} in Krishna Chandrapur Village between October and December 2000
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	



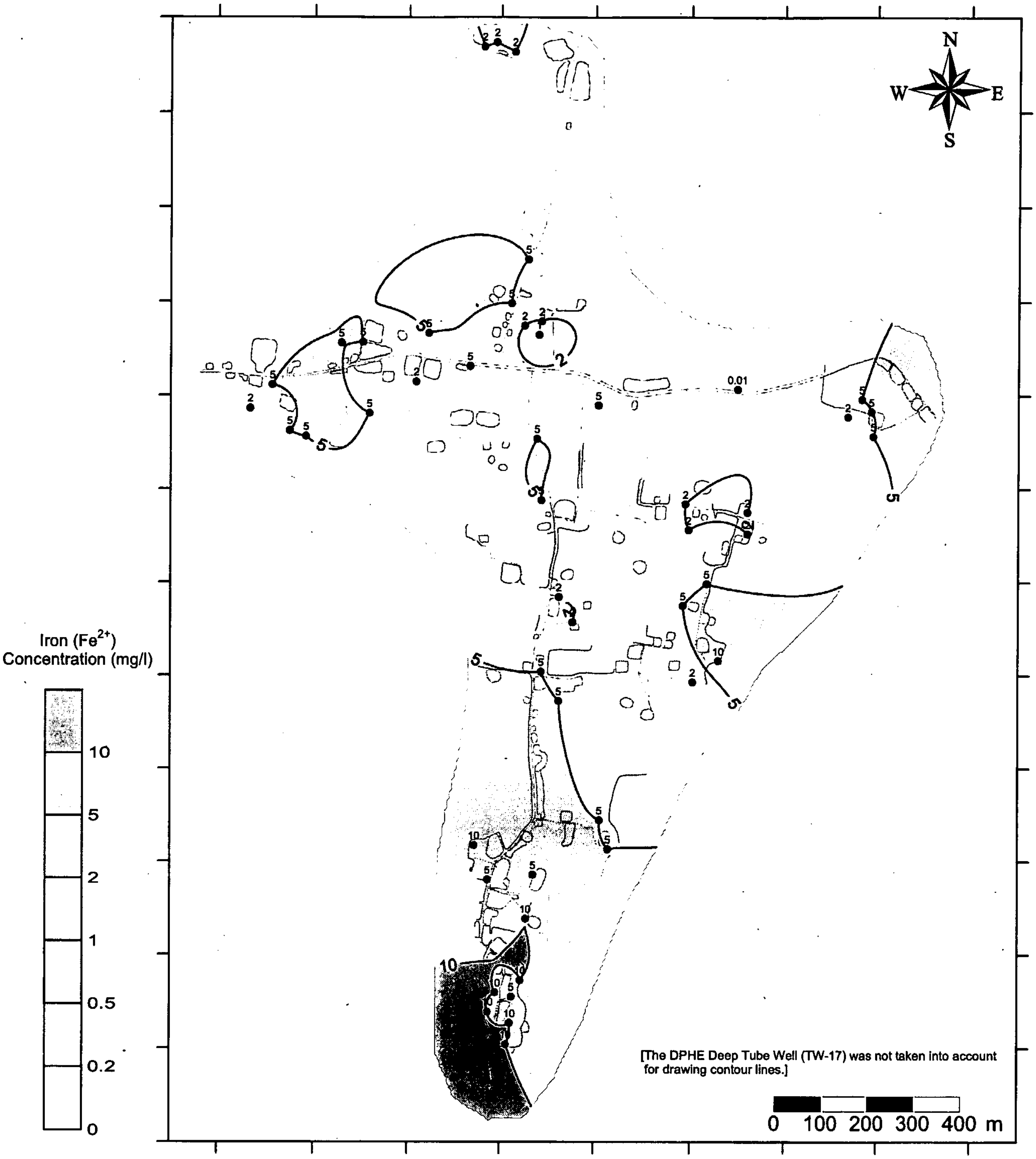
[The groundwater samples were collected from 74 existing wells in October 2000. The Fe^{2+} concentrations were measured at the site by Iron Pack Test Kit.]

5.0 ● Existing Well with Fe^{2+}(mg/l)

Figure 6.3.38	Fe^{2+} Map of Rajnagar Bankabarsi Village (October 2000)

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



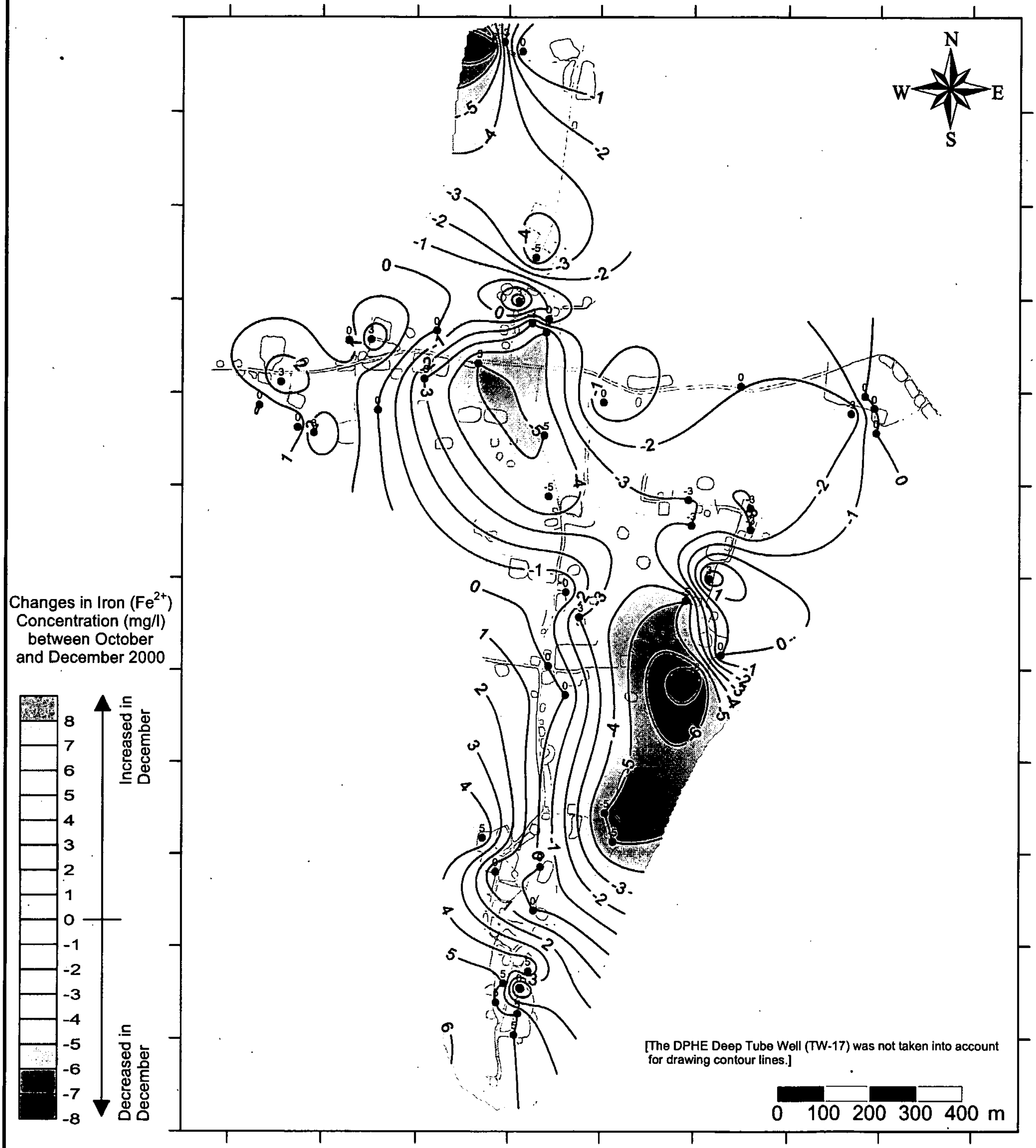
[The groundwater samples were collected from 50 existing wells in December 2000. The Fe^{2+} concentrations were measured at the site by Iron Pack Test Kit.]

5.0 ● Existing Well with Fe^{2+}(mg/l)

Figure 6.3.39	Fe^{2+} Map of Rajnagar Bankabarsi Village (December 2000)

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



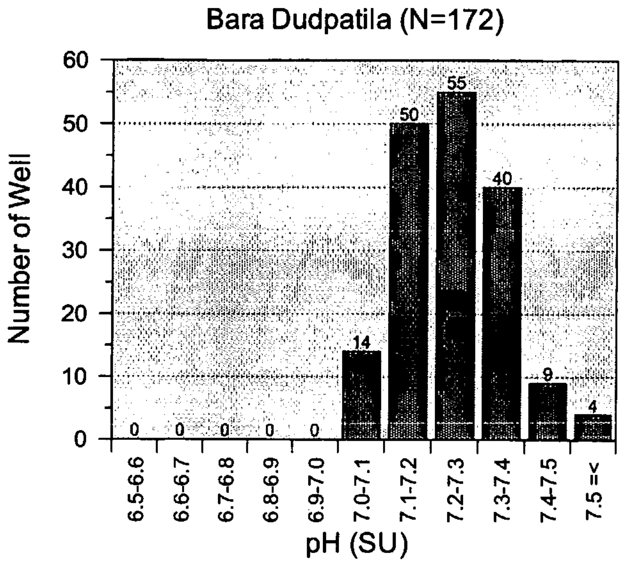
[A total of 50 existing wells' samples were used for the comparison between October and December 2000. The Fe^{2+} concentrations were measured at the site by Iron Pack Test Kit.]

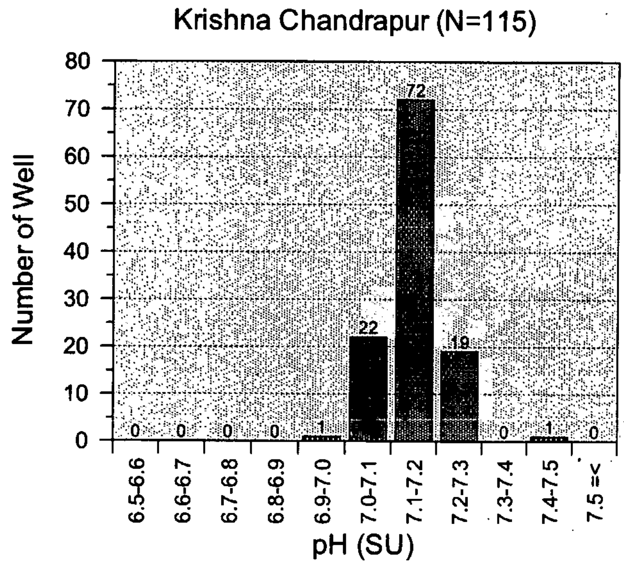
0.3 ● Existing Well with Change in Fe^{2+}(mg/l) [(Fe in Dec)-(Fe in Oct)]

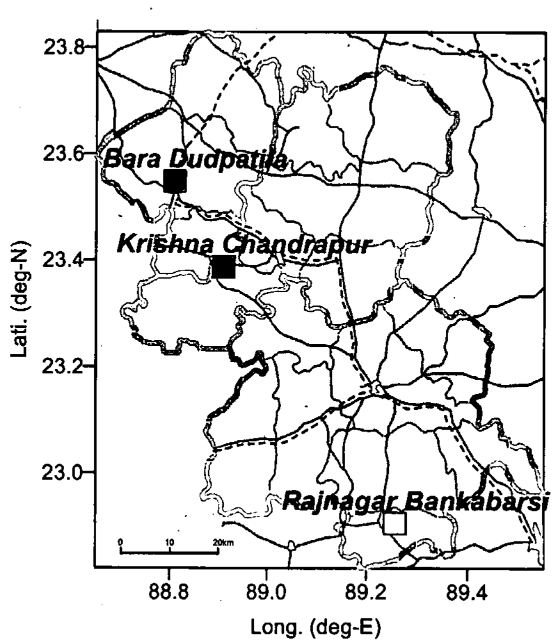
Figure 6.3.40	Changes in Fe^{2+} in Rajnagar Bankabarsi Village between October and December 2000

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

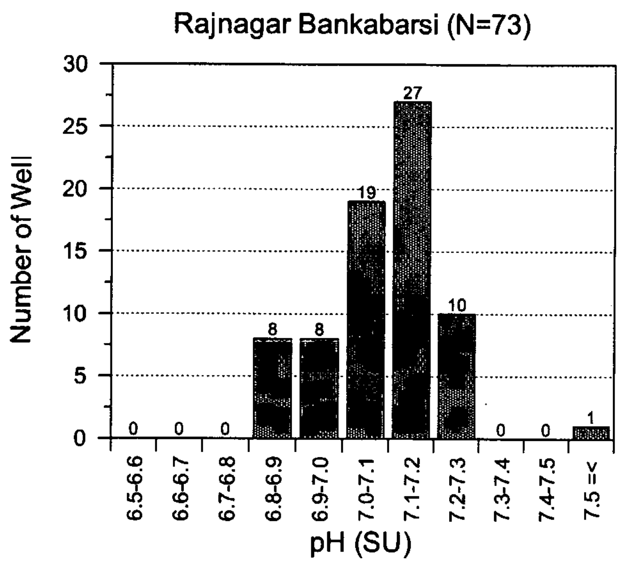
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)





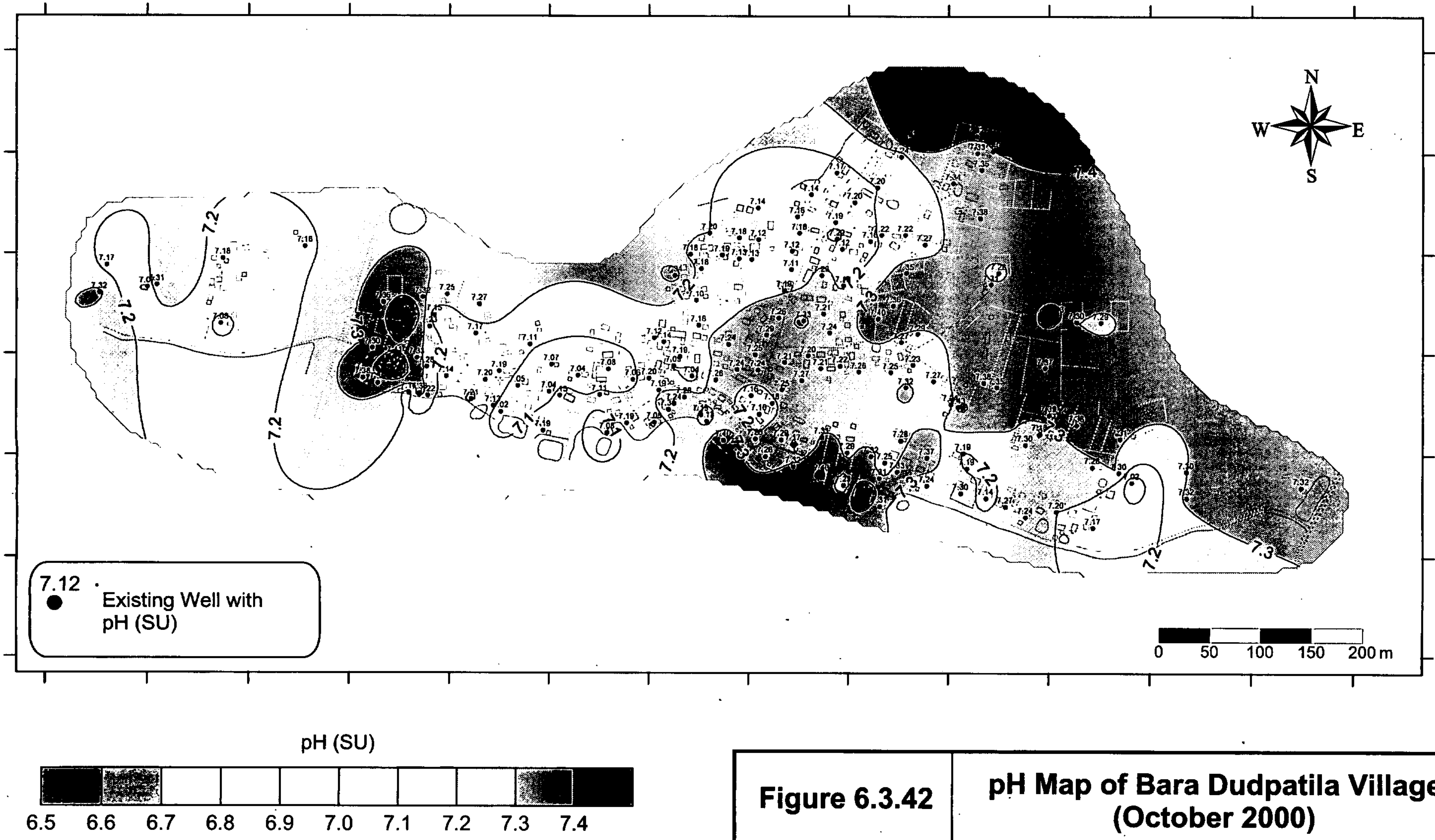


Selected Model Rural Area



[The pH values of existing wells in the model rural areas were measured by Potable pH Meter in October 2000.]

Figure 6.3.41	pH values of Existing Wells in the Model Rural Areas
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	

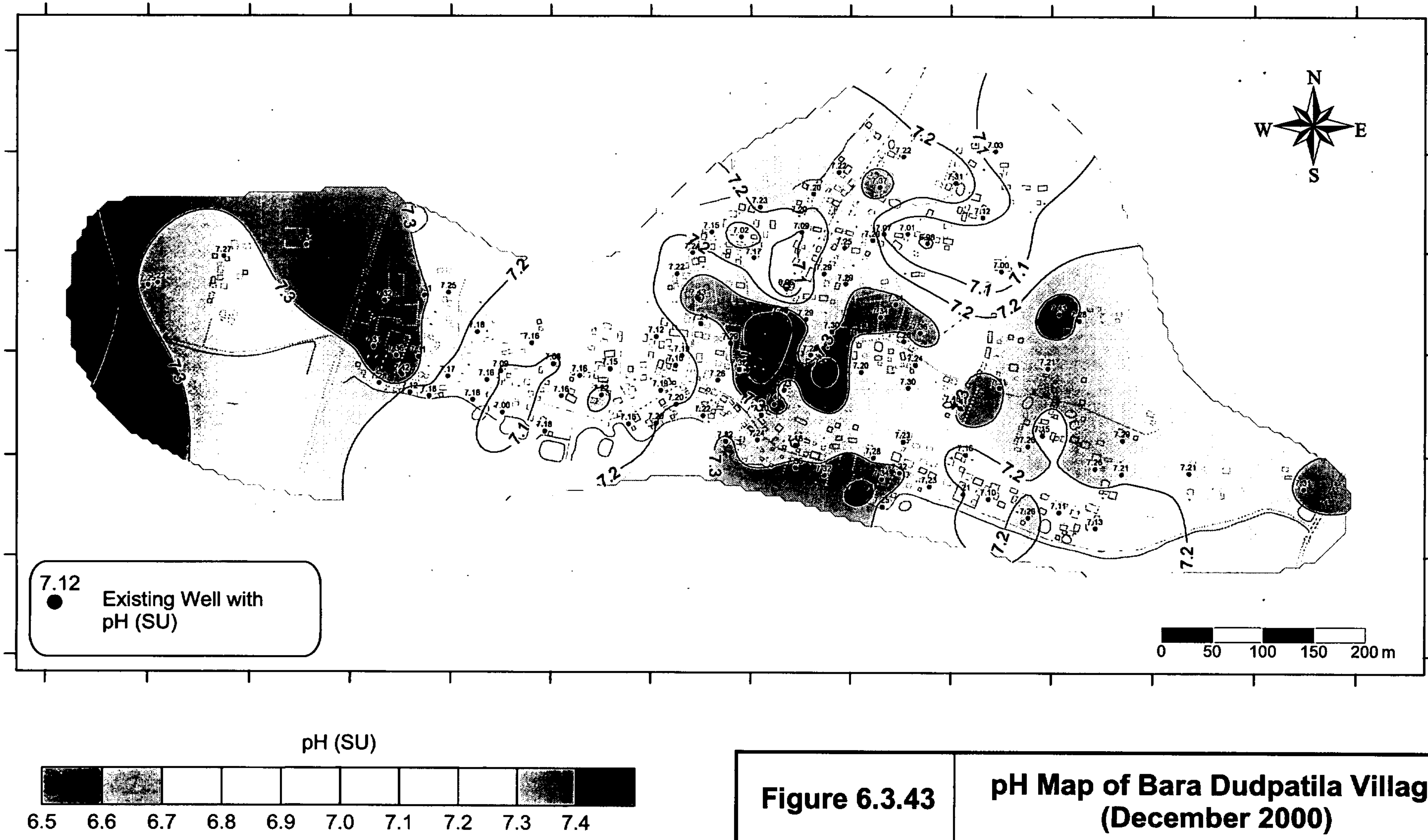


[The groundwater samples were collected from 172 existing wells in October 2000. The pH values were measured at the site by Potable pH Meter.]

Figure 6.3.42	pH Map of Bara Dudpatila Village (October 2000)

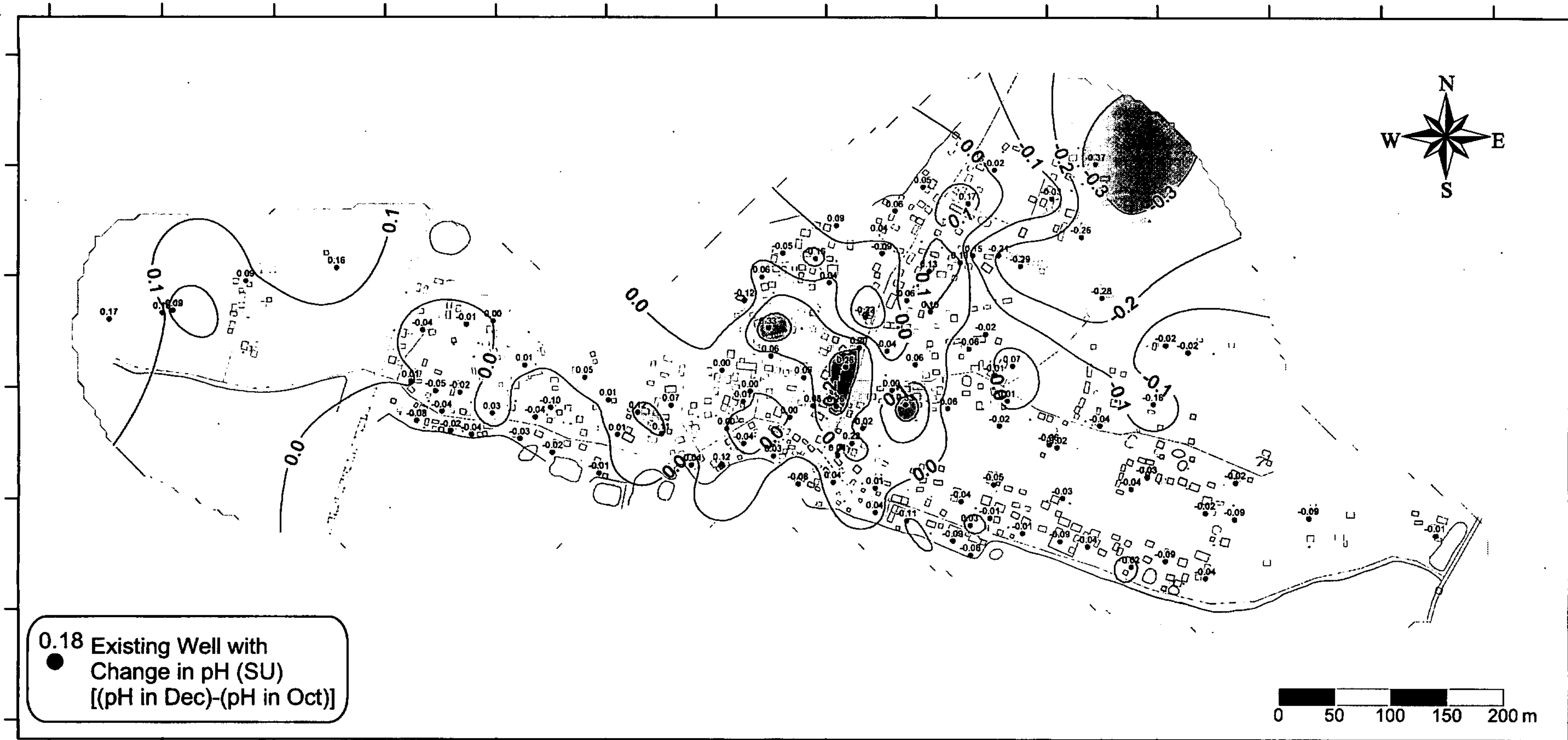
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



[The groundwater samples were collected from 112 existing wells in December 2000. The pH values were measured at the site by Potable pH Meter.]

Figure 6.3.43	pH Map of Bara Dudpatila Village (December 2000)
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	

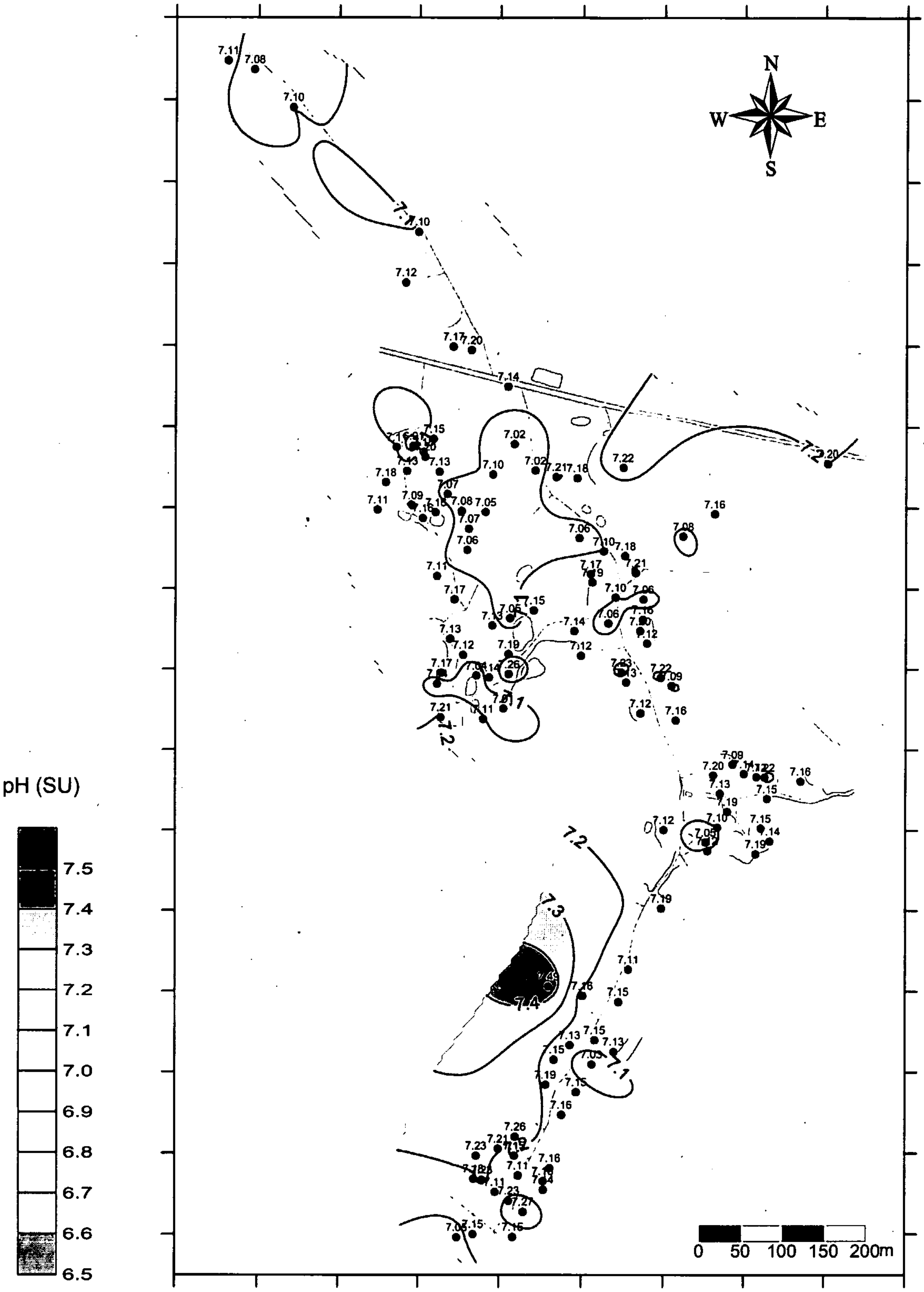


Changes in pH (SU)
between October and December 2000

-0.4 -0.3 -0.2 -0.1 0.0 0.1 0.2 0.3

[A total of 112 existing wells' samples were used for the comparison between October and December 2000.
The pH values were measured at the site by Potable pH Meter.]

Figure 6.3.44	Changes in pH in Bara Dudpatila Village between October and December 2000
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	



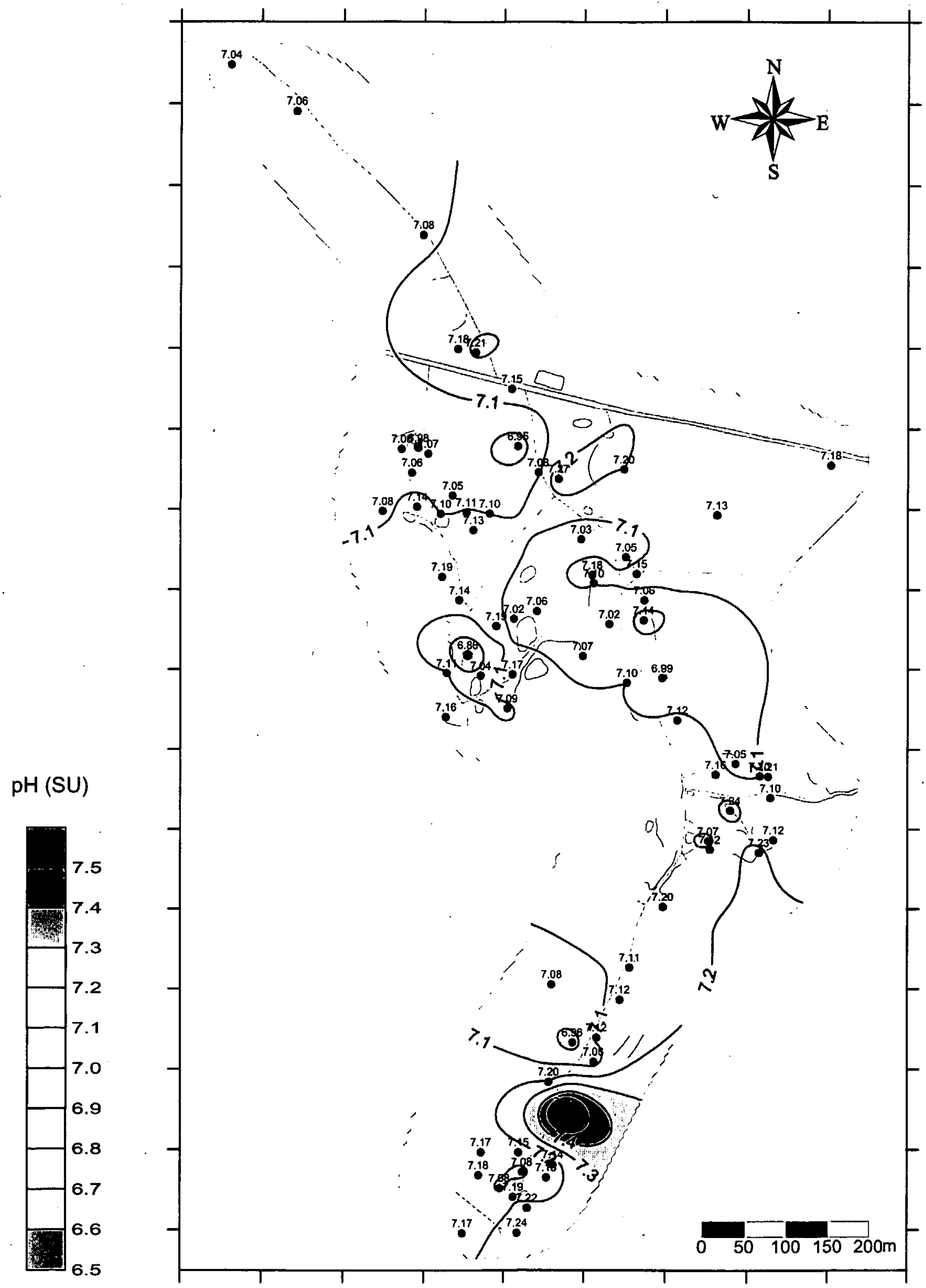
[The groundwater samples were collected from 115 existing wells in October 2000. The pH values were measured at the site by Potable pH Meter.]

7.15
● Existing Well with pH (SU)

Figure 6.3.45	**pH Map of Krishna Chandrapur Village (October 2000)**

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



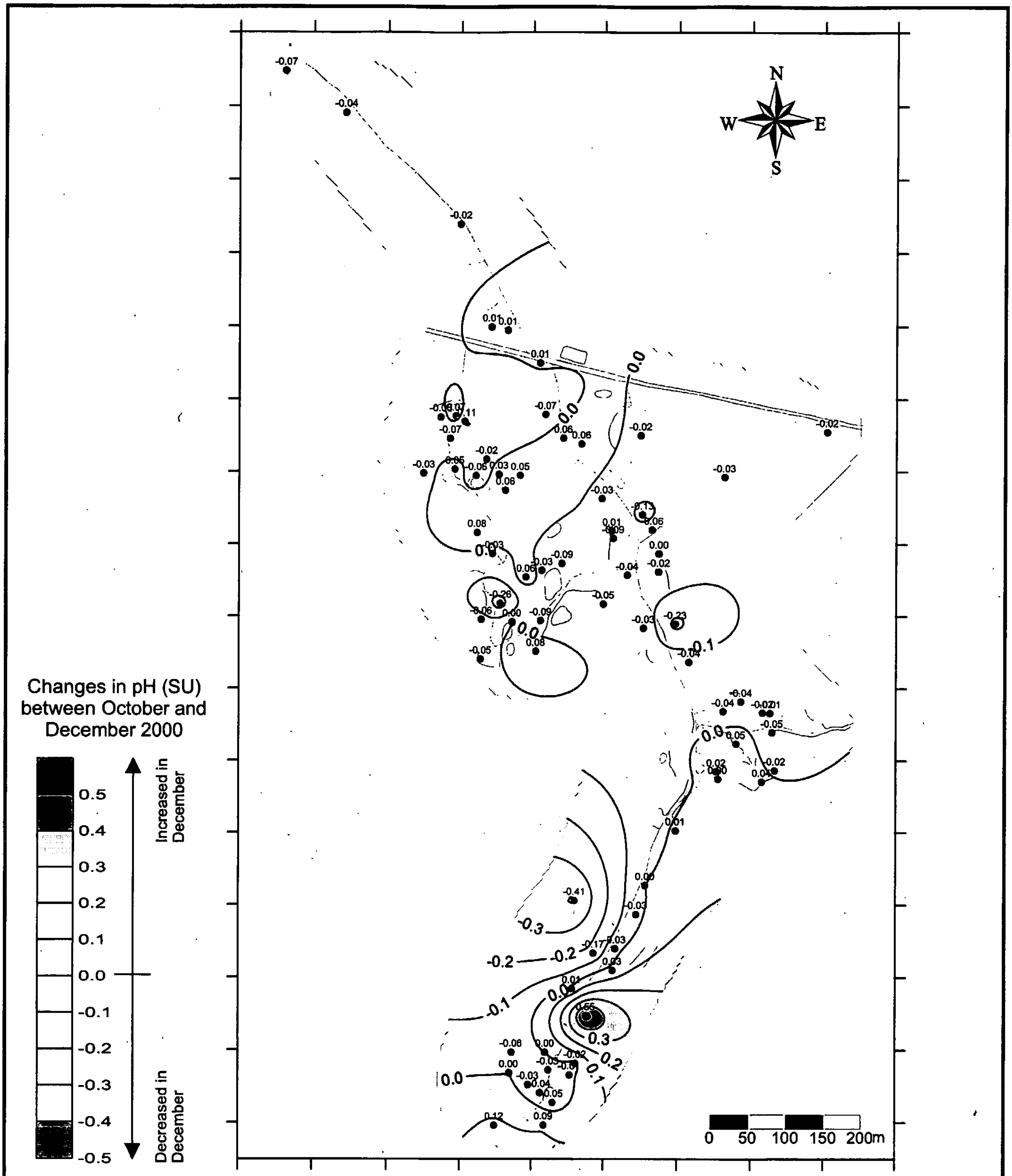
[The groundwater samples were collected from 76 existing wells in December 2000. The pH values were measured at the site by Potable pH Meter.]

7.15 ● Existing Well with pH (SU)

Figure 6.3.46	pH Map of Krishna Chandrapur Village (December 2000)

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

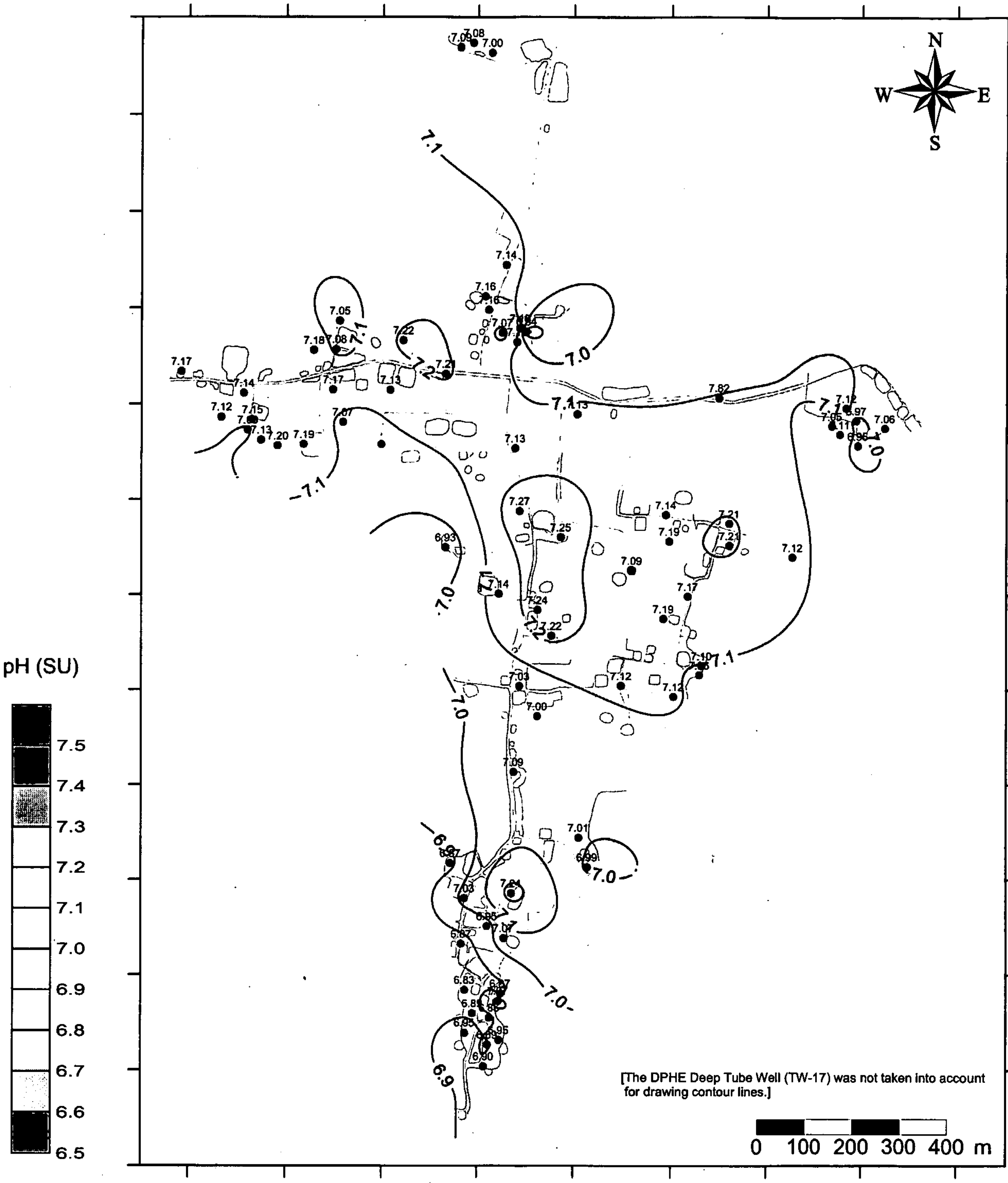
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



[A total of 76 existing wells' samples were used for the comparison between October and December 2000. The pH values were measured at the site by Potable pH Meter.]

-0.25 ● Existing Well with Change in pH (SU) [(pH in Dec)-(pH in Oct)]

Figure 6.3.47	Changes in pH in Krishna Chandrapur Village between October and December 2000
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	



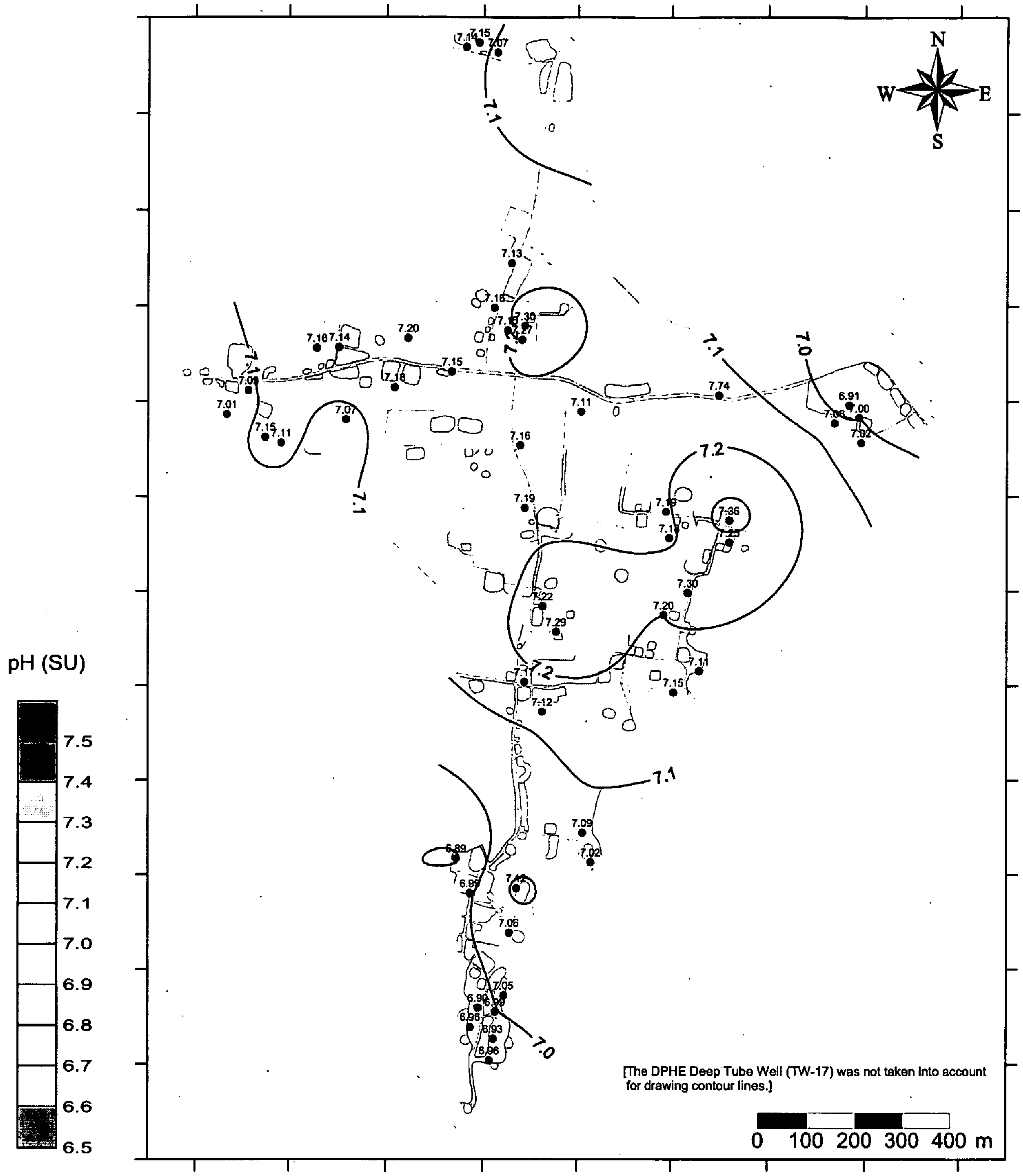
[The groundwater samples were collected from 74 existing wells in October 2000. The pH values were measured at the site by Potable pH Meter.]

7.12 ● Existing Well with pH (SU)

Figure 6.3.48	pH Map of Rajnagar Bankabarsi Village (October 2000)

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



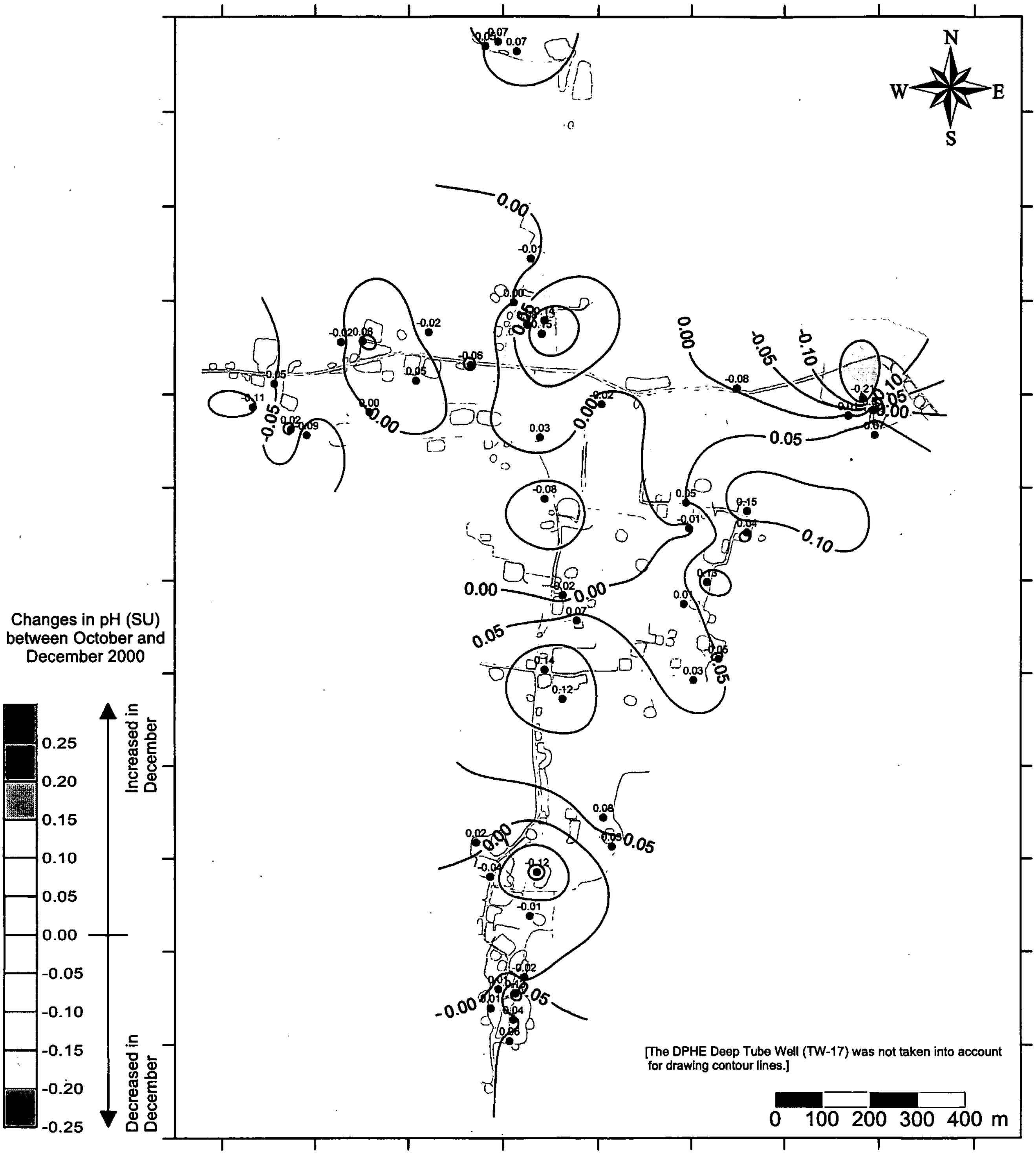
[The groundwater samples were collected from 50 existing wells in December 2000. The pH values were measured at the site by Potable pH Meter.]

7.12 ● Existing Well with pH (SU)

Figure 6.3.49	pH Map of Rajnagar Bankabarsi Village (December 2000)

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



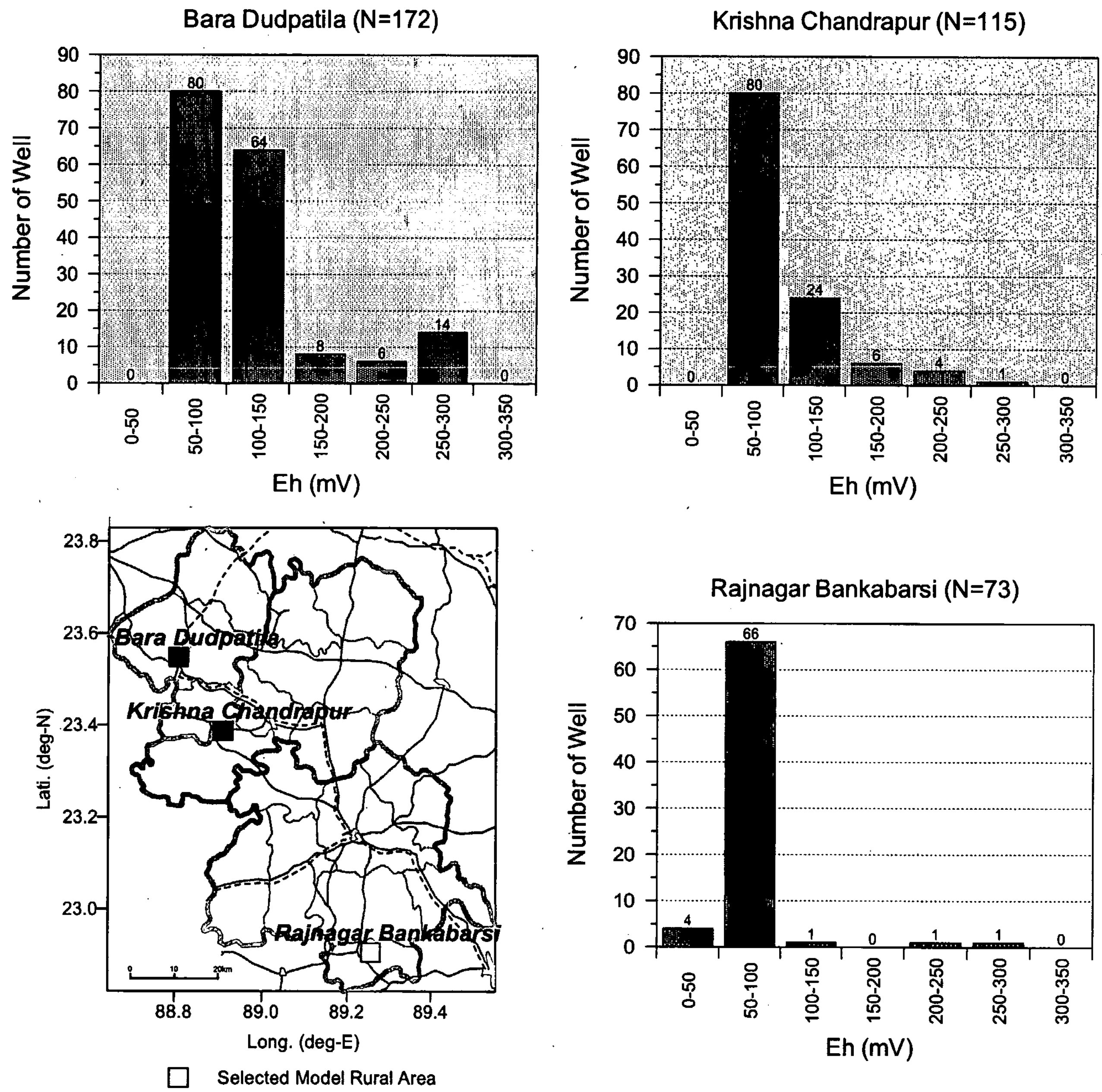
[A total of 50 existing wells' samples were used for the comparison between October and December 2000. The pH values were measured at the site by Potable pH Meter.]

0.18 ● Existing Well with Change in pH (SU) [(pH in Dec)-(pH in Oct)]

Figure 6.3.50 — **Changes in pH in Rajnagar Bankabarsi Village between October and December 2000**

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

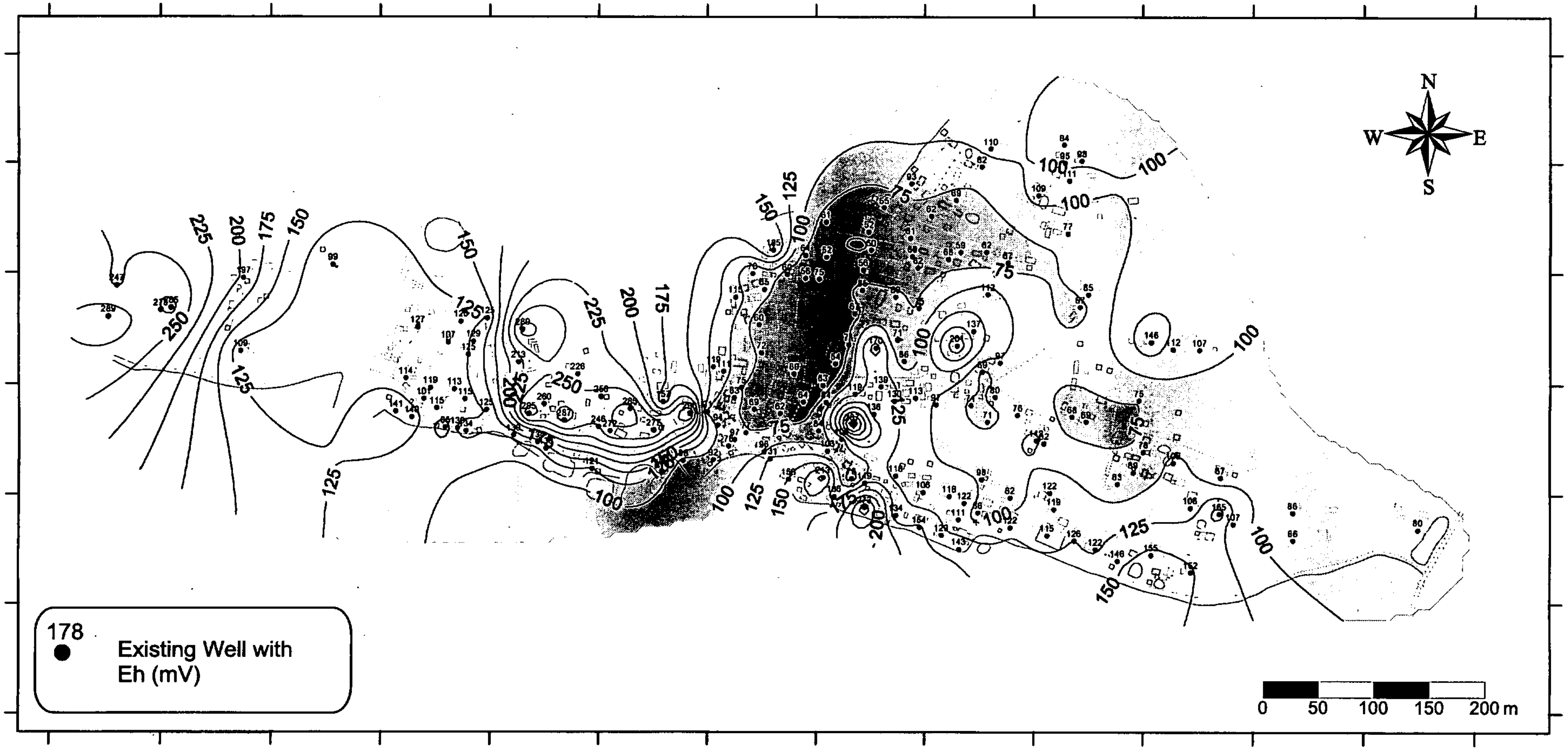


[The ORP values of existing wells in the model rural areas were measured by Potable ORP Meter in October 2000.
Then, the reading ORP values were converted into Eh values by:
Eh (mV) = [ORP meter reading value (mV)] - 0.71978 * [Temp (deg-C)] + 224.363]]

Figure 6.3.51	Eh values of Existing Wells in the Model Rural Areas

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



Oxidation-Reduction Potential, Eh (mV)

0 25 50 75 100 125 150 175 200 225 250 275 300

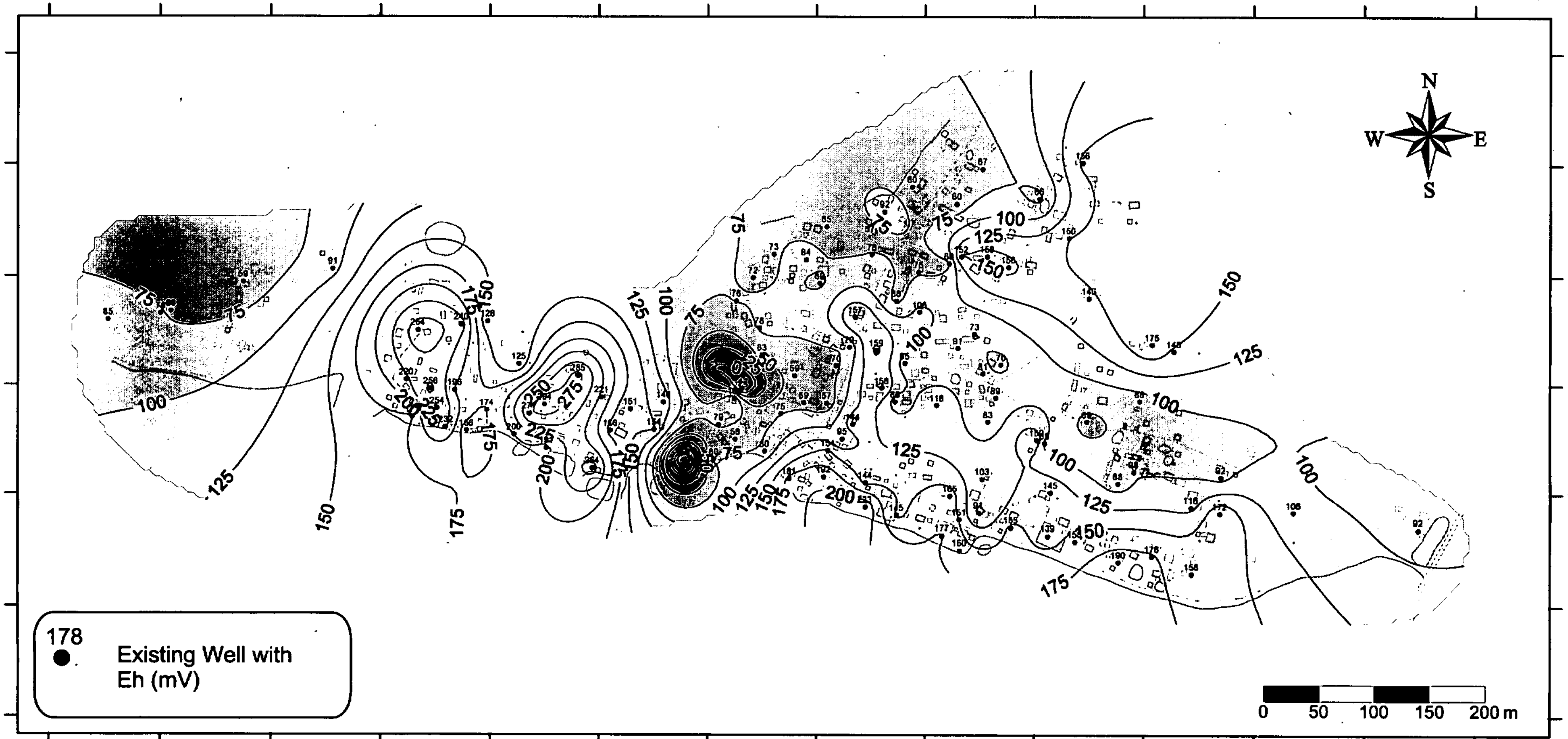
[The groundwater samples were collected from 172 existing wells in October 2000.
The ORP values were measured at the site by Potable ORP Meter.
Then, the reading ORP values were converted into Eh values by:
Eh (mV) = [ORP meter reading value (mV)] - 0.71978 * [Temp (deg-C)] + 224.363]

Figure 6.3.52

Eh Map of Bara Dudpatila Village (October 2000)

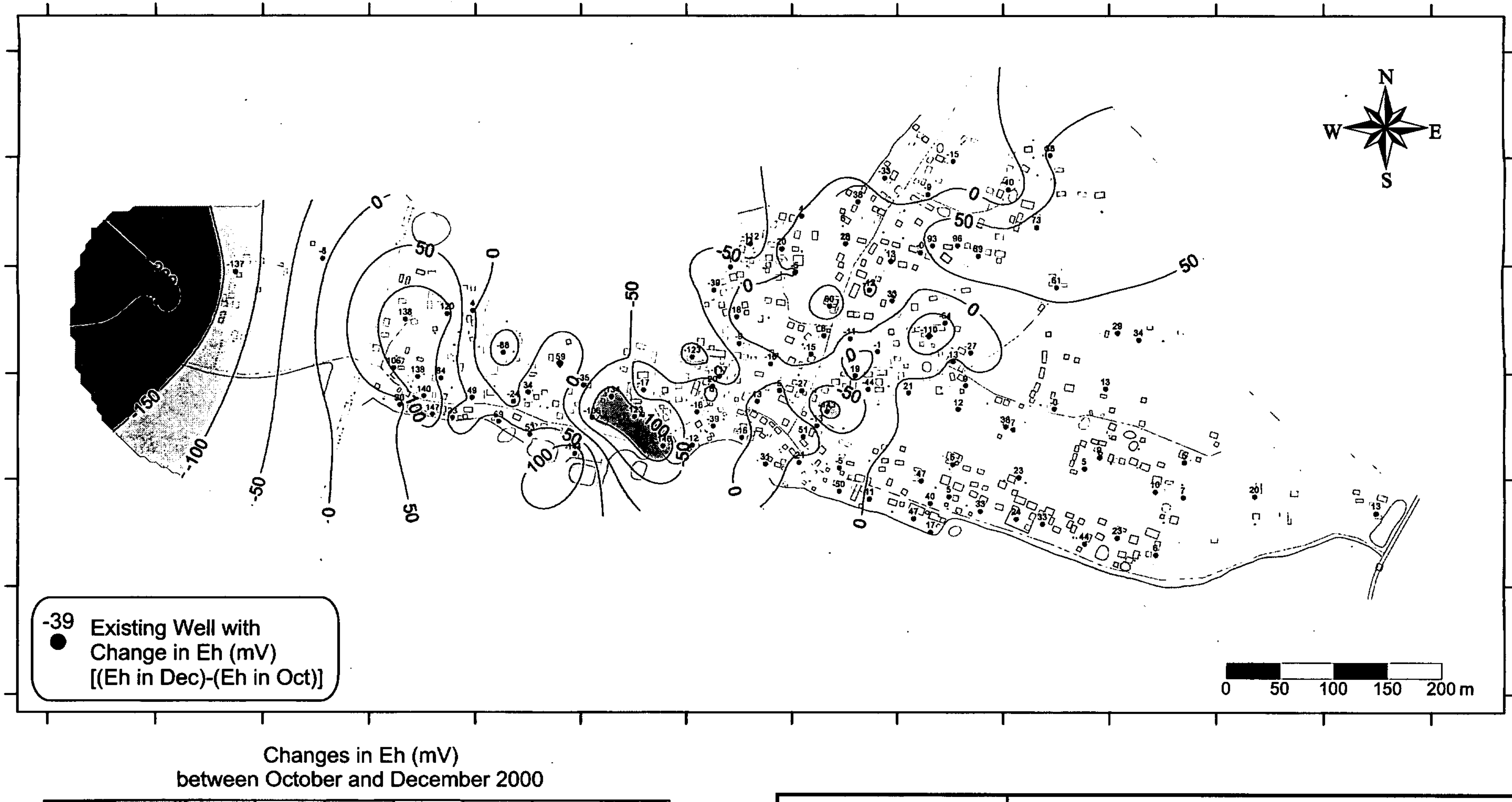
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



[The groundwater samples were collected from 112 existing wells in December 2000.
The ORP values were measured at the site by Potable ORP Meter.
Then, the reading ORP values were converted into Eh values by:
Eh (mV) = [ORP meter reading value (mV)] - 0.71978 * [Temp (deg-C)] + 224.363]

Figure 6.3.53	Eh Map of Bara Dudpatila Village (December 2000)
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	

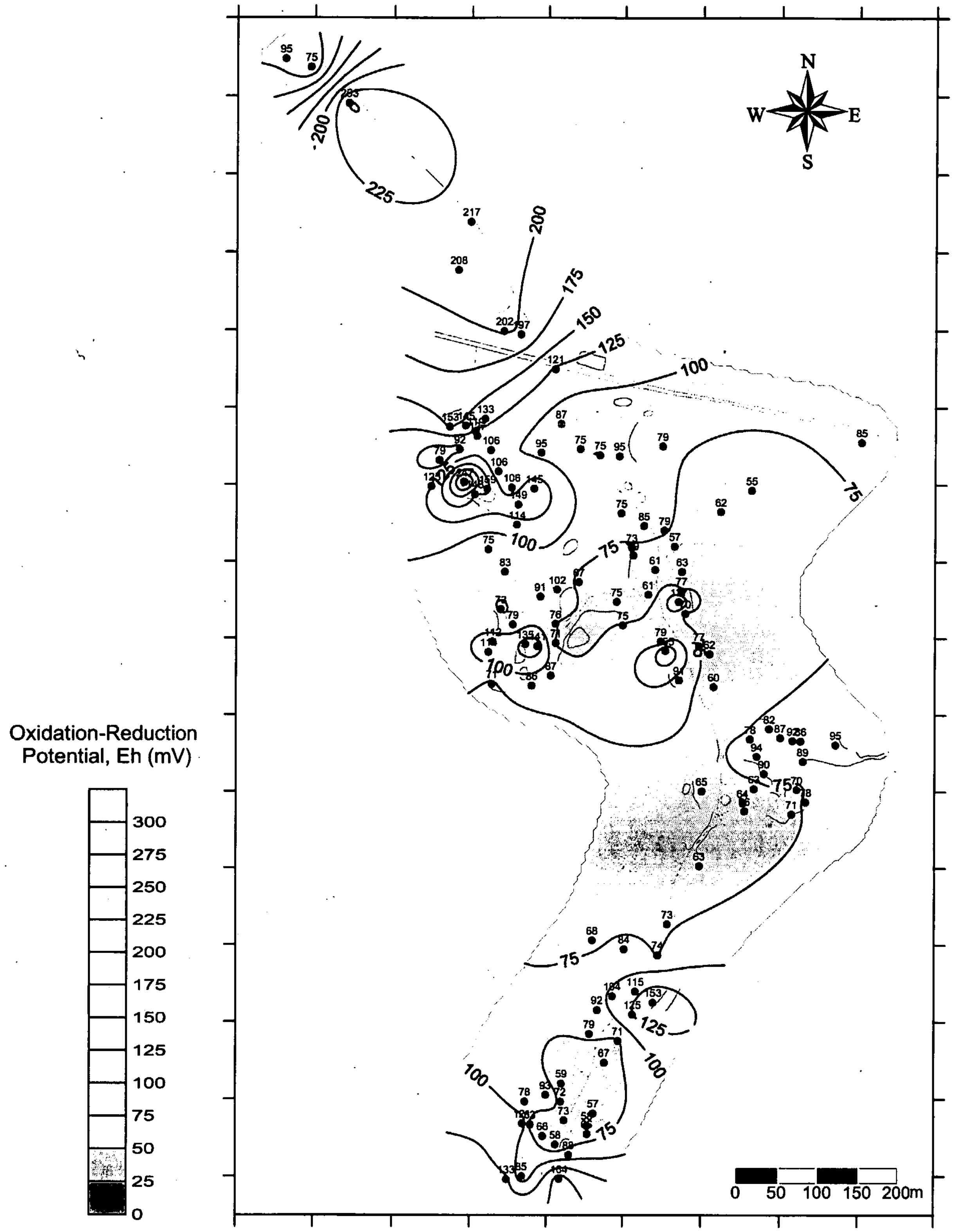


[A total of 112 existing wells' samples were used for the comparison between October and December 2000.
The ORP values were measured at the site by Potable ORP Meter.
Then, the reading ORP values were converted into Eh values.]

Figure 6.3.54	Changes in Eh in Bara Dudpatila Village between October and December 2000

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



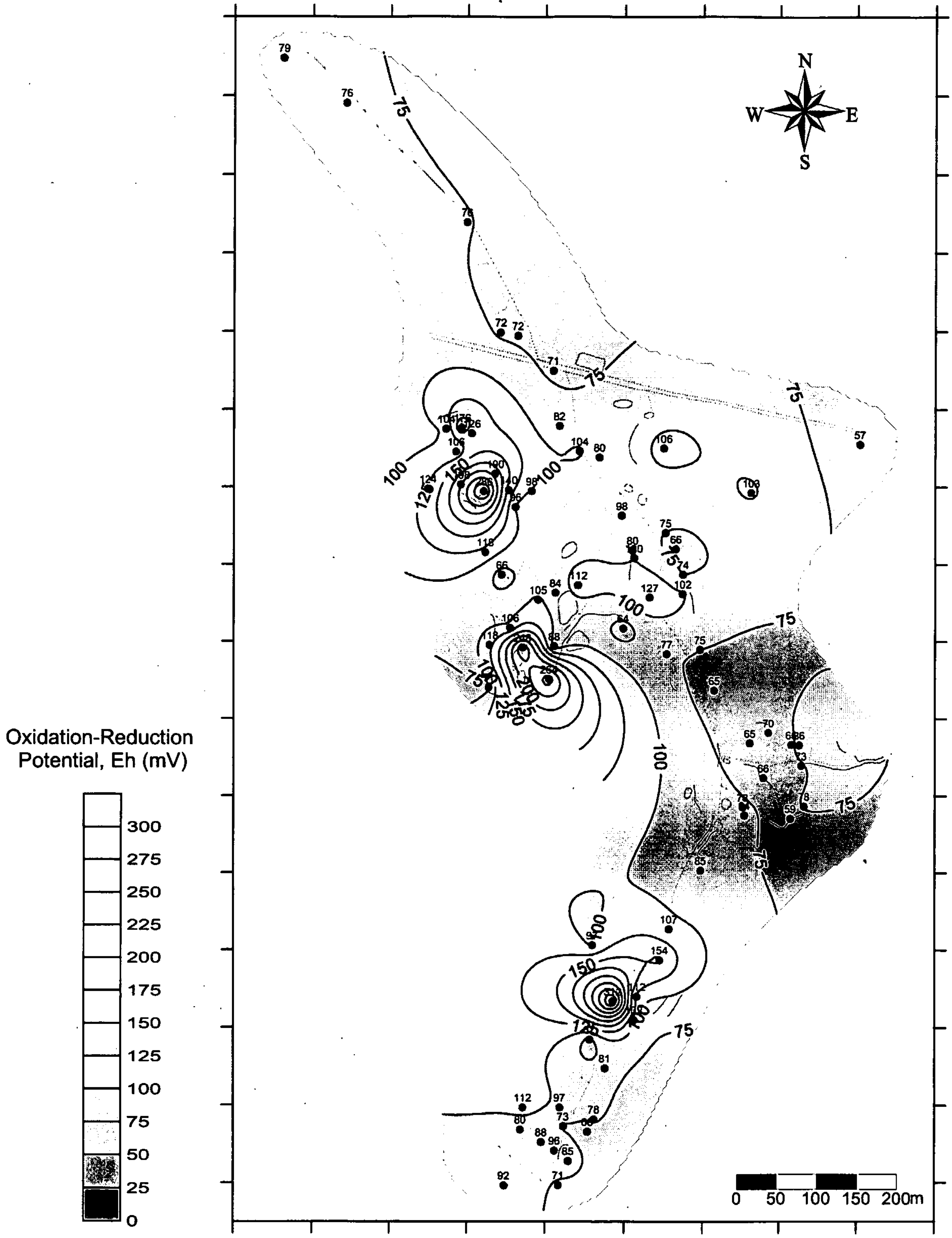
[The groundwater samples were collected from 115 existing wells in October 2000. The ORP values were measured at the site by Potable ORP Meter. Then, the reading ORP values were converted into Eh values by: Eh (mV) = [ORP meter reading value (mV)] - 0.71978 * [Temp (deg-C)] + 224.363]

235
● Existing Well with Eh (mV)

Figure 6.3.55	Eh Map of Krishna Chandrapur Village (October 2000)

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



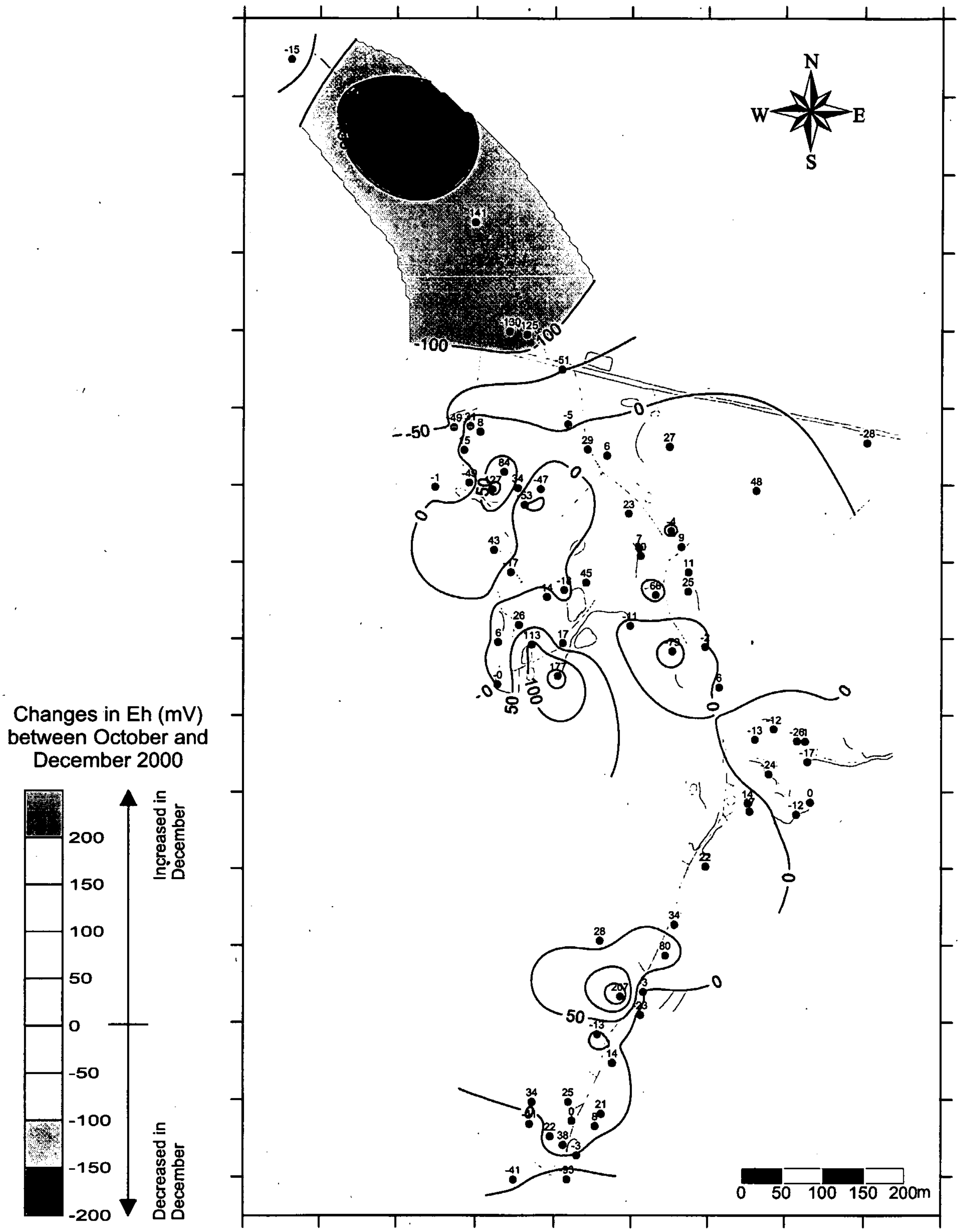
[The groundwater samples were collected from 76 existing wells in December 2000. The ORP values were measured at the site by Potable ORP Meter. Then, the reading ORP values were converted into Eh values by: Eh (mV) = [ORP meter reading value (mV)] - 0.71978 * [Temp (deg-C)] + 224.363]

235
● Existing Well with Eh (mV)

Figure 6.3.56	Eh Map of Krishna Chandrapur Village (December 2000)

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

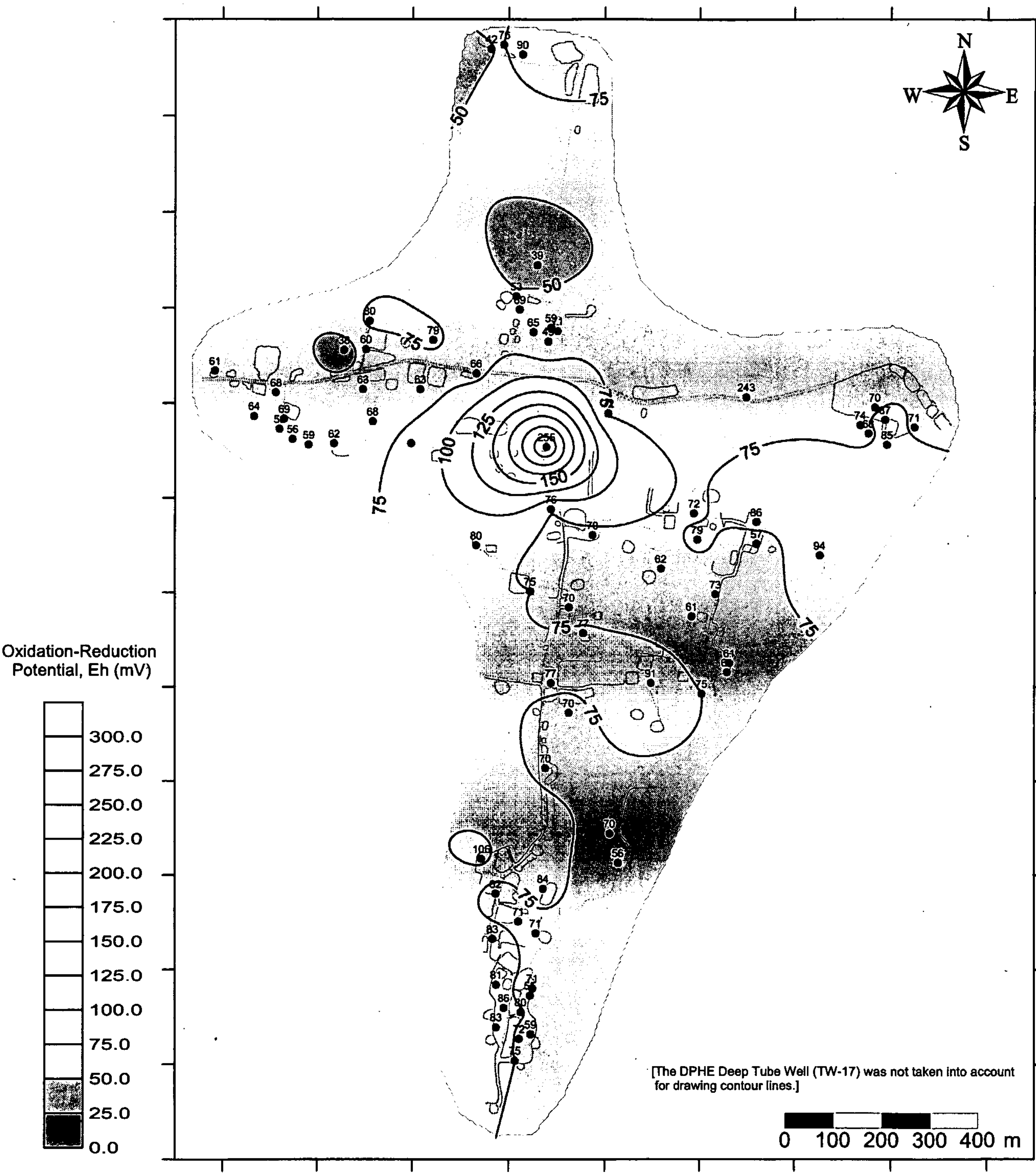
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



[A total of 76 existing wells' samples were used for the comparison between October and December 2000. The ORP values were measured at the site by Potable ORP Meter, then the ORP values were converted into Eh values.]

-0.25 ● Existing Well with Change in Eh (mV) [(Eh in Dec)-(Eh in Oct)]

Figure 6.3.57	Changes in Eh in Krishna Chandrapur Village between October and December 2000
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	



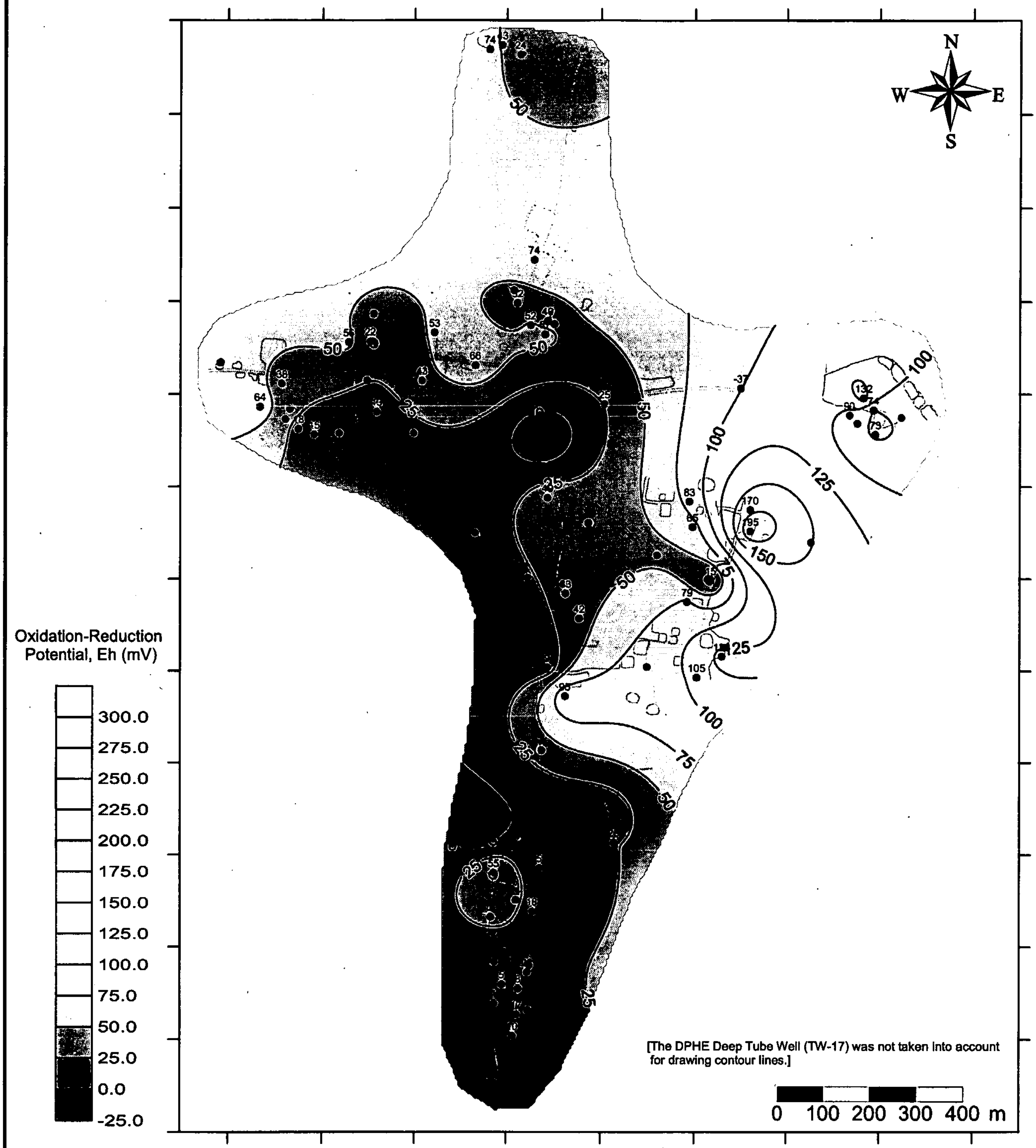
[The groundwater samples were collected from 74 existing wells in October 2000. The ORP values were measured at the site by Potable ORP Meter. Then, the reading ORP values were converted into Eh values by: Eh (mV) = [ORP meter reading value (mV)] - 0.71978 * [Temp (deg-C)] + 224.363]

178 ● Existing Well with Eh (mV)

Figure 6.3.58 Eh Map of Rajnagar Bankabarsi Village (October 2000)

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



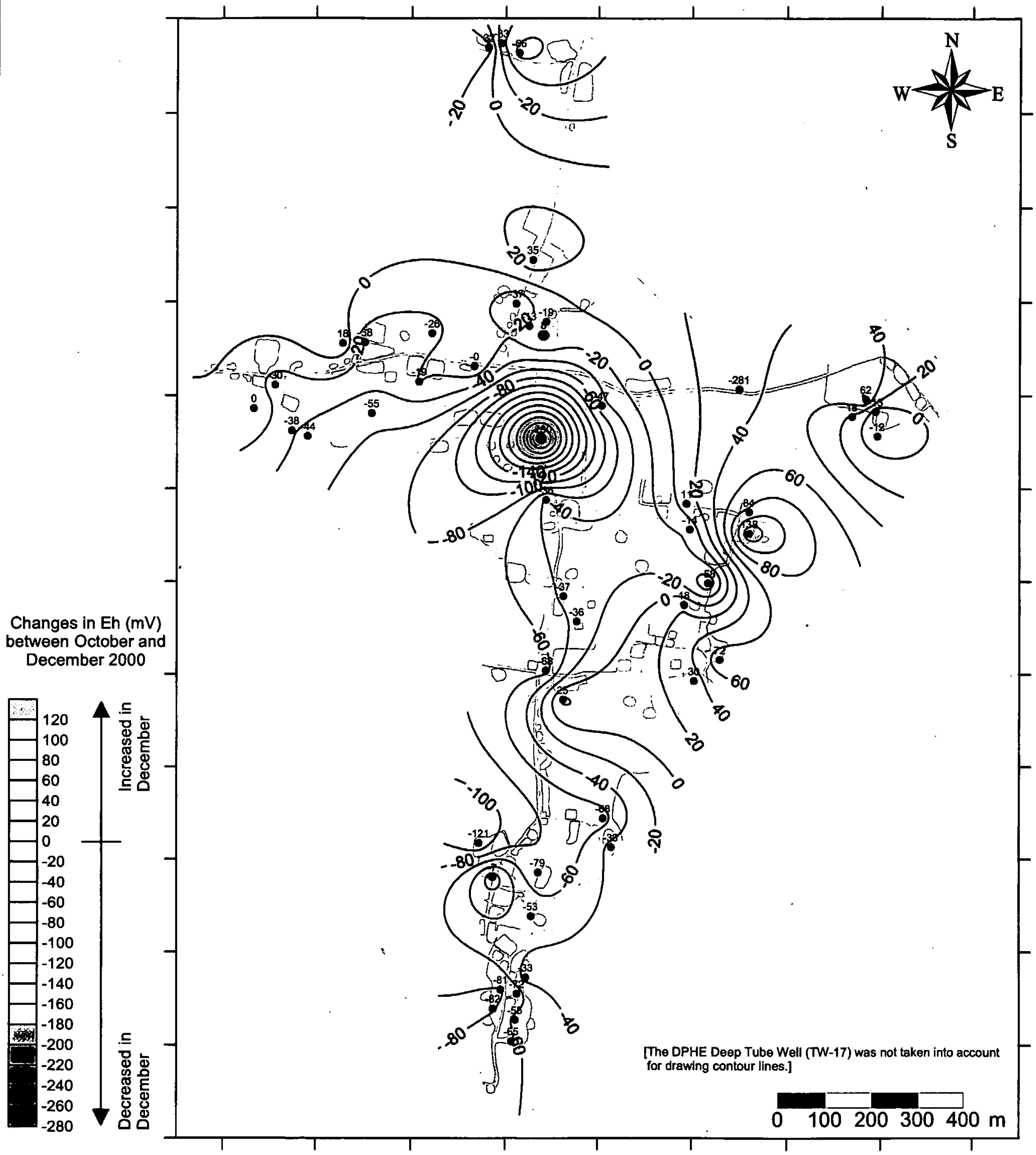
[The groundwater samples were collected from 50 existing wells in December 2000. The ORP values were measured at the site by Potable ORP Meter. Then, the reading ORP values were converted into Eh values by: Eh (mV) = [ORP meter reading value (mV)] - 0.71978 * [Temp (deg-C)] + 224.363]

178 ● Existing Well with Eh (mV)

Figure 6.3.59	Eh Map of Rajnagar Bankabarsi Village (December 2000)

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

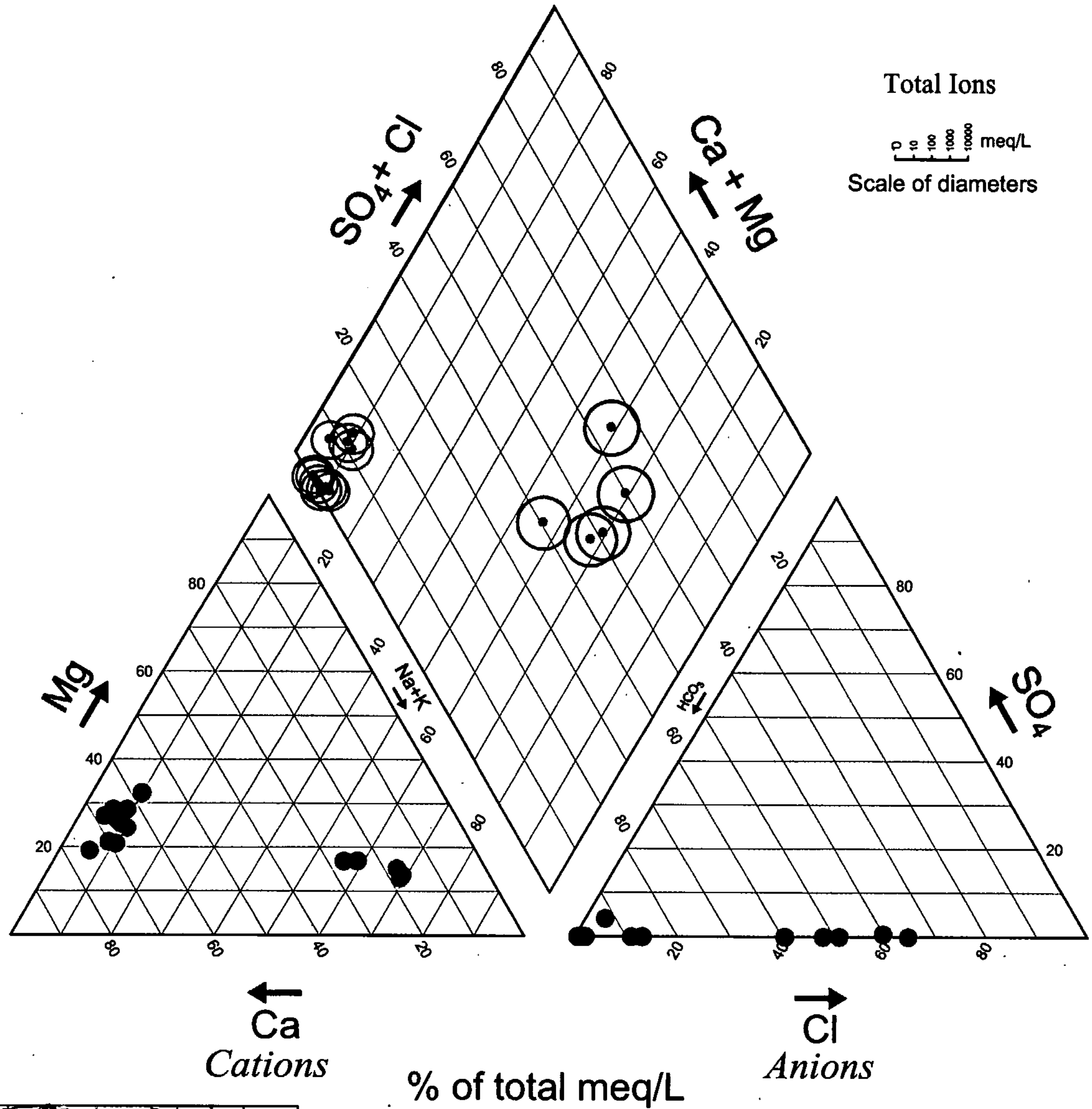
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



[A total of 50 existing wells' samples were used for the comparison between October and December 2000. The ORP values were measured at the site by Potable ORP Meter, then the ORP values were converted into Eh values.]

-39 ● Existing Well with Change in Eh (mV) [(Eh in Dec)-(Eh in Oct)]

Figure 6.3.60	Changes in Eh in Rajnagar Bankabarsi Village between October and December 2000
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	



Shallow Tubewell Groundwater Samples

- Bara Dudpatila
- Krishna Chandrapur
- Rajnagar Bankabarsi

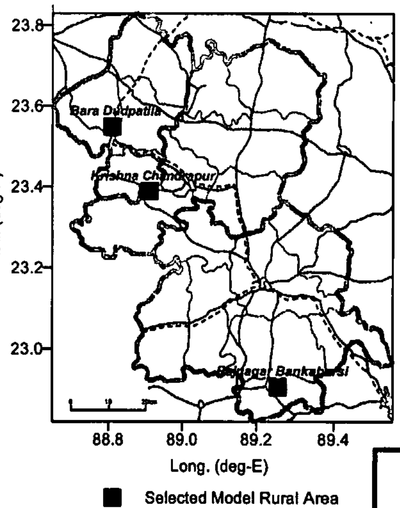
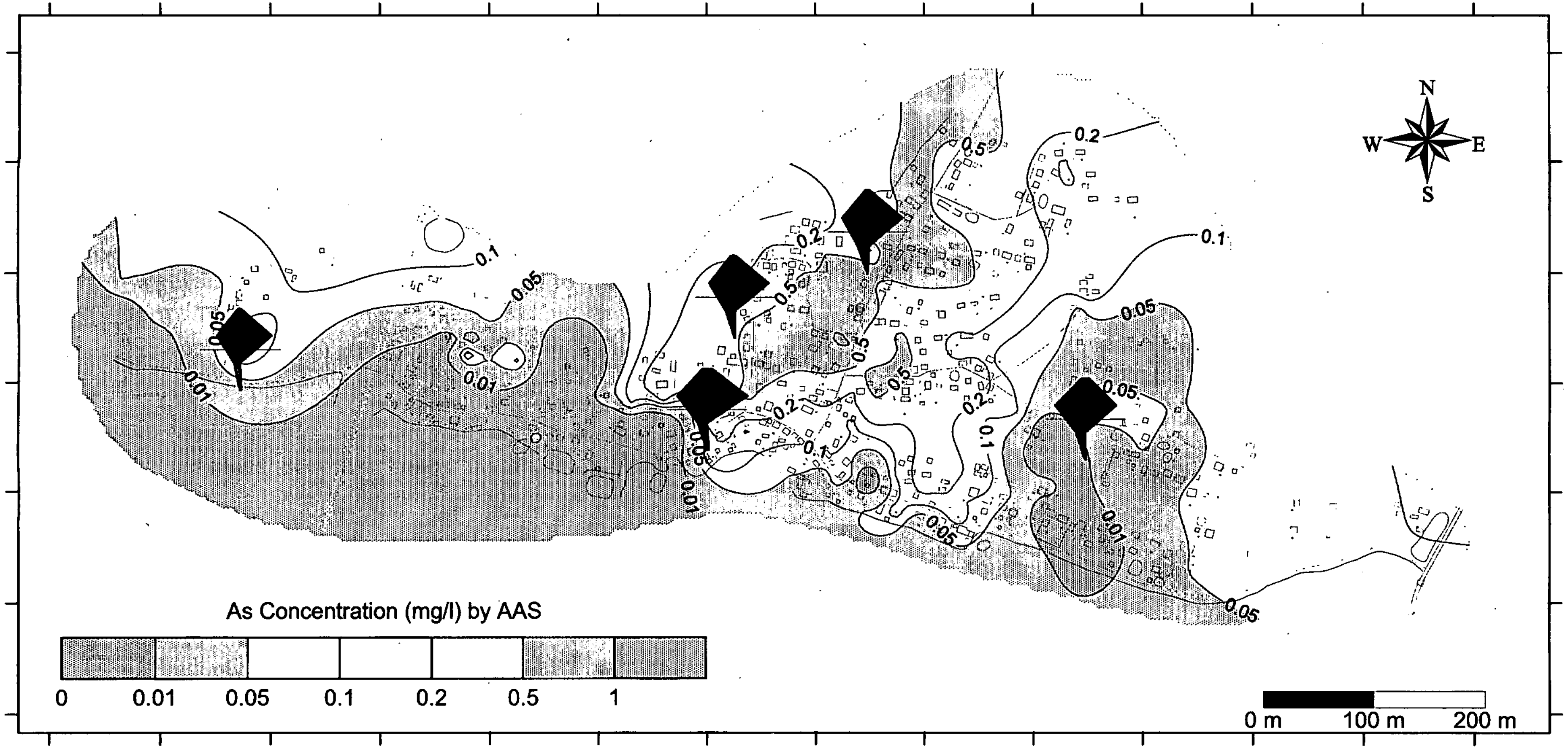
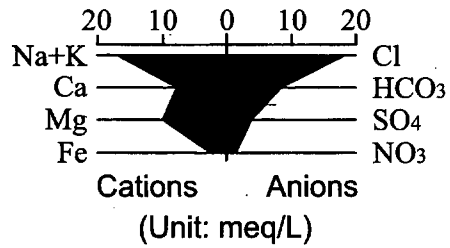


Figure 6.3.61	Trilinear Diagram of Shallow Groundwater in the Model Rural Areas

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



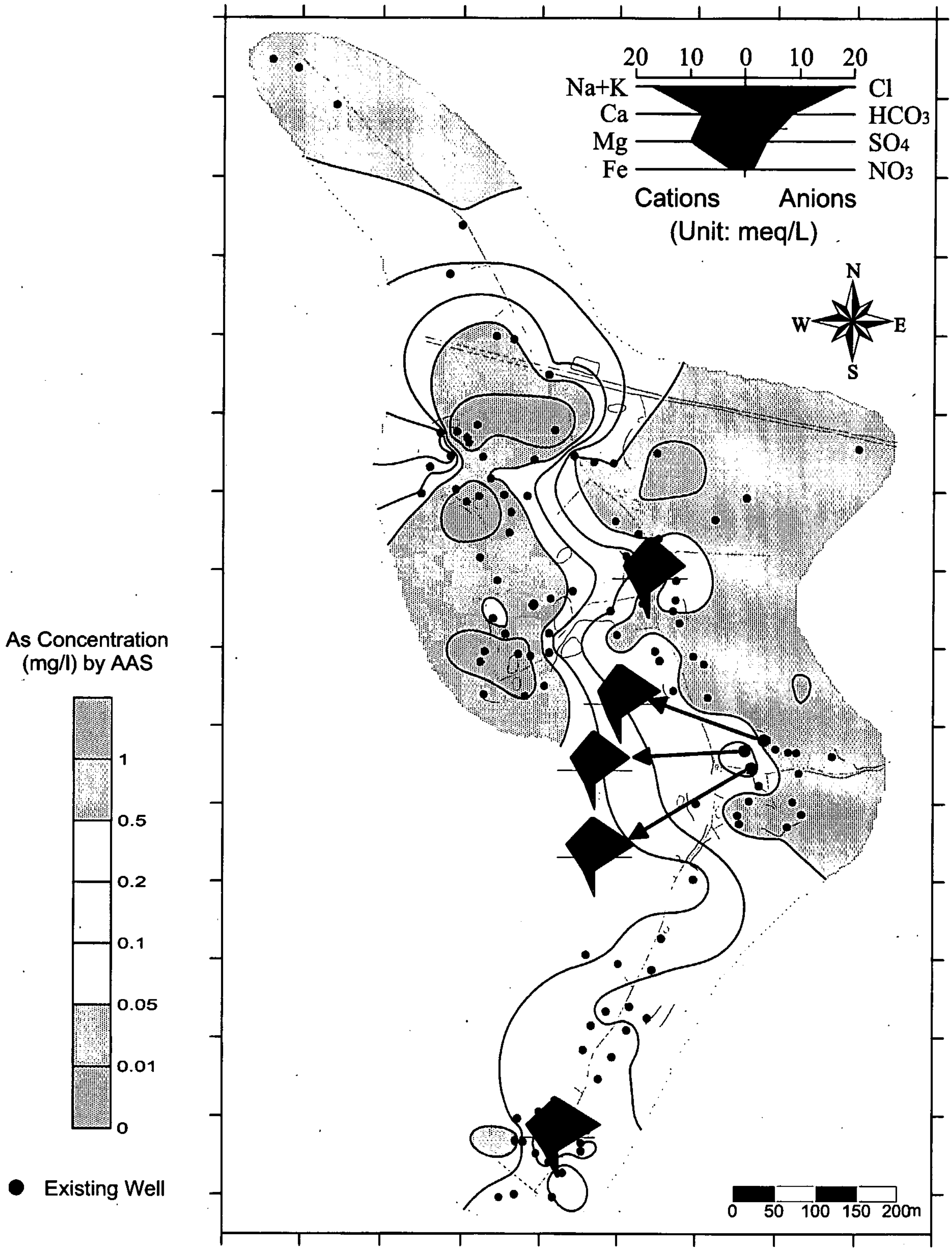


[The arsenic concentrations were measured at 172 existing wells in October 2000 by AAS in Jhenaidah Laboratory. A total of 5 groundwater samples were collected in October 2000 and analyzed.]

Figure 6.3.62	Stiff Diagram of Shallow Groundwater in Bara Dudpatila Village

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

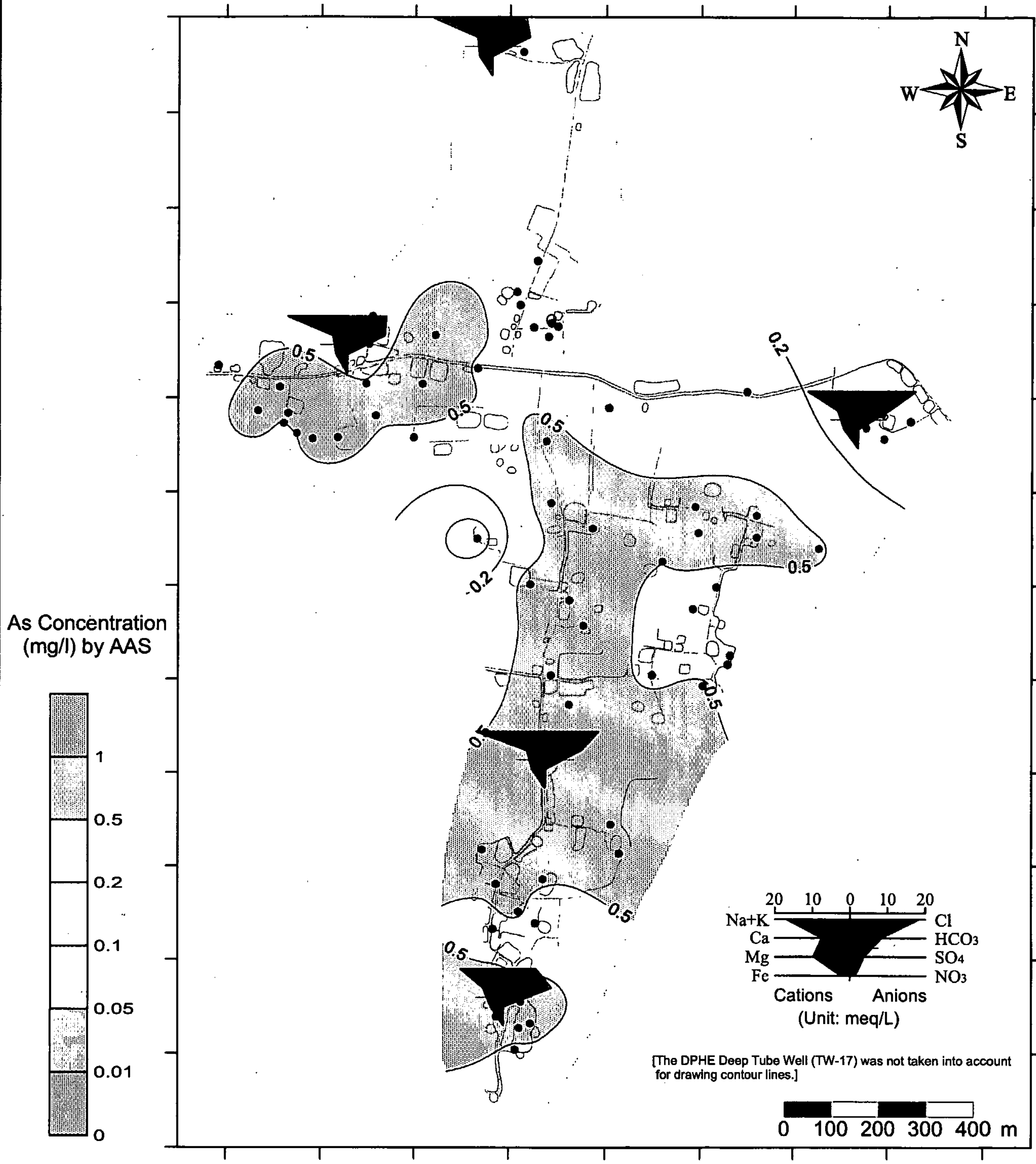


[The arsenic concentrations were measured at 115 existing wells in October 2000 by AAS in Jhenaidah Laboratory. A total of 5 groundwater samples were collected in October 2000 and analyzed.]

Figure 6.3.63	Stiff Diagram of Shallow Groundwater in Krishna Chandrapur Village

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



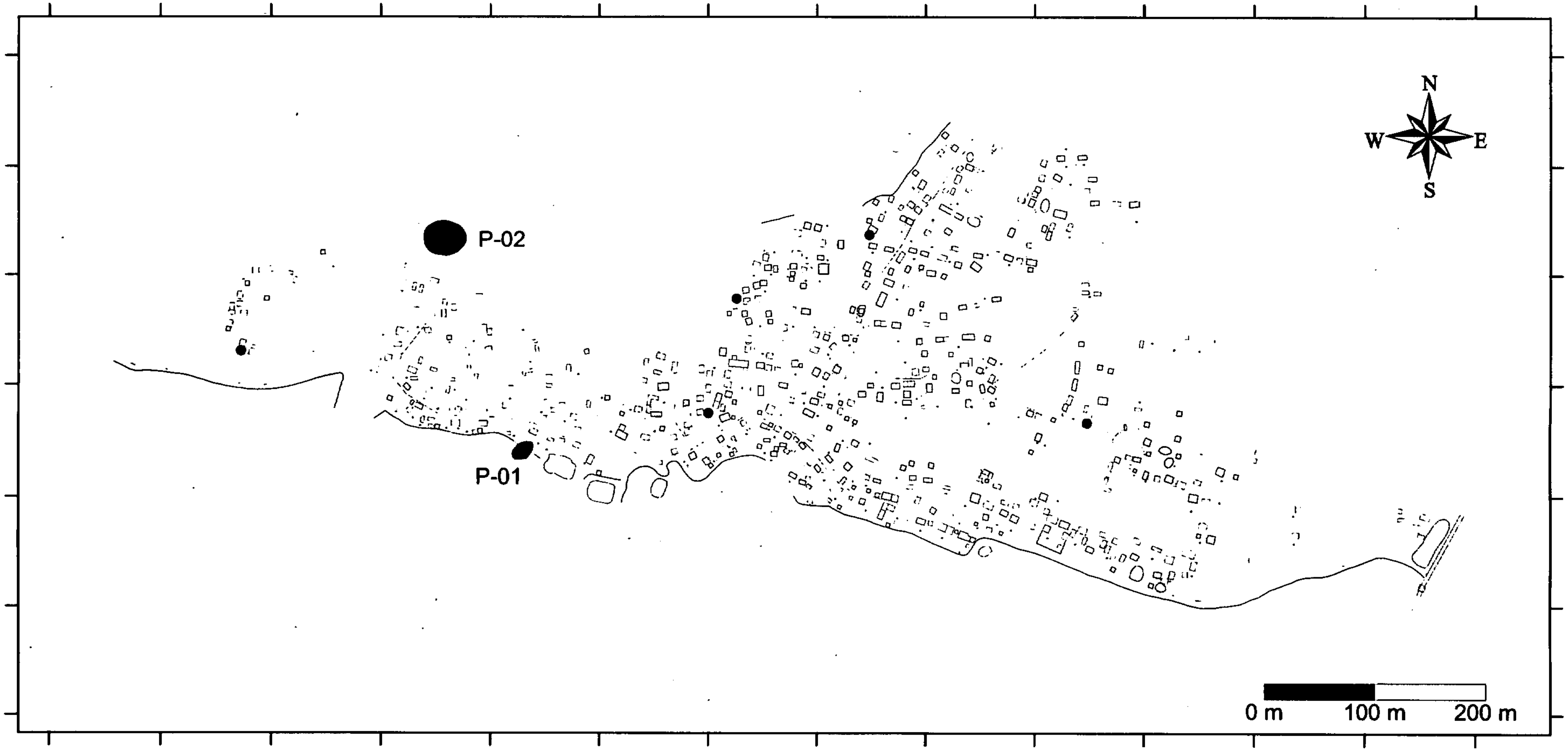
[The arsenic concentrations were measured at 74 existing wells in October 2000 by AAS in Jhenaidah Laboratory. A total of 5 groundwater samples were collected in October 2000 and analyzed.]

● Existing Well

Figure 6.3.64	Stiff Diagram of Shallow Groundwater in Rajnagar Bankabarsi Village

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



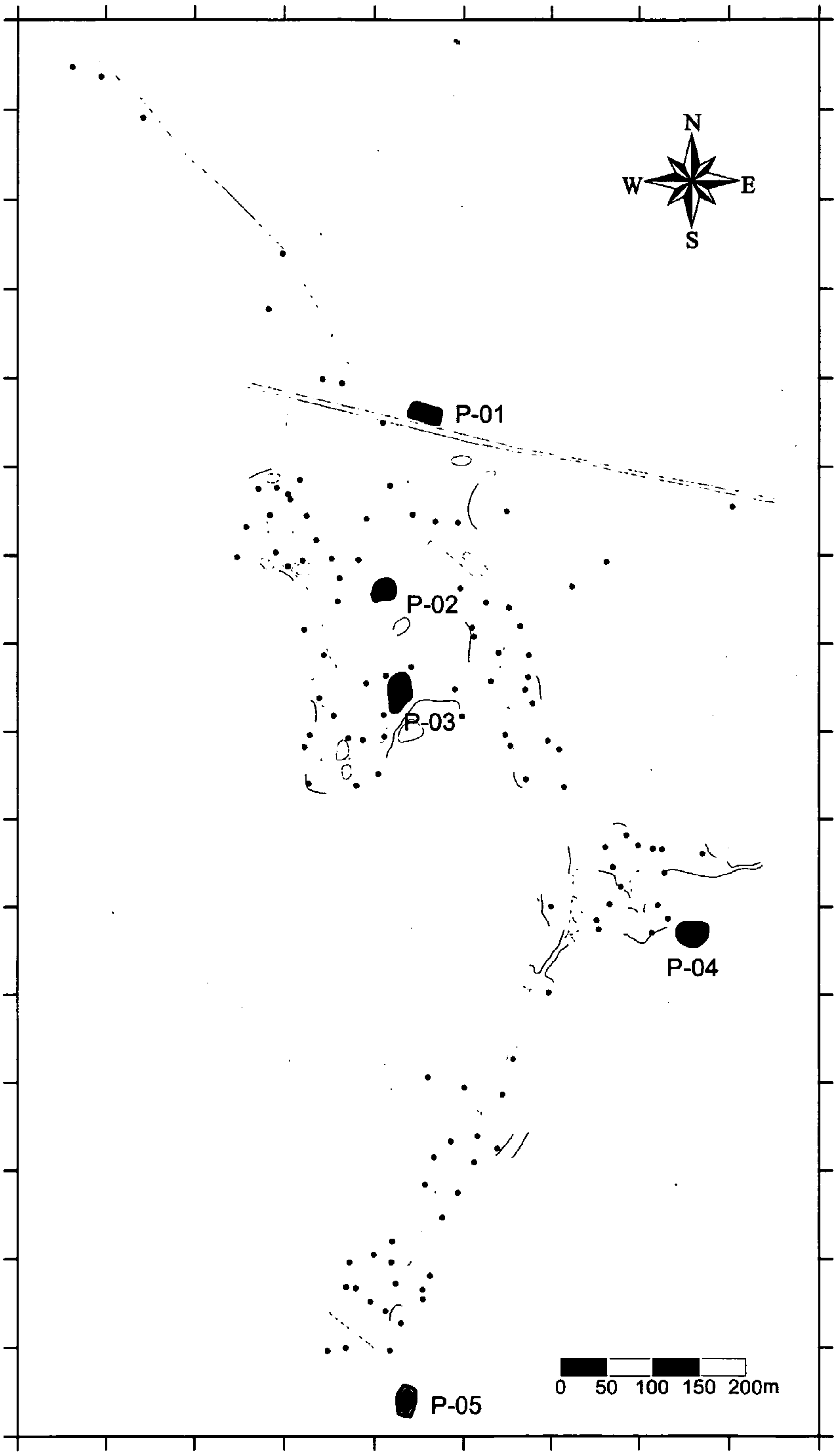
P-02 — Pond where General Water Quality Sample Collected

Figure 6.3.65

Location Map of Ponds in Bara Dudpatila Village

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



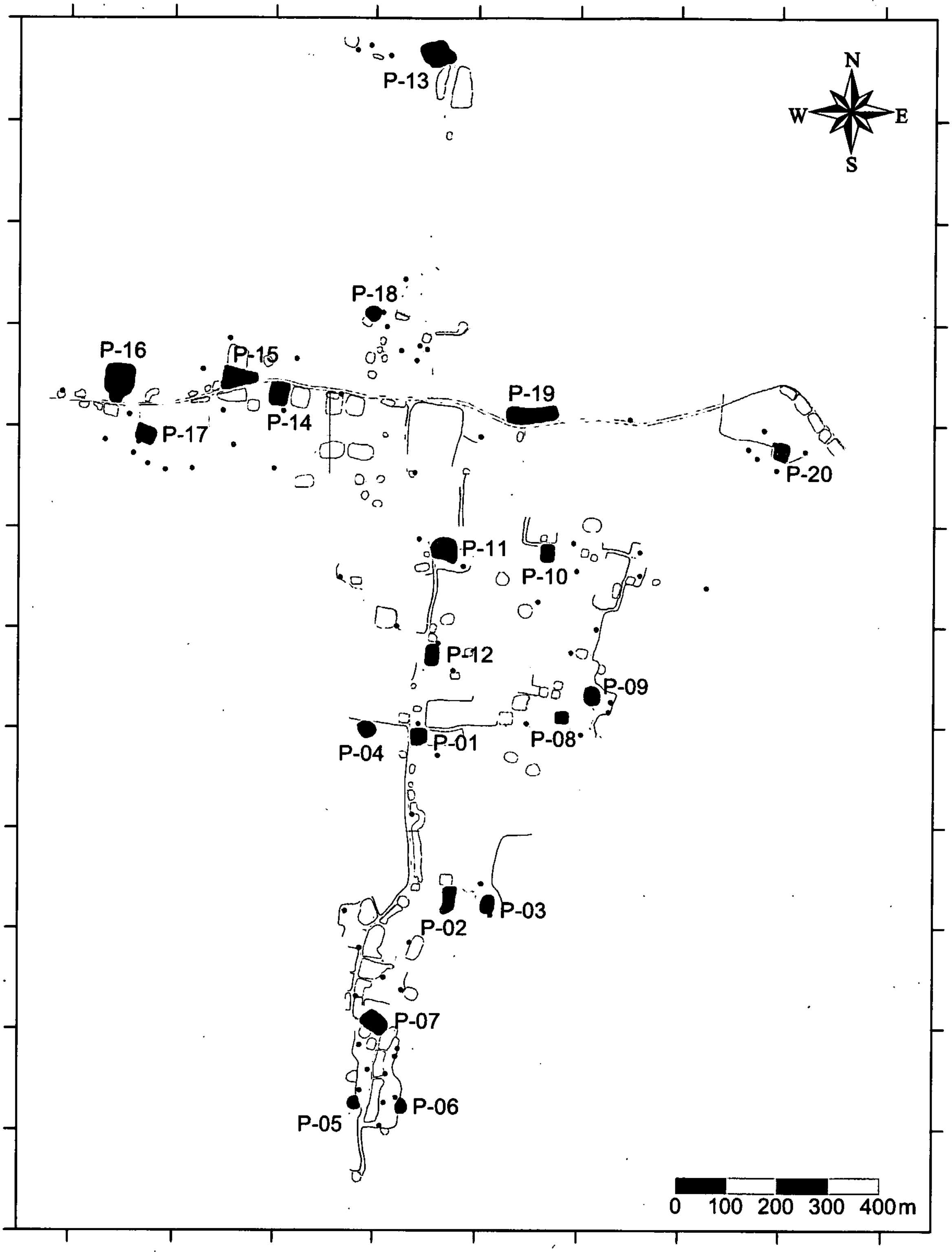
• Existing Well

Pond where General Water Quality Sample Collected
P-05

Figure 6.3.66 | **Location Map of Ponds in Krishna Chandrapur Village**

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



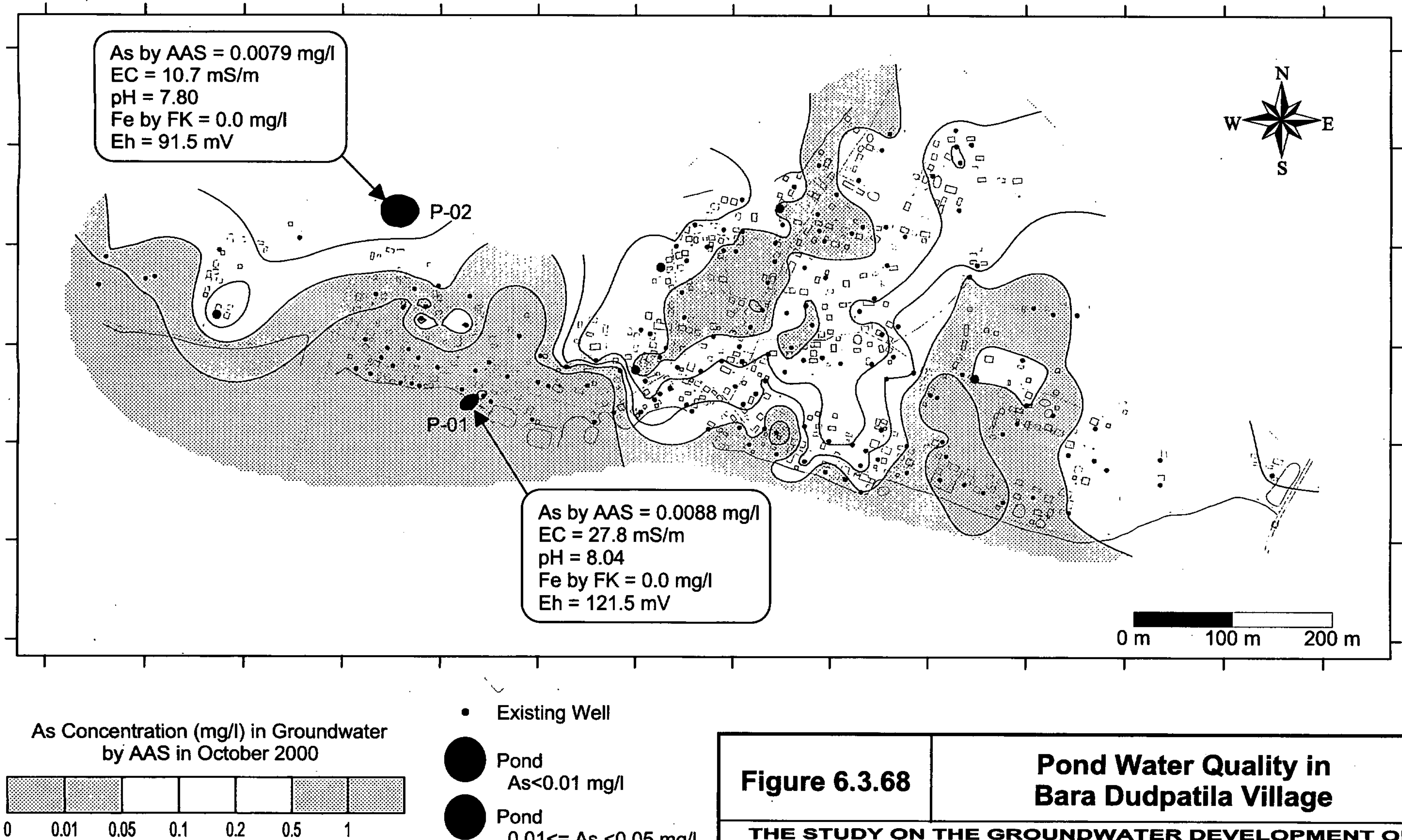
• Existing Well

Pond where General Water Quality Sample Collected

Figure 6.3.67	Location Map of Ponds in Rajnagar Bankabarsi Village

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

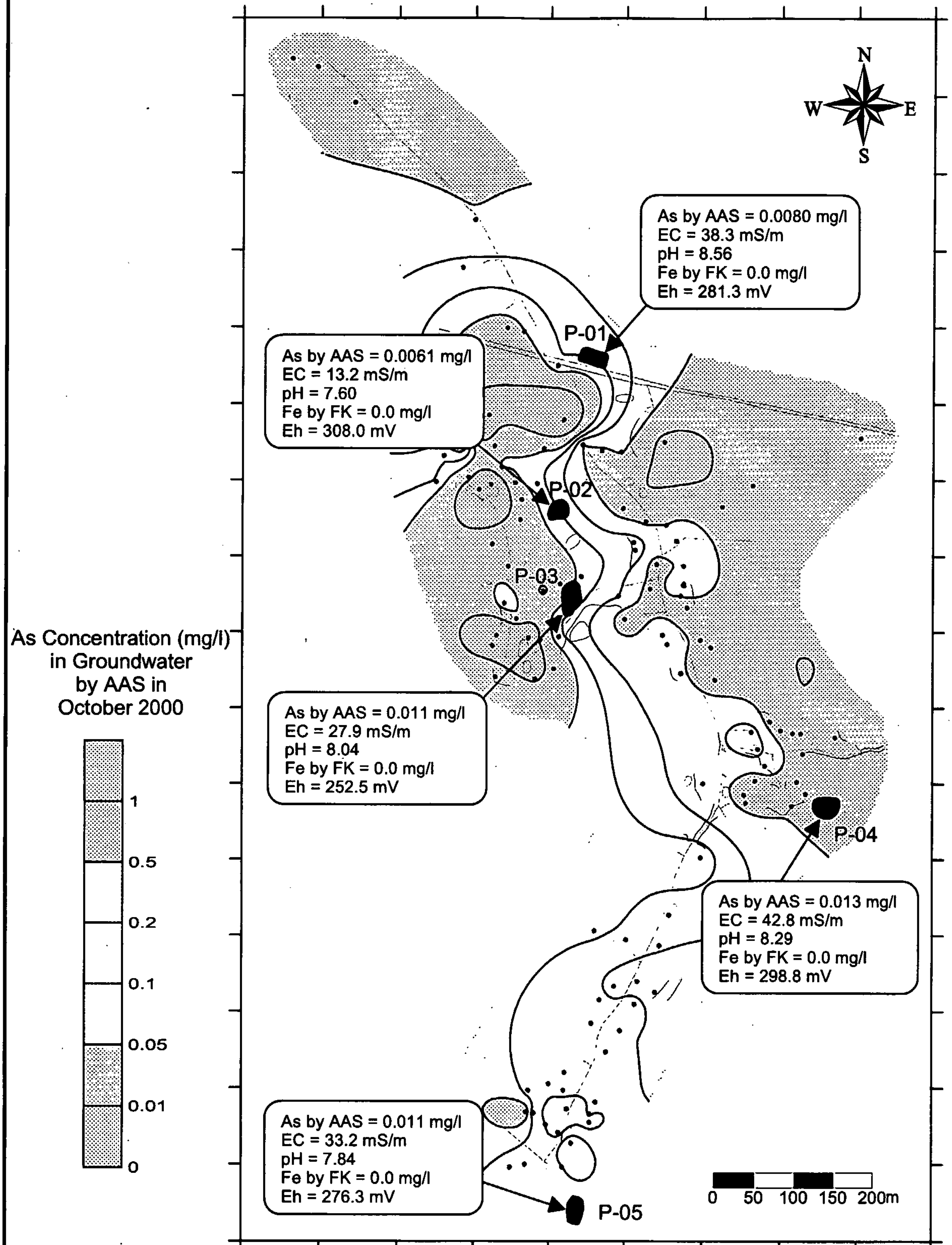


[Pond water quality was tested in October 2000.]

Figure 6.3.68 | **Pond Water Quality in Bara Dudpatila Village**

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



[Pond water quality was tested in October 2000.]

• Existing Well

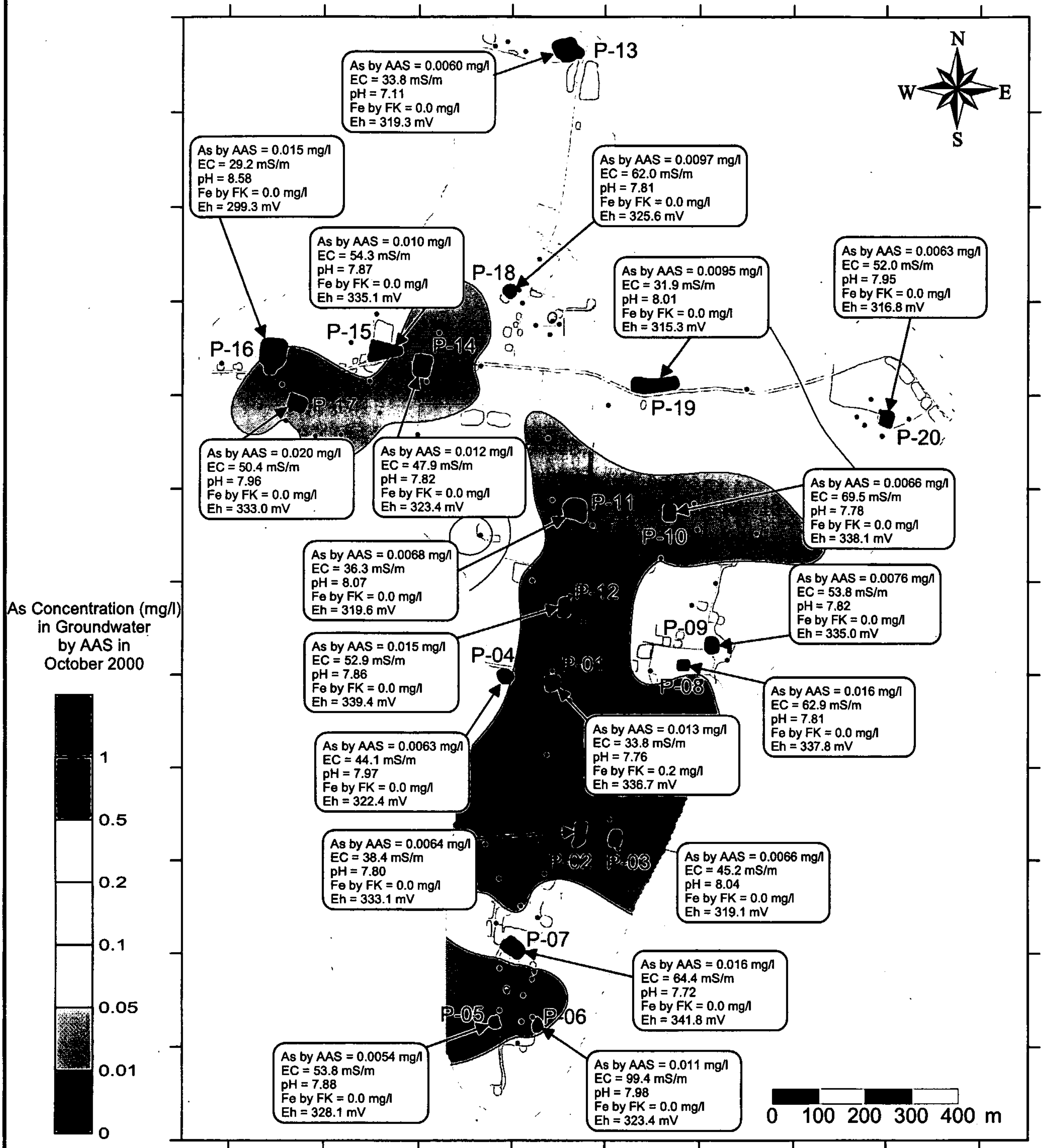
Pond As<0.01 mg/l

Pond 0.01<= As <0.05 mg/l

Figure 6.3.69 **Pond Water Quality in Krishna Chandrapur Village**

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



[Pond water quality was tested in October 2000.]

- Existing Well
- Pond As<0.01 mg/l
- Pond 0.01<= As <0.05 mg/l

Figure 6.3.70 | **Pond Water Quality in Rajnagar Bankabarsi Village**

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

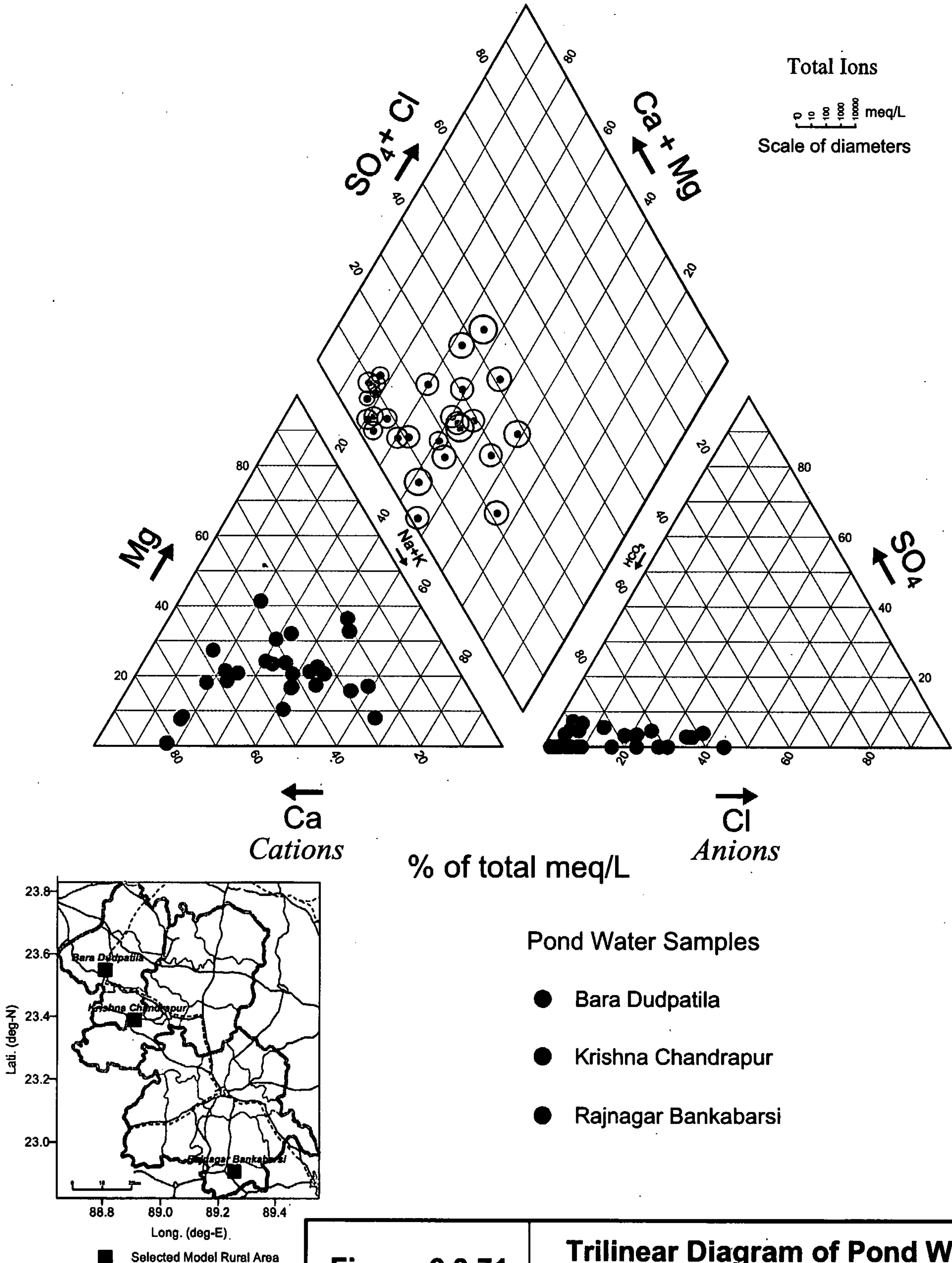
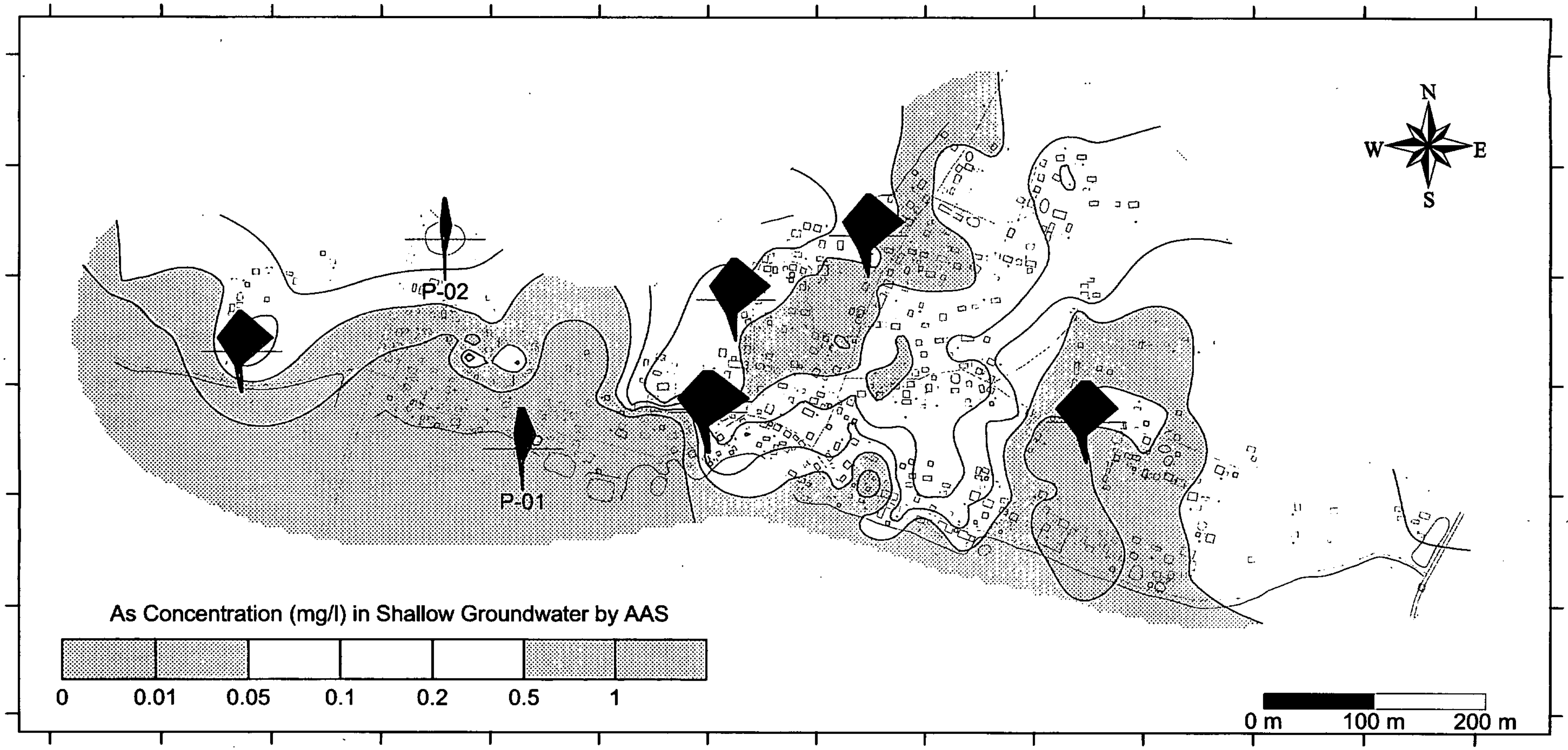
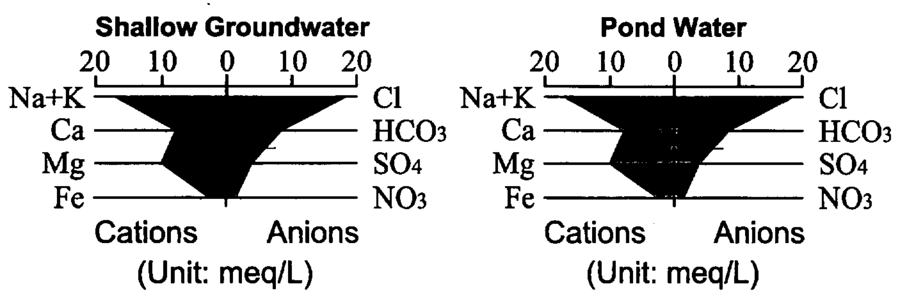


Figure 6.3.71	Trilinear Diagram of Pond Water in the Model Rural Areas

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



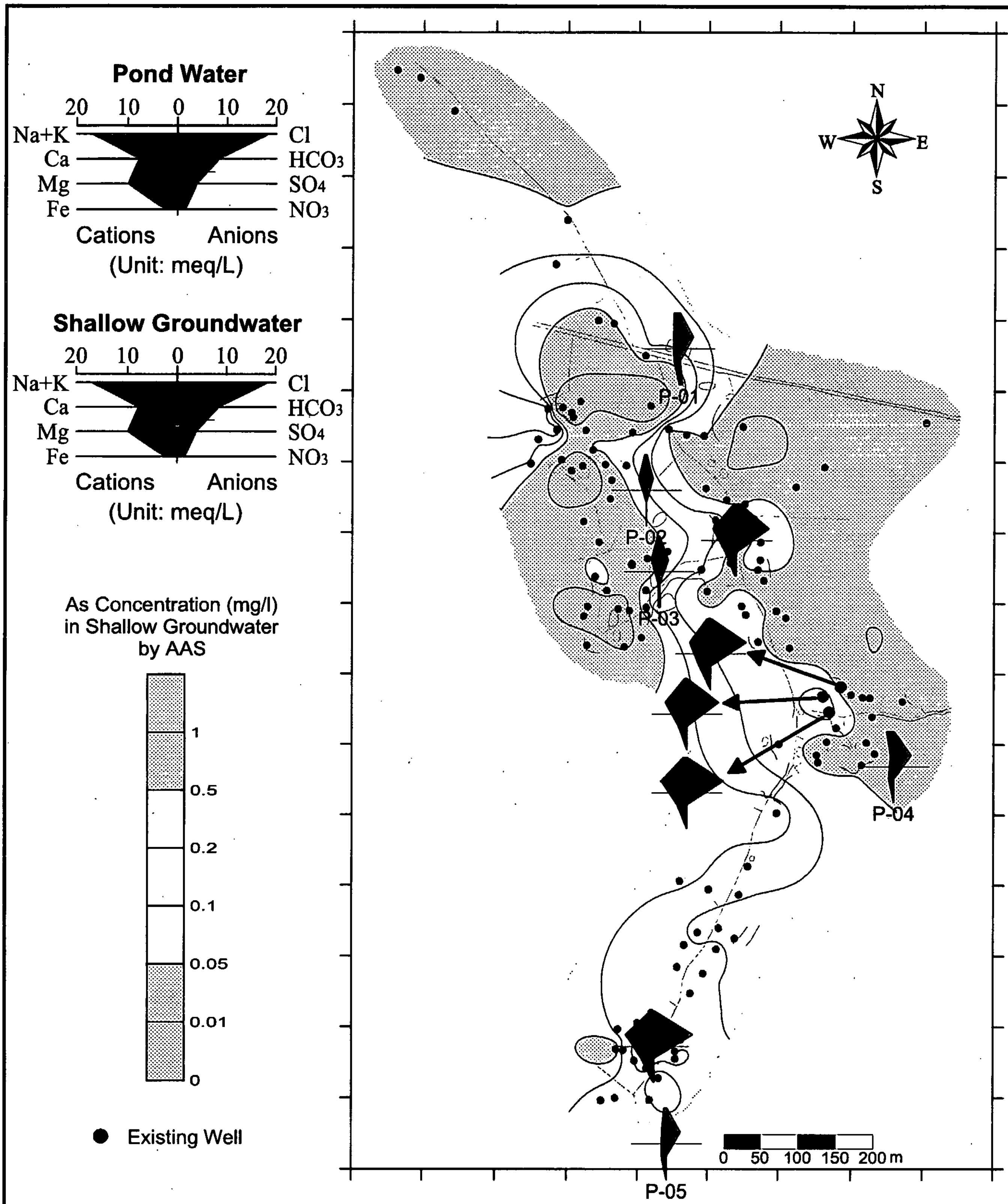


[The arsenic concentrations were measured at 172 existing wells in October 2000 by AAS in Jhenaidah Laboratory. Two pond water samples and 5 groundwater samples were collected in October 2000 and analyzed.]

Figure 6.3.72 **Stiff Diagram of Pond Water in Bara Dudpatila Village**

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

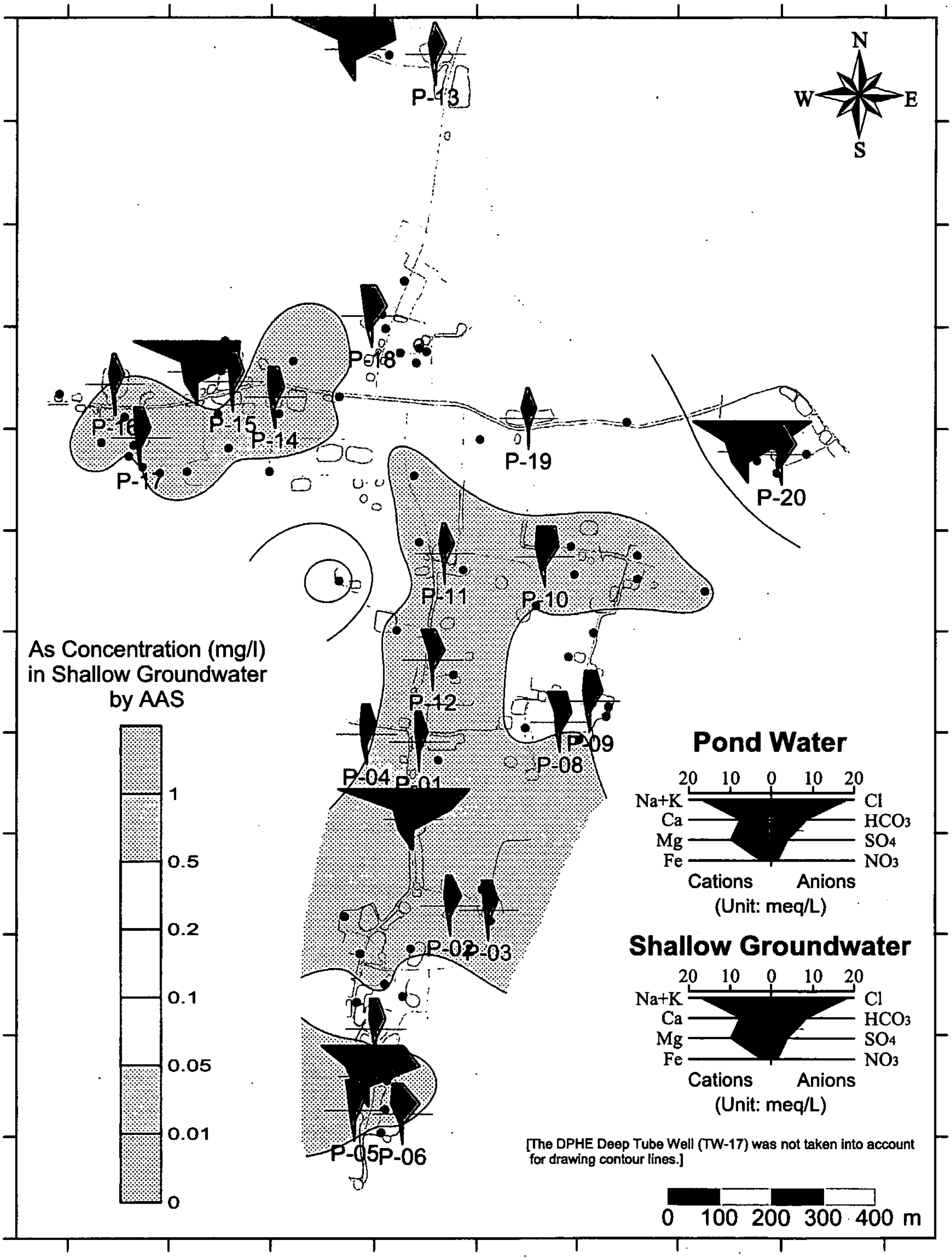


[The arsenic concentrations were measured at 115 existing wells in October 2000 by AAS in Jhenaidah Laboratory. Five pond water samples and 5 groundwater samples were collected in October 2000 and analyzed.]

Figure 6.3.73	Stiff Diagram of Pond Water in Krishna Chandrapur Village

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



[The arsenic concentrations were measured at 74 existing wells in October 2000 by AAS in Jhenaidah Laboratory. Twenty pond water samples and 5 groundwater samples were collected in October 2000 and analyzed.]

● Existing Well

Figure 6.3.74	Stiff Diagram of Pond Water in Rajnagar Bankabarsi Village

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

6.4 Study on Socioeconomic Conditions in Model Rural Areas

6.4.1 Objective of the Study

To consider the applicability of mitigation measures to be included in the master plan to cope with arsenic problems in the study area, basic information on water fetching and consumption practices, health injury due to arsenic poisoning, sanitary condition, diet, income, and expenditure was collected at the household level. Findings from the study are used for formulation of the master plan including educational programs and the feasibility study on priority projects identified in the master plan.

6.4.2 Methodology of the Study

1) Methods of Information Collection

Information on socioeconomic conditions in the Model Rural Areas was collected through interviews with households. Using the questionnaire shown in Annex 6.4.1, interviews in Bengali were conducted during September and October in the year of 2000. As in the second to last page of the questionnaire in Annex 6.4.1, spatial information such as location of wells and ponds and their users was also collected through observation supplemented by household interviews.

2) Interviewees and Interviewers

According to the results of the socioeconomic study in the 260 villages in the study area, the wife is generally in charge of water fetching in a family. Since there are questions to be asked to those who are in charge of water fetching (see Q7 to Q20 and Q28 in Annex 6.4.1), one female interviewer was recruited from a local NGO to be able to approach female interviewees in each Model Rural Area. Two interviewers (one female and one male) are dispatched to each Model Rural Area to conduct household interviews after having training on this socioeconomic study.

The JICA Study Team held a two-day training session to train interviewers on how to ask questions in Bengali in a proper manner and record answers on the questionnaire. In addition, the interviewers were trained so that they can inform villagers of arsenic problems, diagnose arsenicosis patients, and tell villagers how to prevent arsenicosis.

3) Selection of Target Households

Based on the existing information, the total household number in each Model Rural Areas was estimated as 500 in Bara Dudpatila, 480 in Rajnagar Bankabarsi, and 250 in Krishna Chandrapur (see Annex 6.4.2 for the estimation process). The direction to select the 200 households to be interviewed in each Model Rural Area was given to the interviewees as summarized below.

(a) Selection of the 200 Households in Bara Dudpatila and Rajnagar Bankabarsi

Start interviews with the household of house #1. If there are several houses with the same house number and letters such as 1A and 1B, only visit the house with the letter A. Then go to the house just across the road. If there is no house on the other side of the road, visit houses at one in two and one in three intervals (total two in five) from the house with house #1 until you find one on the other side of the road. If there are houses on both sides of the road, visit houses at one in two and one in three intervals on each side of the road. Keep records on locations and house numbers of the houses of which no interview is conducted.

= Case1 =   = Case 2=

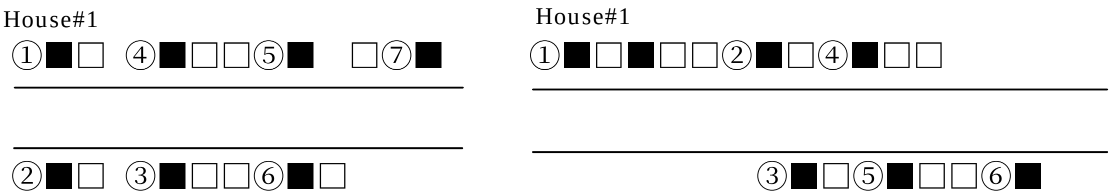


Figure 6.4.1 Selecting Target Households for Interviews

If no one is available in the house, skip the house and go to the next house.

If the number of interviews with households is less than 200 after visiting all the houses following the above, allocate the remaining interviews to each para based on the numbers of households in the para, and visit houses at the appropriate intervals.

(b) Selection of the 200 Households in Krishna Chandrapur

Start interviews with the household of house #1. Visit every house but skip one in five on one side of the road. Keep records on locations and house numbers of the houses of which no interview is conducted.

If no one is available in the house, skip the house and go to the next house. Please make sure not to interview the same household; sometimes one household has several house buildings (each house building has one house number).

After interviewing the 200 households in Krishna Chandrapur, another three paras were found in the village, and additional interviews with 29 households were conducted. Therefore, the number of the households interviewed in Krishna Chandrapur is 229.

6.4.3 Preliminary Findings of the Study

1) General Features of the Households

(a) Household Size and Population

A "Household" is the minimum social unit in which its members live together and their daily expenses such as food and clothes are covered by one wallet. If there is a joint family in which its members live together but their daily expenses are covered by each of the sub-families, it is not considered a household.

The average household size in each Model Rural Areas is summarized in Table 6.4.1.

Table 6.4.1 Household Size

	Bara Dudpatila	Rajnagar Bankabarsi	Krishna Chandrapur
Average (1991 Census)	4.46 (5.67)	4.71 (5.10)	4.58 (5.23)
Maximum	10	13	14
Minimum	1	1	1

Compared to the average household size reported in the 1991 Census, the current average household size is smaller in each Model Rural Area. Figure 6.4.2 shows the number of households by household size. In each Model Rural Area, households with 4 members are most common, but there still exist large families. The largest household has equal to or over 10 members in each Model Rural Area.

Based on the number of households interviewed for the first round following the selection of the households described in Section 6.4.2, the number of households and consequently the population in each Model Rural Area are estimated as in Table 6.4.2.

Table 6.4.2 Estimated Number of Households and Population

	Bara Dudpatila	Rajnagar Bankabarsi	Krishna Chandrapur
Interval of target selection	2 in 5	2 in 5	4 in 5
# of households interviewed for the first round	200	150	150 (three paras missed)*
Estimated # of households	500+	375	220
Average HH size	4.46	4.71	4.58
Estimated population	2,230	1,766	1,008
Rounded population	2,300	1,800	1,000

Notes: *The three paras have 29 households.

(b) Household Structure

The average number of males and females per household are about the same, and the number of adults (age 15 or over) is larger than that of infants (age 0-3) and children (age 4-14). The average household structure in each Model Rural Area is summarized in Table 6.4.3.

Table 6.4.3 Household Structure

	Bara Dudpatila	Rajnagar Bankabarsi	Krishna Chandrapur
Male	2.3	2.3	2.3
Female	2.2	2.4	2.3
Infant (0-3)	0.3	0.3	0.3

Child (4-14)	1.5	1.4	1.3
Adult (15+)	2.6	3.1	2.9

(c) Literacy level

The average number of literate people per target household is more than one; however, this does not necessarily mean that every household has a literate person. There are households with no literate person in each Model Rural Area, and Rajnagar Bankabarsi has the highest ratio of households with no literate person (see Table 6.4.4). In addition, there are many cases that children are literate, but parents are not literate or can only sign their names. This implies that it might be effective to target children as a key person in a household to disseminate information on arsenic problems.

Table 6.4.4 Literacy Level

	Bara Dudpatila	Rajnagar Bankabarsi	Krishna Chandrapur
Avg. # of literate per HH	2.32	1.79	2.45
Ratio of HH with no literate	17.0%	32.0%	14.0%

(d) Property Ownership

In the Model Rural Areas, most of the target households own land for their house but not the house building per se (see Table 6.4.5). This situation could be explained by the fact that a father gives his son a part of his land upon his son's marriage while the son starts his new life in a different section of his father's house.

Table 6.4.5 Property Ownership

	Bara Dudpatila	Rajnagar Bankabarsi	Krishna Chandrapur
House (building)	7.0%	8.0%	13.5%
Land for the house	96.0%	96.0%	86.7%
Agricultural land (average size)	49.5% (1.93acres)	75.5% (1.68acres)	59.0% (2.65acres)

The ownership ratio of agricultural land is higher in Rajnagar Bankabarsi, but the average land size is smaller than that in the other two Model Rural Areas.

2) Water Fetching and Consumption

(a) Water Source

All the households interviewed in Bara Dudpatila and Krishna Chandrapur depend on shallow tube wells for their drinking water. About 30% of the households in Rajnagar Bankabarsi drinks water from shallow tube wells while 70% of them from the DPHE deep tube well located at the northeast periphery of the village. As shown in Figure 6.4.3, most of the households own the water source (shallow tubewell) in Bara Dudpatila and Krishna Chandrapur. In

Rajnagar Bankabarsi, those who drink water from a shallow well either own the tube well or use the tube well owned by the *Bari* (a group of 5-10 houses).

Based on the estimated household numbers and identified tube well numbers, the average population served by one tube well is estimated as in Table 6.4.6. One tube well in Rajnagar Bankabarsi was used to serve more than two times as many people as in the other two villages before the DPHE tube well was installed.

Table 6.4.6 Average Population Served by Tube well

	Bara Dudpatila	Rajnagar Bankabarsi	Krishna Chandrapur
# of estimated population	2,300 (515 households)	1,800 (380 households)	1,000 (220 households)
# of identified tubewells	175	74	115
Average population served by one tubewell	13	24 *Shallow TW:7 Deep TW: 1,260	9
Average # of households served by one tubewell	3	5 *Shallow TW: 1.5 Deep TW: 266	2

Notes: * Since 70% of the households depend on the DPHE deep tube well for their drinking water, each shallow tubewell serves less than the average population (24) or households (5).

(b) Water Fetching

According to the socioeconomic study carried out in the 260 villages by the JICA Study Team during June and July 2000, the wife usually takes responsibility for obtaining water for the family. Based on the results of the study in the Model Rural Area, men are also engaged in water fetching when it becomes too heavy a load for women. Figure 6.4.4 shows the ratio of households by water collector (husband, wife, son, daughter, servant, or other). While the wife or daughter is mainly in charge of water fetching in Bara Dudpatila and Krishna Chandrapur, the husband, son, brother, or father is in charge of fetching water in about 30% of the households in Rajnagar Bankabarsi.

In Bangladesh, water fetching is considered as a women’s task. The burden sharing of water fetching between men and women in Rajnagar Bankabarsi could be explained by its heavy workload. Table 6.4.7 shows the average time spent on water fetching per day in each Model Rural Area. While the average household in Bara Dudpatila and Krishna Chandrapur spends only 10 to 20 minutes per day for water fetching, that in Rajnagar Bankabarsi spends more than one hour per day.

Table 6.4.7 Workload of Water Fetching

	Bara Dudpatila	Rajnagar Bankabarsi	Krishna Chandrapur
Average time for water fetching per trip	3 min.	33 min.	5 min.
Average # of water fetching per day	3.3 times	3.3 times	3.4 times
Average total time for water	11 min.	62 min.	17 min.

fetching per day			

In Rajnagar Bankabarsi, men spend more time than women do on water fetching (see Table 6.4.8) although the average number of trips by men is less than that by women.

Table 6.4.8 Workload of Water Fetching in Rajnagar Bankabarsi by Sex

	Men	Women
Average travel and waiting time for water fetching per trip	42 min.	30 min.
Average # of water fetching per day	1.9 times	3.8 times
Average total travel and waiting time per day	72 min.	58 min.

As shown in Figure 6.4.5, water pots are carried not only by hand but also with tools such as carts, rickshaw vans, and bicycles in Rajnagar Bankabarsi while tools are not used in Bara Dudpatila and Krishna Chandrapur. In Rajnagar Bankabarsi, however, most of the water collectors using the tools are men. There are only two households where women use a rickshaw van for a trip to and from the water source; most women carry water pots in arm (see Figure 6.4.6).

(c) Problems concerning Water Fetching

There are several problems concerning water fetching in the Model Rural Areas. The most prevalent problem is pain in the body due to carrying heavy pots (see Figure 6.4.7). Although the average time used for fetching water per day is shorter in Bara Dudpatila than in Krishna Chandrapur, a higher ratio of the interviewees (who are presumably in charge of fetching water) responded that they feel pain in the body due to carrying heavy pots. Because 70% of the households in Rajnagar Bankabarsi depend on the DPHE deep tube well for their drinking water, about 270 households fetch water from the deep tube well. This situation made 69 % of the interviewees in Rajnagar Bankabarsi answer that they have to wait in a long line in front of the tube well.

In Krishna Chandrapur, nearly 40% of households answered that they have to go further to fetch water because the tube well that they usually use is often out of order. This suggests that both private and public (government) tube wells are not maintained properly.

(d) Daily Water Consumption

The average daily water consumption for drinking and cooking (consumed as food or drink, excluding washing dishes and cooking utensils) varies by Model Rural Area. As shown in Table 6.4.9, the average daily water consumption per capita in Krishna Chandrapur is about 1.4 times as much as that in Bara Dudpatila.

Table 6.4.9 Daily Water Consumption (Drinking & Cooking) per Household

	Bara Dudpatila	Rajnagar Bankabarsi	Krishna Chandrapur*
Rainy Season (per capita)	35.0 liter (7.6 liter)	47.5 liter (10.1 liter)	41.4 liter (11.2 liter)
Dry Season (per capita)	39.7 liter (8.7 liter)	57.6 liter (12.2 liter)	46.5 liter (12.5 liter)
Average household size	4.58	4.71	3.71

Notes: *Because the answers of the 200 households in Krishna Chandrapur are in different units, the numbers in this table is the average of data from 29 households interviewed in the village additionally.

Figure 6.4.8 a and Figure 6.4.8 b show daily water consumption for drinking and cooking by household size during the rainy season and the dry season respectively (in the three Model Rural Areas). The maximum and minimum water consumption for every household size is excluded in the figures in order to get a better estimate of the average water consumption. Based on the regression analysis, an average household with 5 members would consume about 45 liters of water for drinking and cooking (consumed as food or drink excluding washing dishes and cooking utensils) per day during the rainy season and about 53 liters during the dry season.

3) Utilization of Water Sources Other than Tubewells

(a) Pond Water

Villagers in the Model Rural Areas depend on tube wells (shallow in Bara Dudpatila and Krishna Chandrapur, shallow and deep in Rajnagar Bankabarsi) for their drinking water; most of the households have experiences in drinking pond water in the past in Rajnagar Bankabarsi and some in Krishna Chandrapur (see Table 6.4.10). On the other hand, drinking pond water is not a common practice even in the past in Bara Dudpatila. This is related to geological conditions in the Model Rural Areas; there are a number of ponds with various sizes in Rajnagar Bankabarsi while there are only two ponds larger than most of the house lots in Bara Dudpatila.

Table 6.4.10 Utilization of Pond Water for Drinking

	Bara Dudpatila	Rajnagar Bankabarsi	Krishna Chandrapur
Ratio of HH drinking pond water at present	0.0%	1.5%	0.4%
Ratio of HH drinking pond water in the past	0.0%	76.6%	13.5%
At the time when stopped drinking pond water	--	33 years ago	28 years ago

(b) Rainwater

Rainwater harvesting is practiced in some of the households in Rajnagar Bankabarsi and

Krishna Chandrapur but none in Bara Dudpatila. About 20% of the households in Rajnagar Bankabarsi and 15% in Krishna Chandrapur are collecting rainwater for the drinking purpose. In each Model Rural Area, most of those who do not harvest rainwater claim that it is easier to use tube well water, and in Rajnagar Bankabarsi nearly 40% of the households responded that drinking rainwater is not sophisticated (see Figure 6.4.9). In Krishna Chandrapur, most of the households in three paras answered the reason why they do not harvest rainwater is because they do not know about rainwater or how to use rainwater. Since some households are drinking rainwater, rainwater harvesting can be applicable to the rural areas as one of the options to obtain arsenic safe drinking water. However, there exists strong hesitation to harvest and drink rainwater; extensive education programs are necessary if it is selected as a major mitigation measure.

4) Arsenic Problems

(a) Knowledge about Arsenic Problems

Most of the households are familiar with the word “arsenic” in Rajnagar Bankabarsi and Krishna Chandrapur while the majority of the households have not heard about “arsenic” in Bara Dudpatila (see Figure 6.4.10). The level of knowledge about arsenicosis or arsenic poisoning also varies by village (see Figure 6.4.11). In Rajnagar Bankabarsi, 84% of the households responded that they have heard about arsenicosis, and 64.5% of the households listed at least one of the symptoms (see Figure 6.4.12) and 53% its cause without looking at any answer options. On the other hand, in Bara Dudpatila and Krishna Chandrapur, only 26-27% of the households could list the symptoms and 20-29% its cause. In addition, one household answered that physical contact with arsenicosis patients was the cause of arsenicosis in Bara Dudpatila. Among the ways to prevent arsenicosis, drinking arsenic-safe water is known to about a quarter of the households in Rajnagar Bankabarsi and Krishna Chandrapur (see Figure 6.4.13) while only 6% in Bara Dudpatila.

Nevertheless Rajnagar Bankabarsi has the highest ratio of households without a literate person among the three Model Rural Areas (see Table 6.4.4), it has the highest awareness of arsenic problems. The high awareness in Rajnagar Bankabarsi was acheived thanks to one arsenic patient, who is teacher and voluntarily educates school children and villagers about arsenicosis and prevention methods.

Within a village, awareness of arsenic problems varies by area. Figure 6.4.14, 6.4.15, and 6.4.16 show the distribution of households having heard about arsenicosis or arsenic poisoning in the Model Rural Area. In Bara Dudpatila, there seems to be no area where households have heard about arsenicosis or those not are concentrated. On the other hand, in Rajnagar Bankabarsi, most of the households that have not heard about arsenicosis are found in the south part of the village. In Krishna Chandrapur, there are three paras in which all the households interviewed have not heard about arsenicosis. Residents of the two *Paras* out of the three are Hindus, and the majority of the villagers are Muslim; there seems to be little communication between the Hindus and the Muslims in the same village.

(b) Practices to Reduce Arsenic in Water and Obtain Arsenic Safe Water

Practices to reduce arsenic in water and obtain arsenic safe water are prevalent in Rajnagar Bankabarsi but not in Bara Dudpatila and Krishna Chandrapur (see Figure 6.4.17). This is assumed to be because arsenic safe water is available and because many villagers are aware of arsenic problems in Rajnagar Bankabarsi.

In Rajnagar Bankabarsi, 70.5% of the households say that they use arsenic safe wells. Since the arsenic concentration of the DPHE deep tube well in Rajnagar Bankabarsi is below the permissible level, arsenic safe water is available to villagers although they have to spend more than one hour per day on fetching water. There is also a DPHE deep tube well in Krishna Chandrapur, but an arsenic concentration over the permissible level was detected in the water. In Bara Dudpatila, there is no deep tube well. Since not all the tube wells had been arsenic tested, availability of confirmed arsenic safe water was very limited in Krishna Chandrapur and Bara Dudpatila.

When water contains both iron and arsenic, letting water sit in a pot overnight helps settlement of arsenic with iron, which 66.5% of the households in Rajnagar Bankabarsi and 22.4% of the households in Krishna Chandrapur practice. As shown in Figure 6.3.31, a high concentration of Fe^{2+} is observed in a large number of tube wells in Rajnagar Bankabarsi and Krishna Chandrapur, whereas it is observed in a small number of tube wells in Bara Dudpatila. Since the iron concentration of tube well water in Rajnagar Bankabarsi is high, it was considered that letting water sit in a pot overnight has been traditionally practiced in order to reduce iron taste of the water. However, according to the interview with the arsenic patient, who is teacher and lets water sit in a pot overnight, he started doing so after he was told by the JICA expert in 2000. He then told villagers to let water sit in a pot to reduce arsenic, and many villagers in Rajnagar Bankabarsi now follow the practice.

(d) Relationship between Awareness of Arsenic Problems and Water Fetching Practice

It seems that awareness of arsenic problems encourages villagers to make efforts to obtain arsenic safe water. In Rajnagar Bankabarsi, although arsenic safe water is available from the DPHE deep tube well, it is located at the periphery of the village. The DPHE deep tube well users are scattered all over the village; therefore, villagers spend about 43 minutes per trip on average to fetch water from the DPHE tube well. Since those who depend on shallow wells for their drinking water only spend about 5 minutes to fetch water per trip on average, obtaining arsenic safe water requires villagers to make considerable efforts.

Figure 6.4.18 shows the ratio of the DPHE deep tube well and the average time spend for water fetching per trip by level of knowledge about arsenicosis. Only 28% of the households that have not heard about arsenicosis fetch water from the DPHE deep tube well, and consequently their average time spent for fetching water is about 24 minutes. On the other hand, about 80% of the households that know the cause of arsenicosis and 92% of the households that know prevention methods of arsenicosis use the DPHE deep tube well and spend 38 minutes and 45 minutes for fetching water respectively. Figure 6.4.19 shows the distribution of DPHE deep tube well users and shallow tube well users. DTW users are not only limited in the vicinity of the tube well but also located a long distance away from the tube well. If one compares the distribution of households having heard about arsenicosis (Figure 6.4.15) with the distribution of deep tube well users (Figure 6.4.19), one can see the similarity in the two distributions. That means awareness of arsenicosis encourages villagers to make efforts to obtain arsenic safe water.

(e) Willingness to Pay for Obtaining Arsenic Safe Water

Villagers' willingness to pay (WTP) for obtaining arsenic safe water varies by village and current water fetching practices[1]. As shown in Figure 6.4.20, the average WTP for obtaining arsenic safe water ranges from 16 to 75 Tk, and the average ratio of WTP to the monthly cash income[2] ranges from 0.7% to 3.5%. Since those depending on the DPHE deep tube well for their drinking water are considered to have access to arsenic safe water, the average WTP by deep tube well users and that by shallow tube well users are calculated separately in Rajnagar Bankabarsi. The average WTP of deep tube well users is higher than that of shallow tube well users, and so is the average ratio of WTP to the monthly cash income. This may be partly explained by high awareness of arsenic problems among the deep tube well users (see Table 6.4.11).

[1] "Current" or "present" in this section means "at the time of the interview being carried out (September to October 2000)."
[2] See the section "4) Economic Condition" for the estimation of the income.

Table 6.4.11 Willingness to Pay for Arsenic Safe Water

	Bara Dudpatila	Rajnagar Bankabarsi		Krishna Chandrapur
		Shallow TW	Deep TW	
Average WTP per month	29 Tk	16 Tk	66 Tk	75 Tk
Average ratio of WTP to cash income	2.5%	0.7%	1.5%	3.5%
Ratio of HH knowing prevention methods	6.0%	6.7%	32.9%	23.1%

Another explanation might be willingness to spend time for fetching arsenic safe water described below.

Villagers' willingness to spend extra time for obtaining arsenic safe water also varies by village and current water fetching practices. Figure 6.4.21 shows the average time spent on fetching water per trip at present and willingness to spend time for fetching arsenic safe water and maintaining the water source or device. As shown in Figure 6.4.21, shallow well users (29% of the households in Rajnagar Bankabarsi and all the households in Bara Dudpatila and Krishna Chandrapur) spend 3 to 5 minutes per trip to fetch water at present. The shallow well users' willingness to spend extra time for fetching water and their knowledge about arsenicosis prevention methods are summarized in Table 6.4.12.

Table 6.4.12 Shallow Well Users' Willingness to Spend Time for As Safe Water

	Bara Dudpatila	Rajnagar Bankabarsi	Krishna Chandrapur
Time for fetching water	3.7 min.	7.9 min.	15.0 min.
Time for maintenance	5.6 min.	11.7 min.	17.4 min.
Ratio of HH knowing arsenicosis prevention methods	6.0%	6.9%	23.1%

Among the shallow well users, the higher ratio of households having the knowledge, the more households willing to spend extra time for fetching arsenic safe water.

Deep tube well users spend 42 minutes per trip at present, and their willingness to spend extra time for fetching arsenic safe water is negative 31 minute. Given that their willingness to pay for arsenic safe water is about 65 Tk per month, they seem willing to pay more than shallow tube well users if they could shorten the time spent on fetching water.

(f) Arsenicosis patients

Trained interviewers preliminarily diagnosed arsenicosis patients during the interviews and found probable patients and information about their treatment (see Table 6.4.13). Section 6.5 discusses the confirmed number of arsenicosis patients in each Model Rural Area and their characteristics in detail.

Table 6.4.13 Number of Patients in the Households Interviewed

	Bara Dudpatila	Rajnagar Bankabarsi	Krishna Chandrapur
# of people with arsenicosis symptoms	27	12	43
# of patients treated	11	3	23
Average monthly costs of treatment per person	4,306 Tk	1,500 Tk	309 Tk
Ratio of treatment costs to monthly cash income	322.4%	13.8%	18.5%

Treatment costs account for more than 10% of the monthly cash income of the household in Rajnagar Bankabarsi and Krishna Chandrapur and over 300% in Bara Dudpatila. It is necessary to identify impacts of arsenicosis in terms of extra expenditure for the treatment costs and loss of income due to the health effects.

5) Economic Conditions

(a) Cash Income

The average annual cash income in each Model Rural Areas is within the range of 25,000 Tk to 35,000 Tk, but the median is about 18,000 Tk in Bara Dudpatila and 25,000 Tk in Rajnagar Bankabarsi and Krishna Chandrapur. The annual cash income of each household is estimated based on the information about cash income from selling crops, livestock, and other goods, labor work, salary work, and other sources such as remittance and gifts. The annual cash income does not include the monetary value of goods for domestic consumption such as vegetables from their garden and milk from domestic animals. Information on monthly expenditure was also collected, and when the total monthly cash income is smaller than the monthly expenditure, the average of the income and the expenditure is used for estimating the annual income. Figure 6.4.22 shows the distribution of households by annual cash income in each Model Rural Area. As the median tells, the largest income group is 10,000 to 20,000 Tk in Bara Dudpatila and 20,000 to 30,000 Tk in Rajnagar Bankabarsi and Krishna Chandrapur. Figure 6.4.23 shows the distribution of households by annual cash income per capita; as in the case of annual cash income, Rajnagar Bankabarsi and Krishna Chandrapur show a similar distribution. Table 6.4.14 summarizes the average annual cash income per household and per capita in each Model Rural Area. Within a village, there exists a large gap between those who are wealthy and those who are poor although there are only several hundred households in one village. The lowest annual cash income per capita is about 1/10 of the highest in Bara Dudpatila, and 1/20 of the highest in Rajnagar Bankabarsi and Krishna Chandrapur.

Table 6.4.14 Annual Cash Income in Model Rural Areas

		Bara Dudpatila	Rajnagar Bankabarsi	Krishna Chandrapur
Cash income per HH	Median	17,600	25,400	24,600
	Max.	142,000	182,100	128,600
	Min.	7,200	7,100	4,300
Cash income per capita	Median	4,900	6,100	5,900
	Max.	19,300	43,300	27,900
	Min.	1,800	1,900	1,300

In Bara Dudpatila and Rajnagar Bankabarsi, the distribution of households by annual cash income per capita does not show a concentration of a specific income group in one area (see Figure 6.4.24 and 6.4.25). However, in Krishna Chandrapur, there are areas where wealthy and poor households are concentrated separately (Figure 6.4.26). The higher income households are concentrated in two paras south of the main road, and so are the lower income households north of the main road. Community based arsenic removal plants that require relatively large capital costs cannot be installed and maintained by the villagers in poor neighborhoods.

Most of the households have several income sources as shown in Figure 6.4.27; more than 80% of the households have income from labor work such as rickshaw (van) driver and agricultural labor. The average income by source is shown in Figure 6.4.28; for most of the households, labor work is the main source of income while for the households having salary workers so is the salary. Therefore, most of the households are vulnerable to economic hardship if a bread-earner (labor worker) is severely affected by arsenic intake.

(b) Household Expenditure

The average household spends 60 to 70% of its cash income on food as shown in Figure 6.4.29. Expenditure on water was reported from only one household in Rajnagar Bankabarsi among more than 600 households. In Rajnagar Bankabarsi, where 18.5% of the households are using rickshaw van or bicycle for fetching water, there should be some more household spending on water as payment of transportation fee. Since villagers get water free of charge at present, there are households whose willingness to pay for obtaining arsenic safe water is zero. The ratio of the households whose WTP is zero is 45% in Bara Dudpatila, 10% in Rajnagar Bankabarsi, and 2% in Krishna Chandrapur.

6) Health and Sanitary Condition

(a) Nutrition

In Bangladesh, rice is the staple food, and all the households answered that they eat rice almost every day. Figure 6.4.30 shows the relative frequency of food intake in each Model Rural Area. Since the average intake frequency of rice and beans does not vary by village, that of foods other than rice and beans is shown. The foods on the upper half of the radar chart are rich in vitamins and those on the bottom are rich in protein. When the three Model Rural Areas are compared, protein intake in Bara Dudpatila is less frequent in Rajnagar Bankabarsi and Krishna Chandrapur. In Bara Dudpatila, meat is consumed less than once a month, and fish less than once a week but more than once a month. On the other hand, in Rajnagar Bankabarsi and Krishna Chandrapur, meat is consumed more than once a month, and fish nearly almost every day. Because low protein in the diet decreases methylation of inorganic arsenic, villagers in Bara Dudpatila may be more susceptible to arsenicosis even if they intake the same amount of arsenic through drinking water. The relationship between diet and arsenicosis is discussed in Section 6.5.

(b) Sickness

As far as the interviewees' memory is correct, villagers in Bara Dudpatila are less prone to get ill compared to those in Rajnagar Bankabarsi and Krishna Chandrapur. Figure 6.4.31 shows the ratio of households where at least one member got sick during the past year. The ratio is calculated by age group: infant (age 0-3), child (age 4-14), and adult (age 15 and over); and the ratio of the households regarding sickness of infants and children takes only households with infants or children into account. The higher ratio of sickness among households in Krishna Chandrapur is reflected in the higher ratio of medical expenses (average 9.2%) to the monthly expenditure as shown in Figure 6.4.26.

In Krishna Chandrapur, a much higher ratio of households experienced a family member with diarrhea compared to the other two villages. This is considered to be because awareness of hygiene in Krishna Chandrapur is lower than that in the other two.

Table 6.4.15 shows the ratio of households practicing hygienic water use, such as storing water in a pot with a lid and not dipping into water with a glass or other utensils. There is a slight difference in the ratios among the three Model Rural Areas. Other evidence of awareness of hygiene is discussed in the next section.

Table 6.4.15 Ratio of HH Practicing Hygienic Water Use

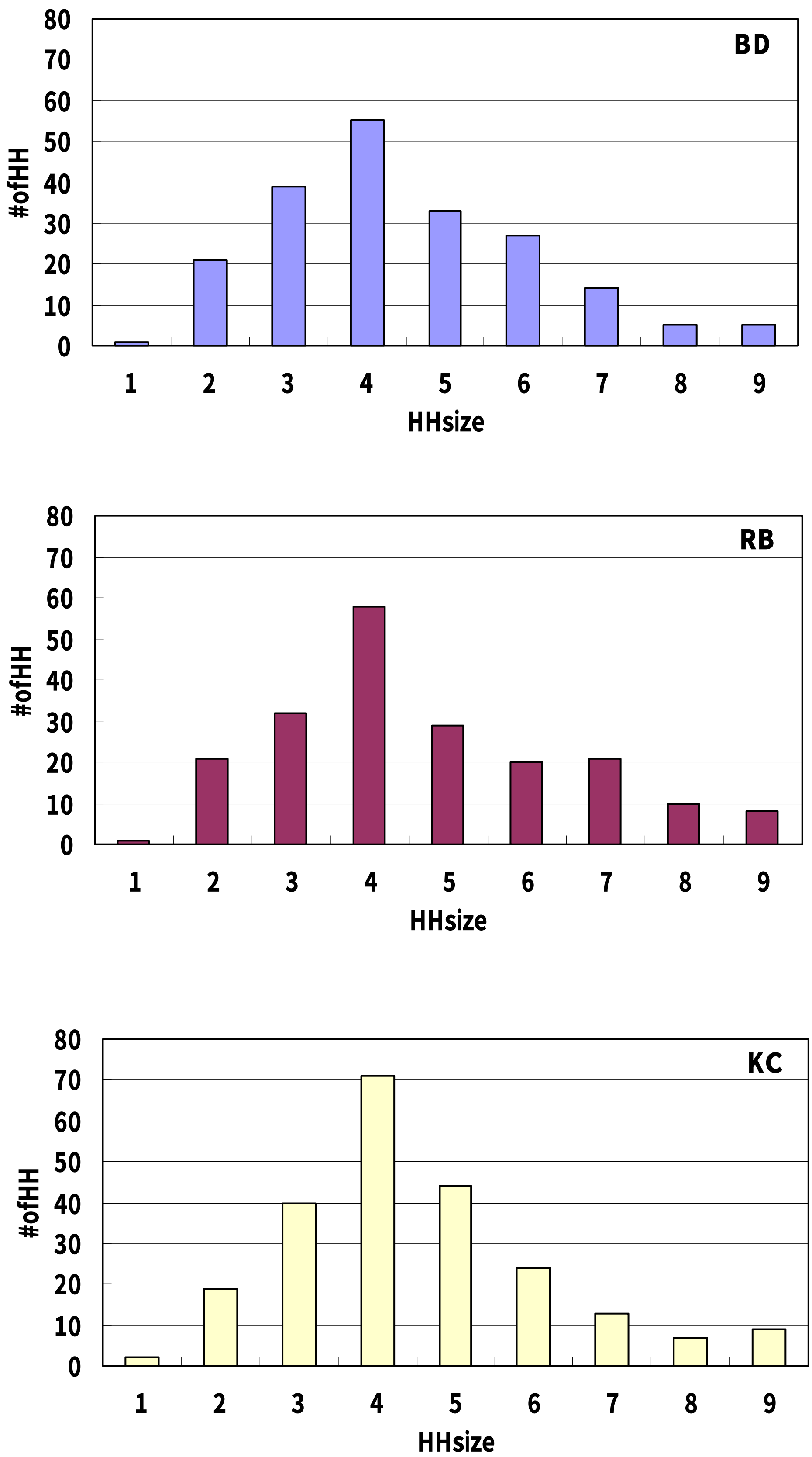
	Bara Dudpatila	Rajnagar Bankabarsi	Krishna Chandrapur
Putting a lid on water pots	100%	94%	84%
Not dipping water with a glass	100%	99.5%	87.8%

(c) Sanitation

Use of a latrine is most prevalent in Bara Dudpatila although the average income in the village is the lowest among the Model Rural Areas (see Figure 6.4.32). This could be considered as one of the manifestations of higher awareness of hygiene in Bara Dudpatila compared to the other two villages. On the other hand, the ratio of households using a latrine in Krishna Chandrapur is the lowest among the Model Rural Areas, and that of discarding garbage outside the house lot (see Figure 6.4.33), which is considered as not being controlled, is the highest. This may be due to a low awareness of hygiene in Krishna Chandrapur, which could make it difficult to maintain the good health condition of the villagers.

Reference

WHO (2000): *Towards an assessment of the socioeconomic impact of arsenic poisoning in Bangladesh*.



BD: Bara Dudpatila, RB: Rajnagar Bankabarsi, KC: Krishna Chandrapur

Figure 6.4.2 Distribution of Households by Household Size

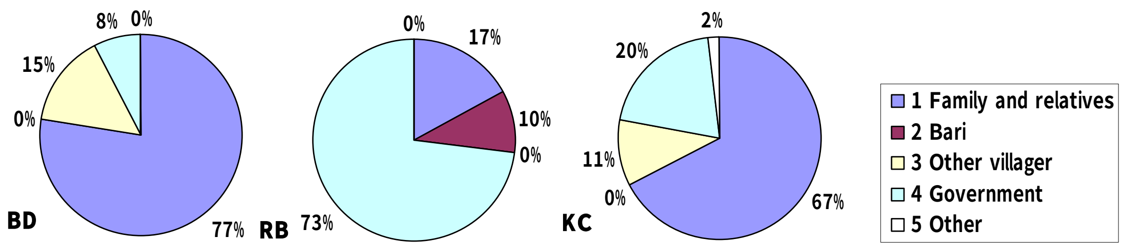


Figure 6.4.3 Ownership of Water Source (Tubewell)

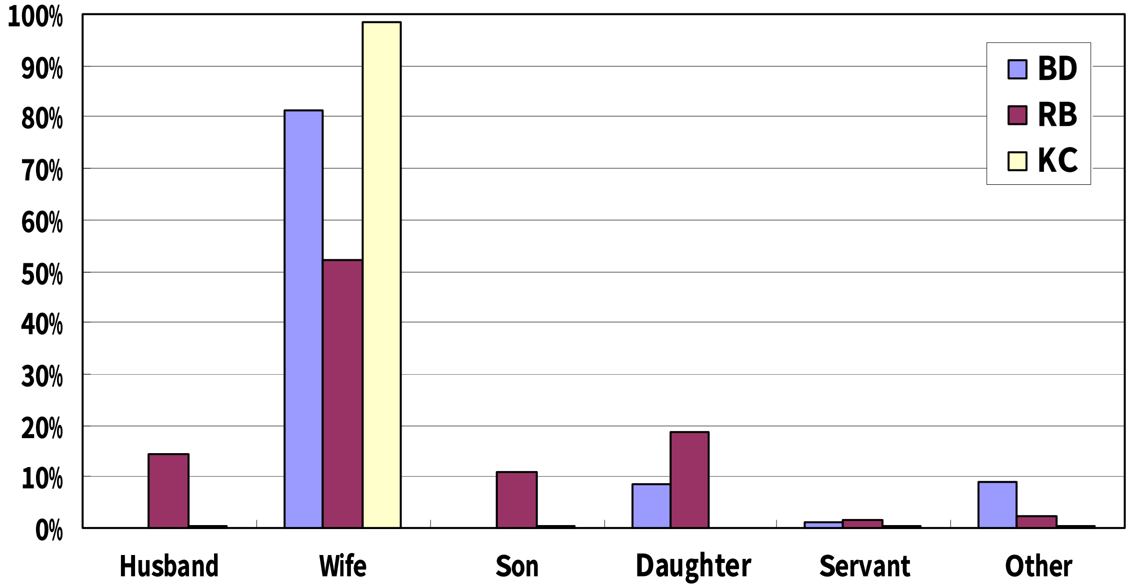


Figure 6.4.4 Ratio of Households by Water Collector

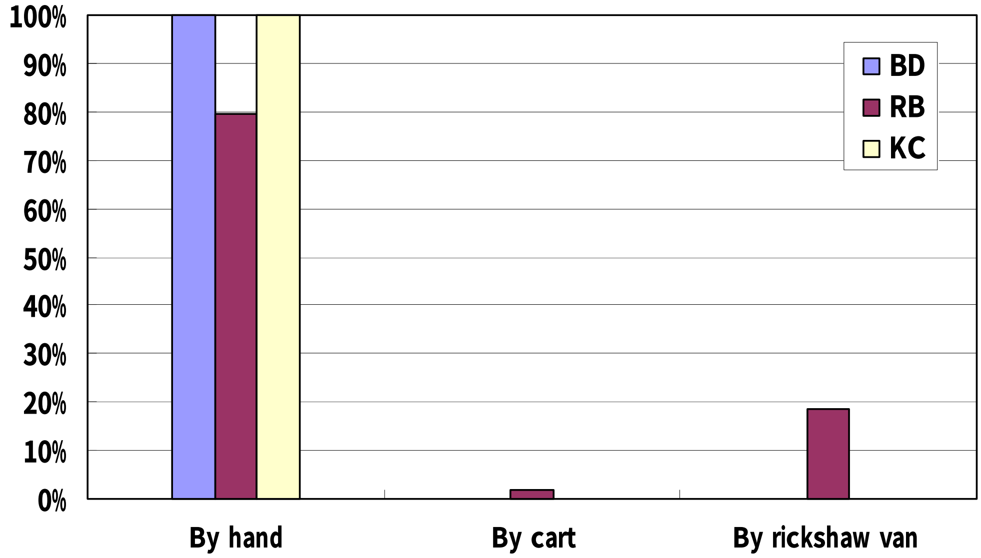


Figure 6.4.5 Carrying Method of Water Pots

Figure 6.4.6 Way of Carrying Water Pots in Arm

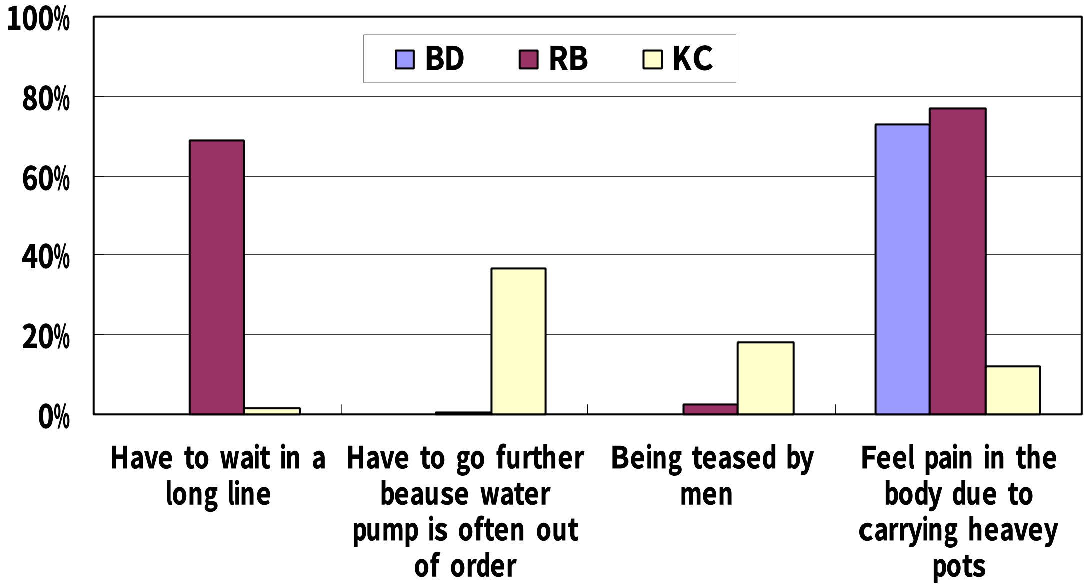


Figure 6.4.7 Problems concerning Water Fetching

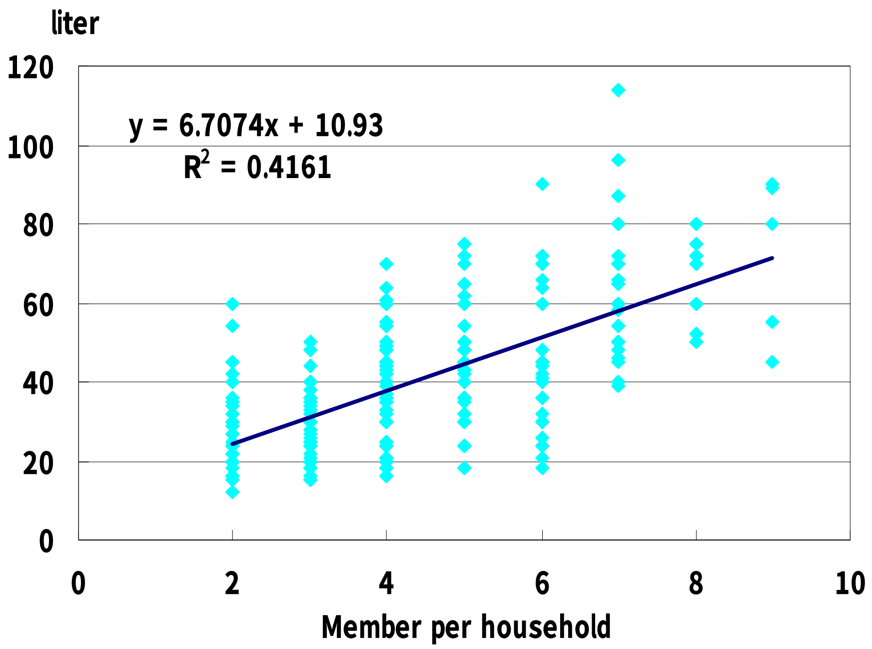


Figure 6.4.8a Water Consumption by Household Size (Rainy Season)

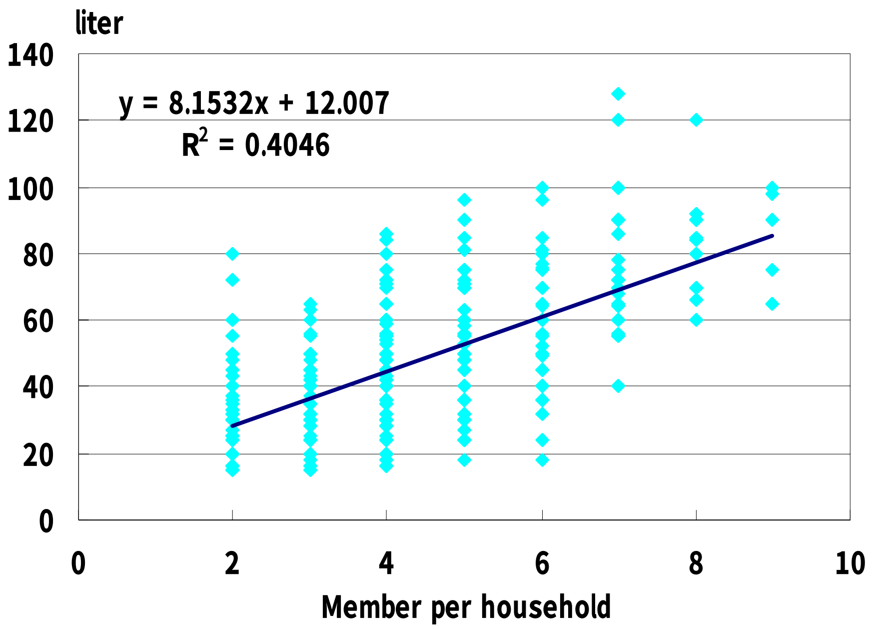


Figure 6.4.8b Water Consumption by Household Size (Dry Season)

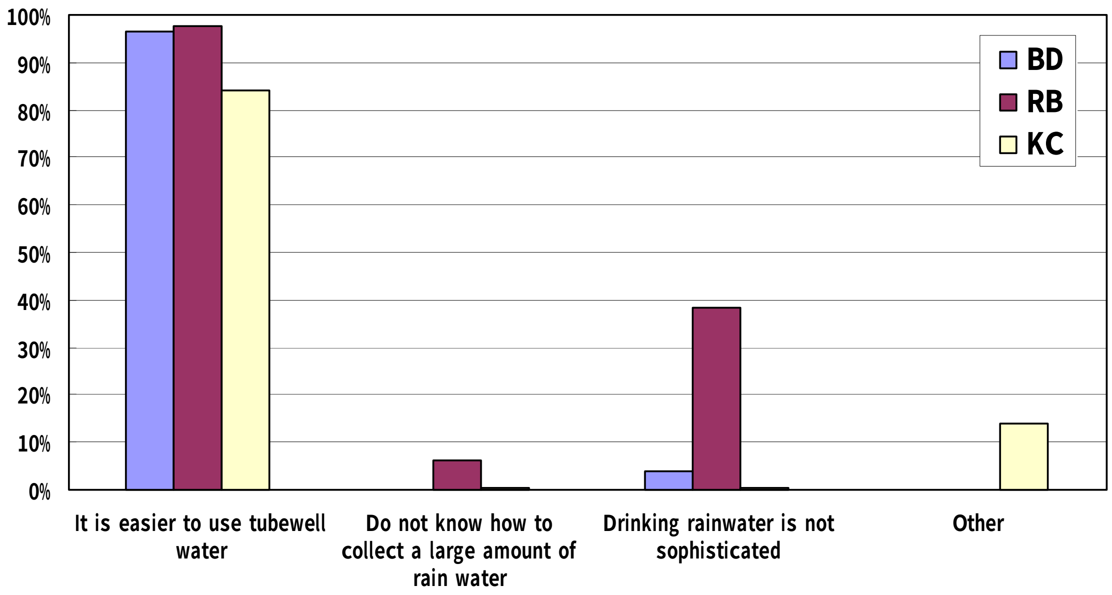


Figure 6.4.9 Reasons for not Drinking Rainwater

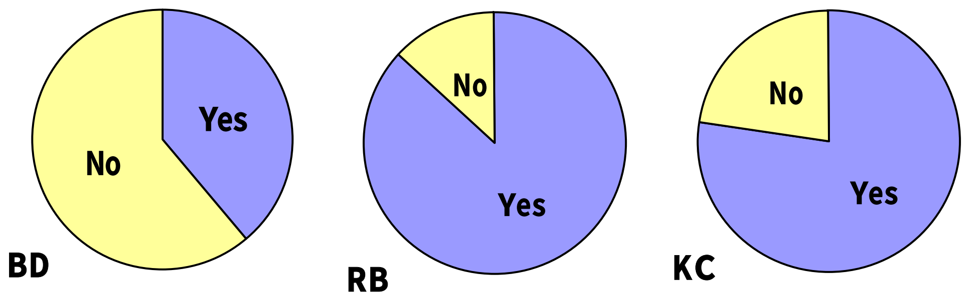


Figure 6.4.10 Ratio of Households Having Heard about Arsenic

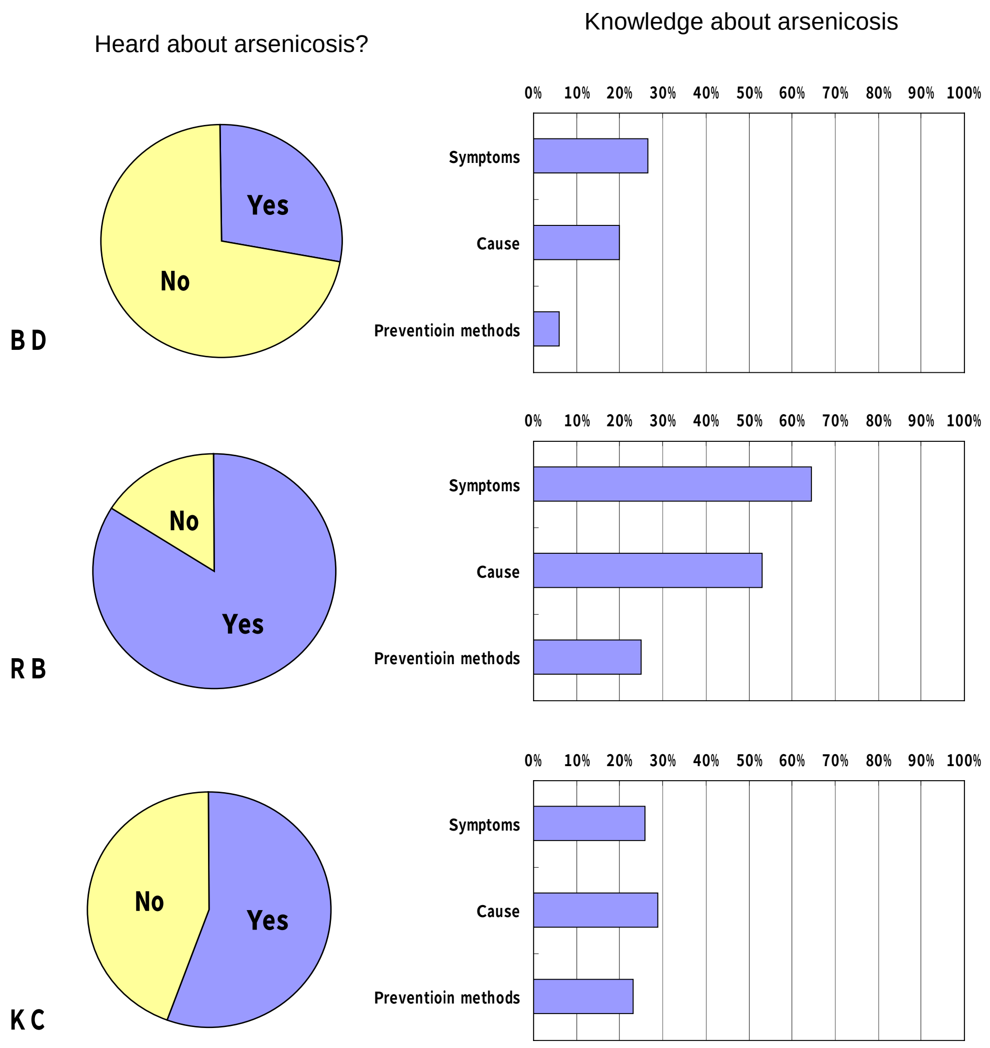


Figure 6.4.11 Ratio of Households with Knowledge about Arsenicosis

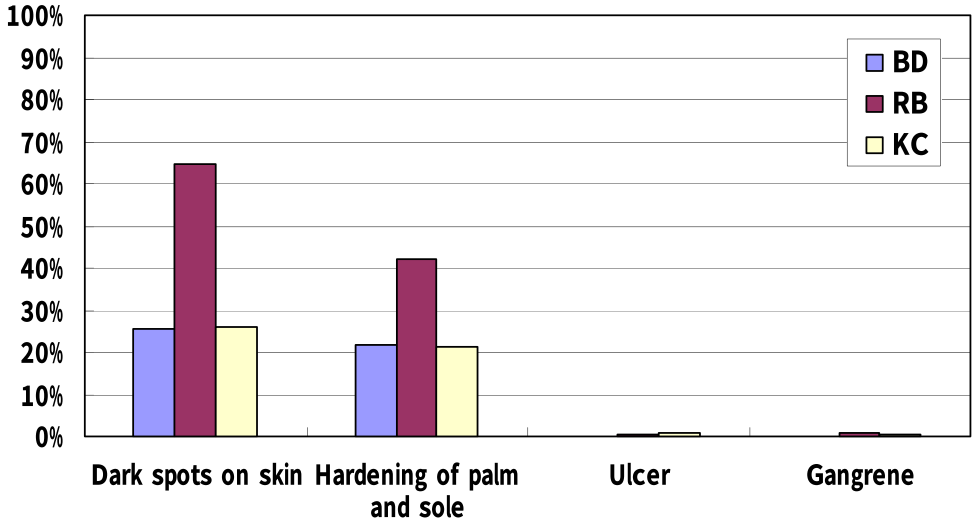


Figure 6.4.12 Ratio of Households with Knowledge about Symptoms of Arsenicosis

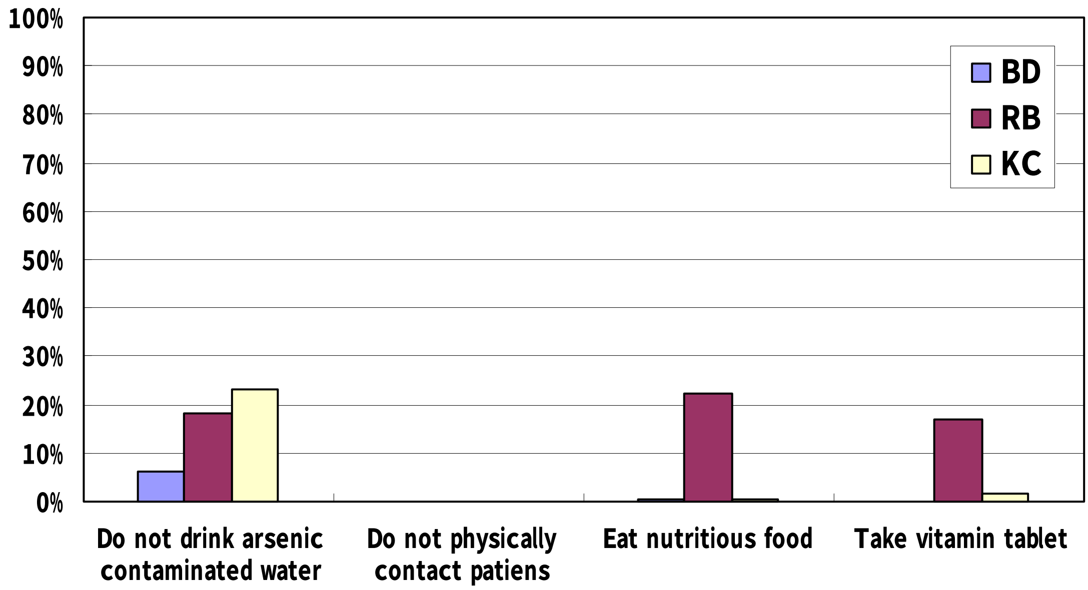


Figure 6.4.13 Ratio of Households with Knowledge about Preventing Arsenicosis

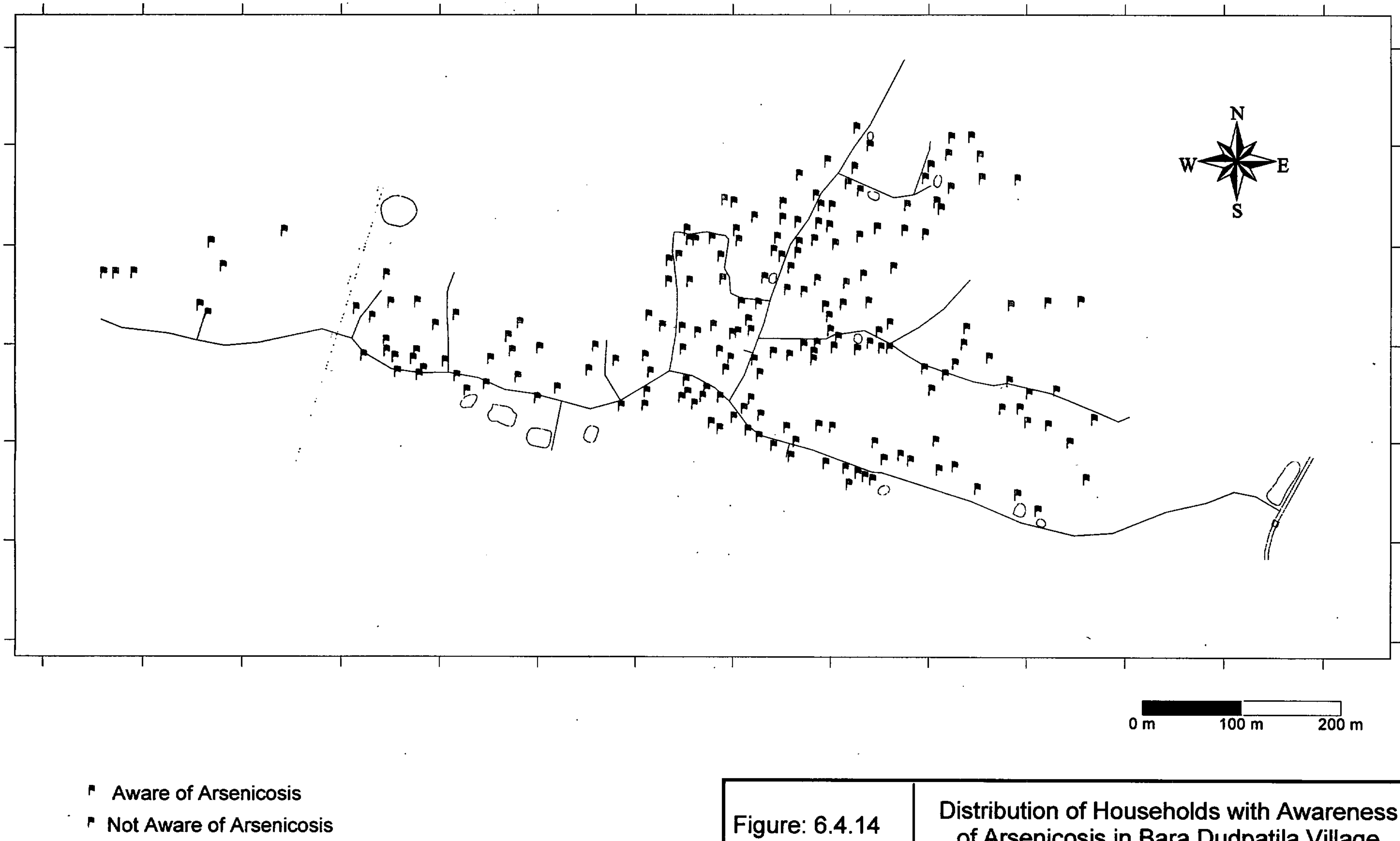
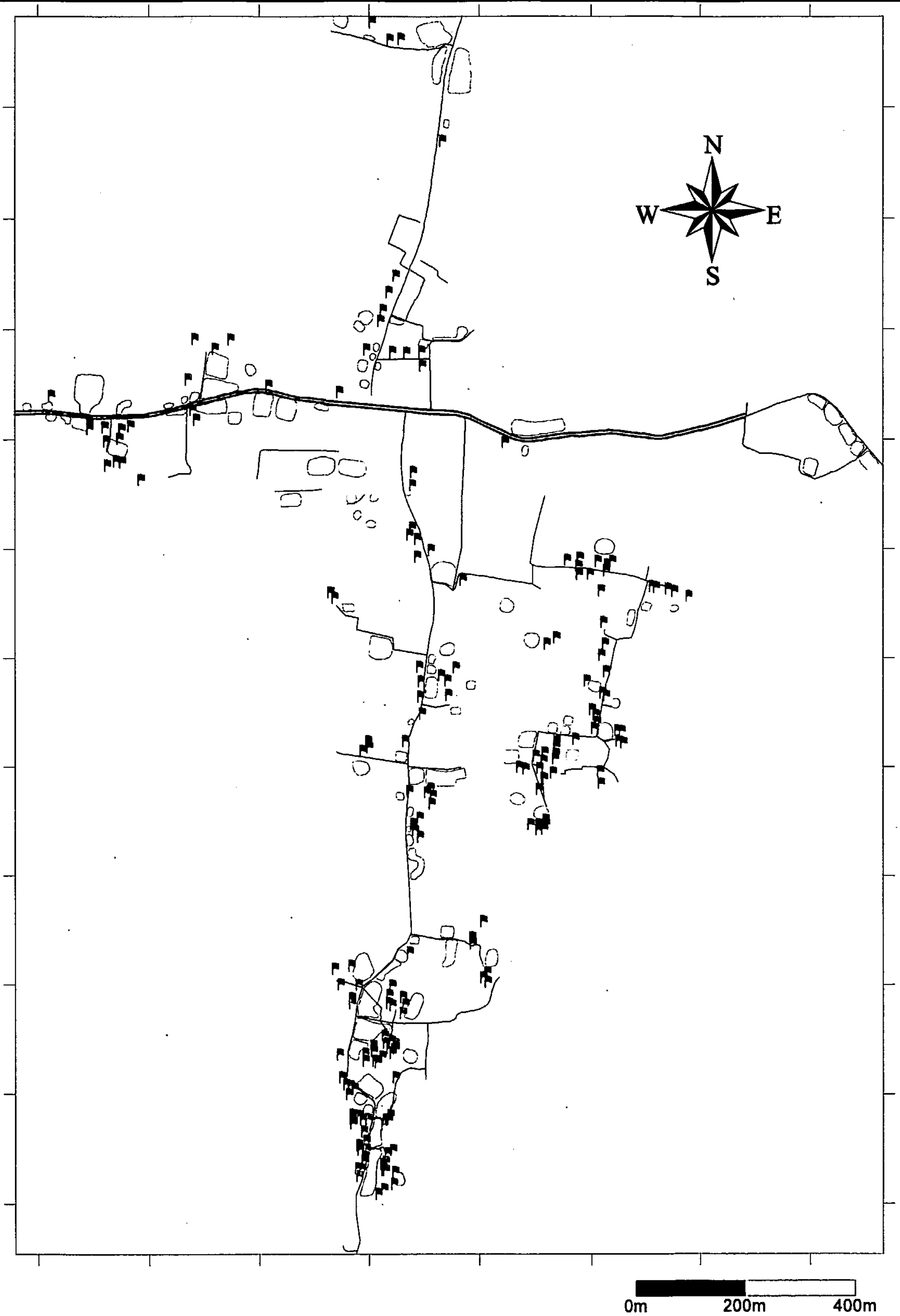


Figure: 6.4.14	Distribution of Households with Awareness of Arsenicosis in Bara Dudpatila Village

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



Aware of Arsenicosis

Not Aware of Arsenicosis

Figure: 6.4.15	Distribution of Households with Awareness of Arsenicosis in Rajnagar Bankabarsi Village

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

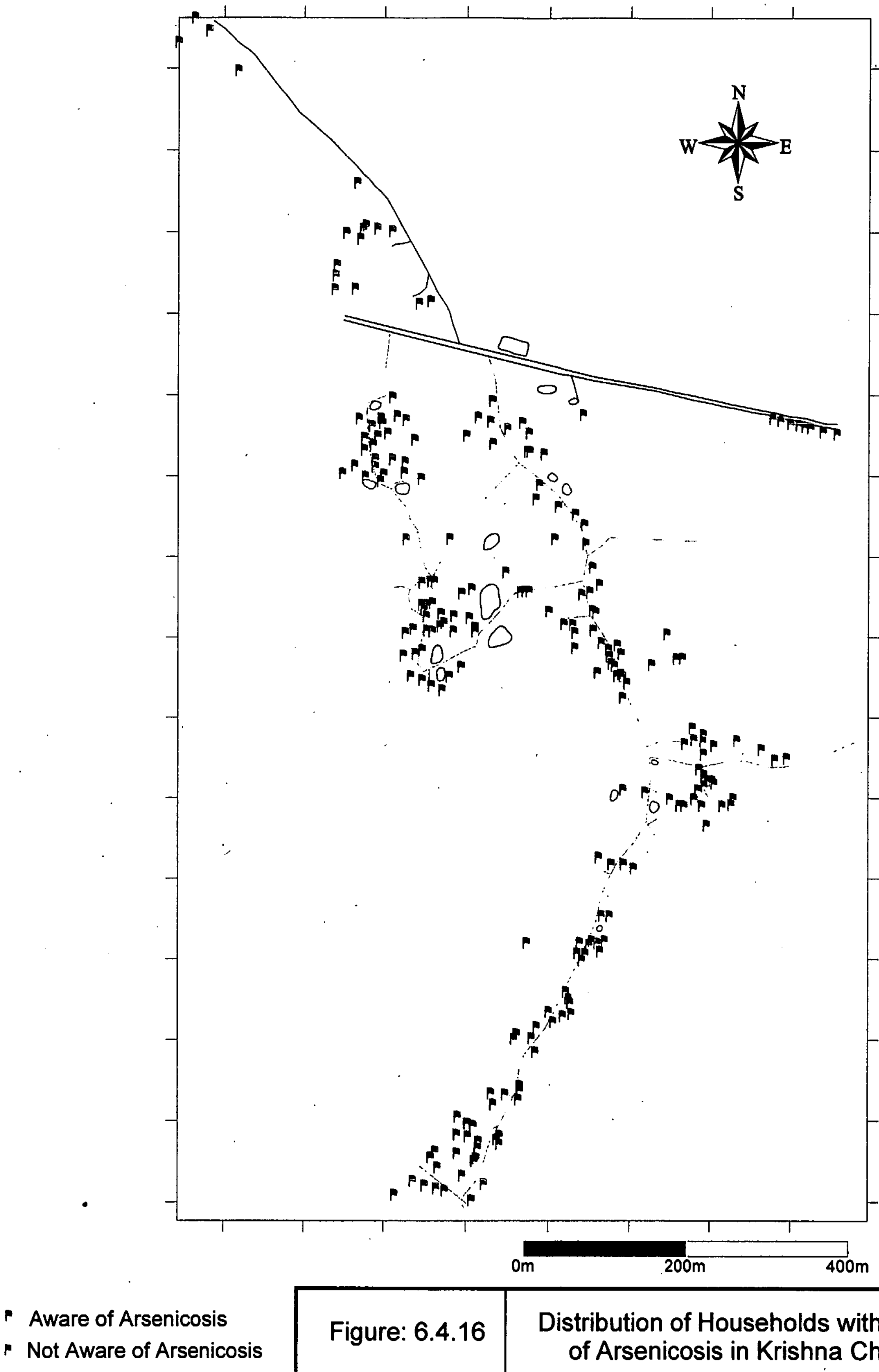


Figure: 6.4.16	Distribution of Households with Awareness of Arsenicosis in Krishna Chandrapur

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

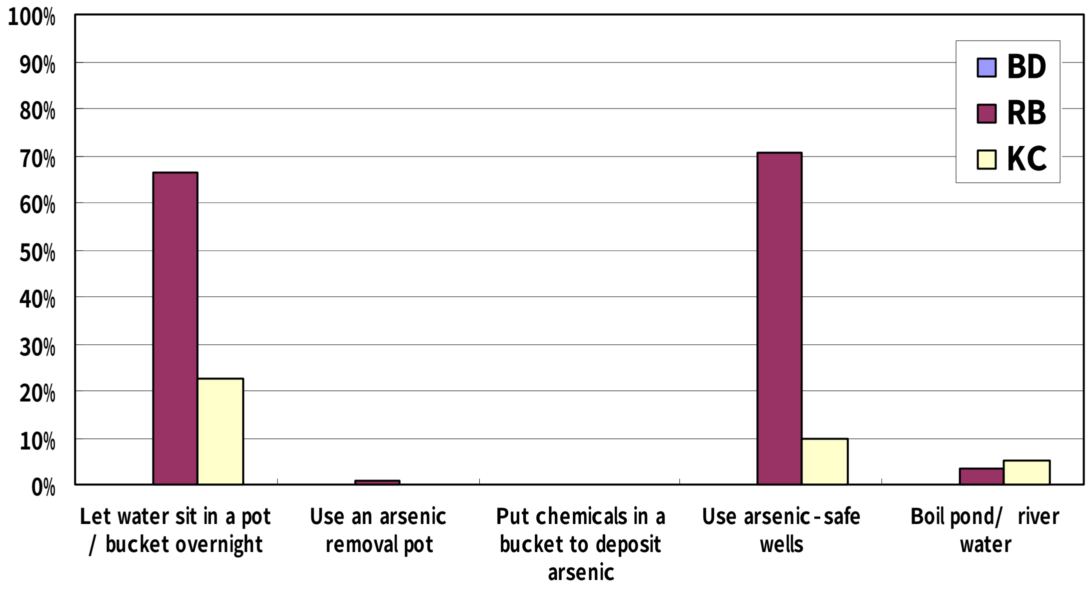


Figure 6.4.17 Ratio of Households Reducing Arsenic or Obtaining Arsenic Safe Water

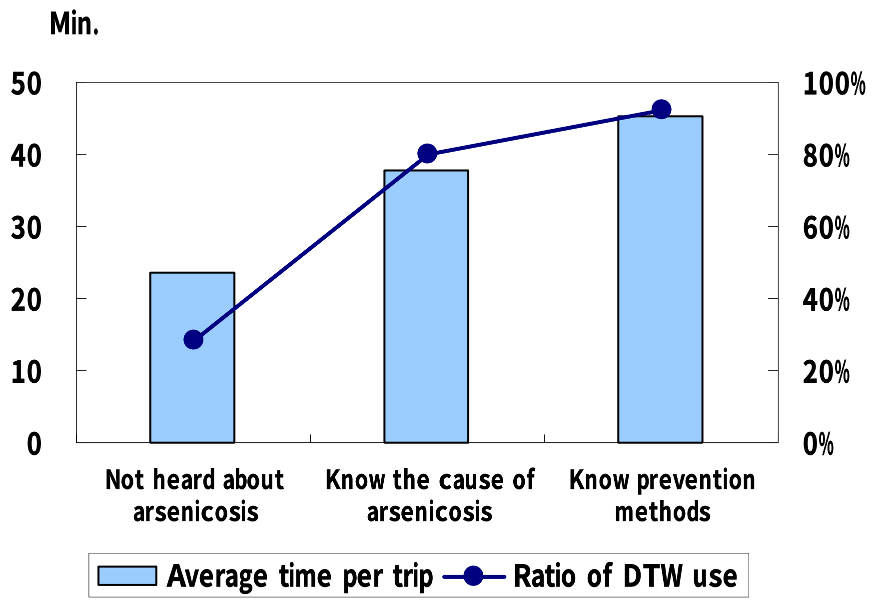


Figure 6.4.18 Efforts for Obtaining Arsenic Safe Water by Knowledge about Arsenicosis in Rajnagar Bankabarsi

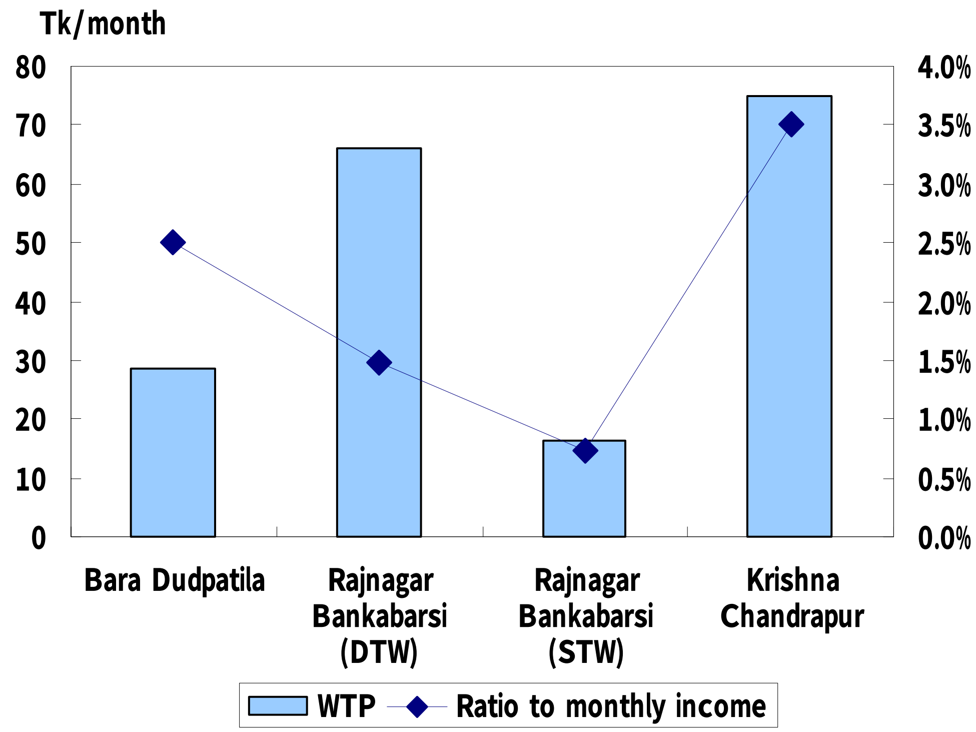


Figure 6.4.20 Willingness to Pay for Arsenic Safe Water

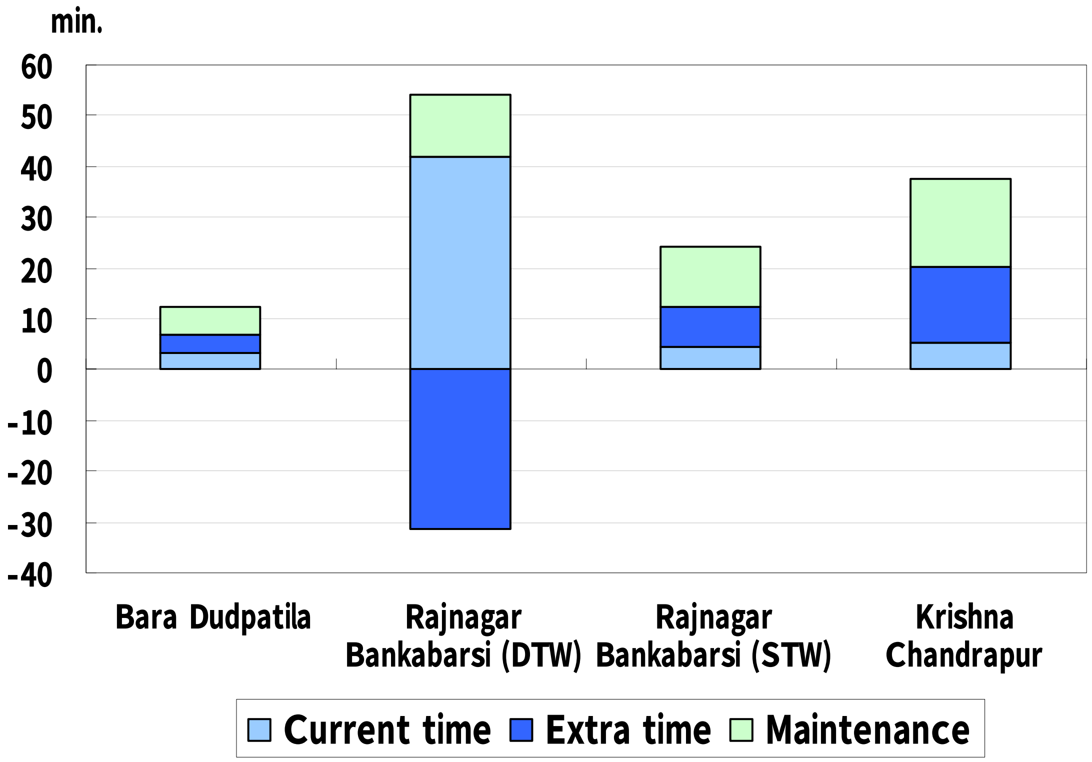
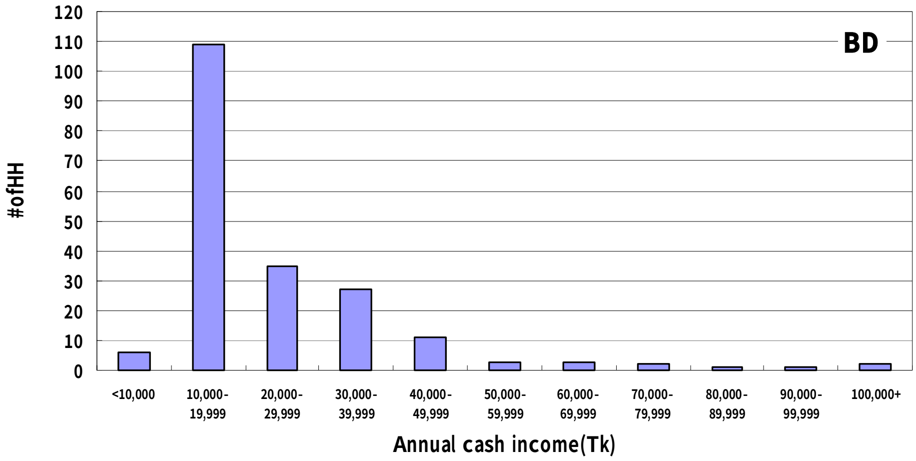
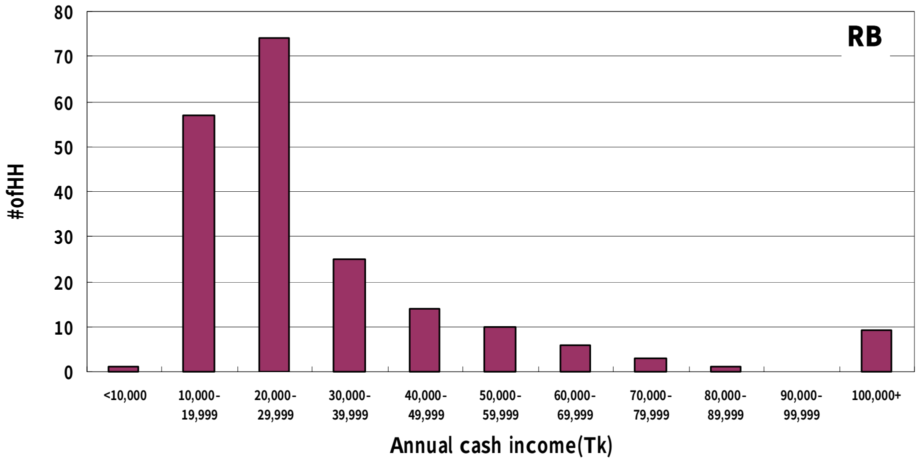


Figure 6.4.21 Willingness to Spend Time for Arsenic Safe Water





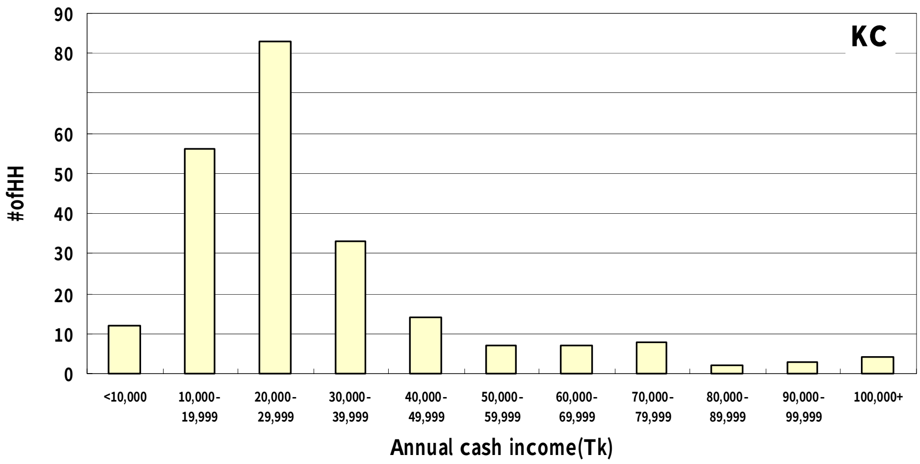


Figure 6.4.22 Distribution of Households by Annual Cash Income

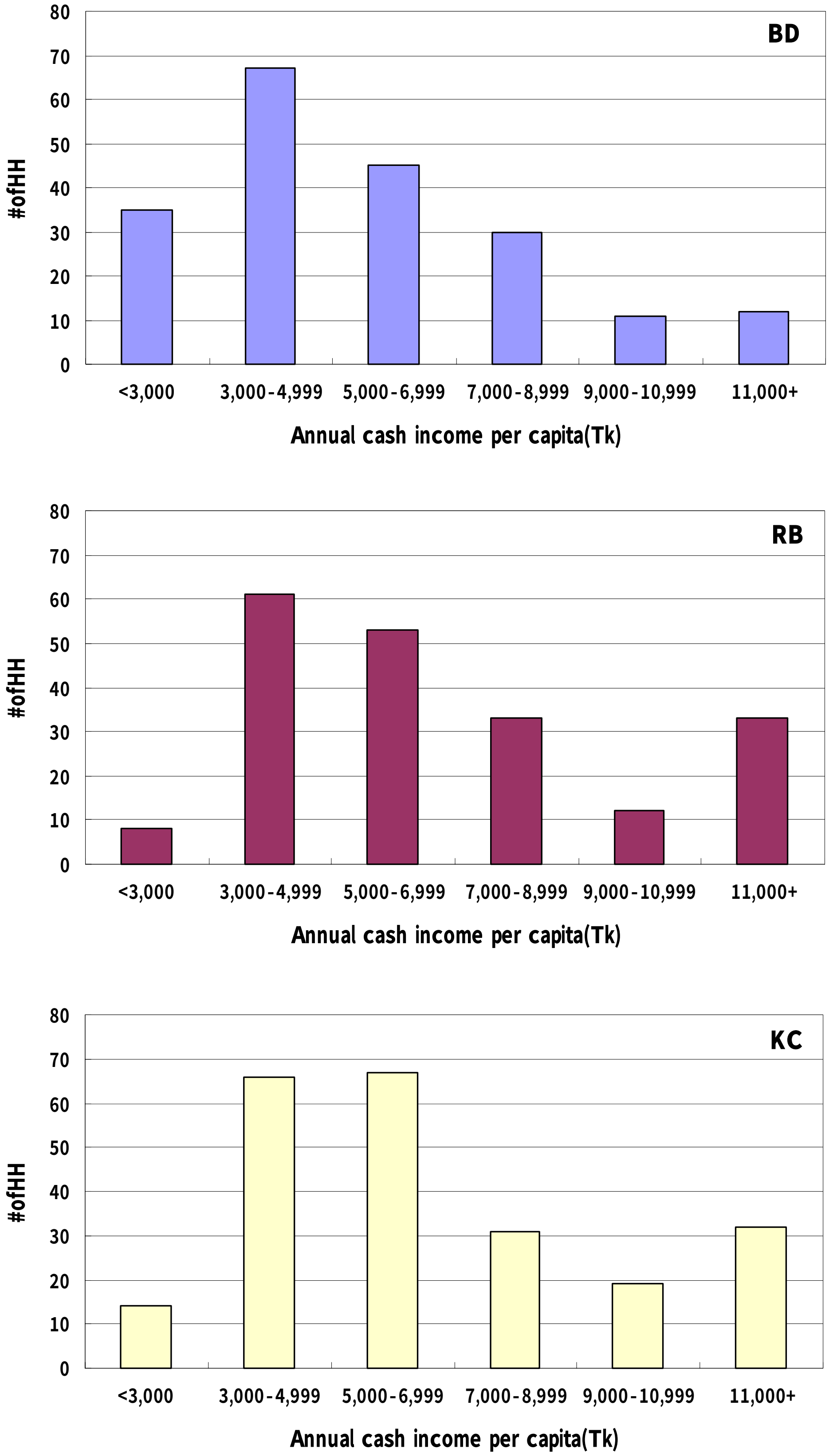


Figure 6.4.23 Distribution of Households by Annual Cash Income per Capita

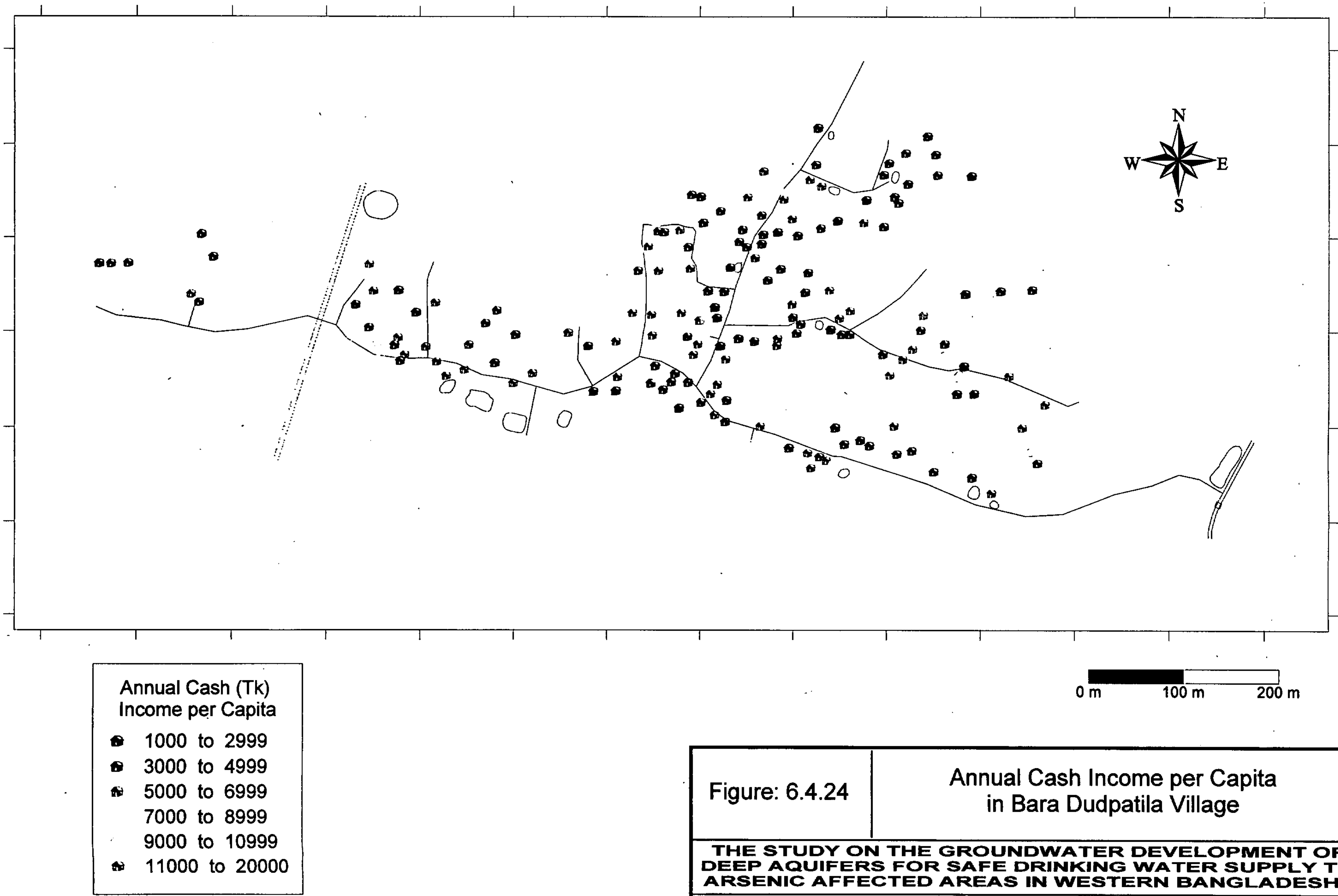
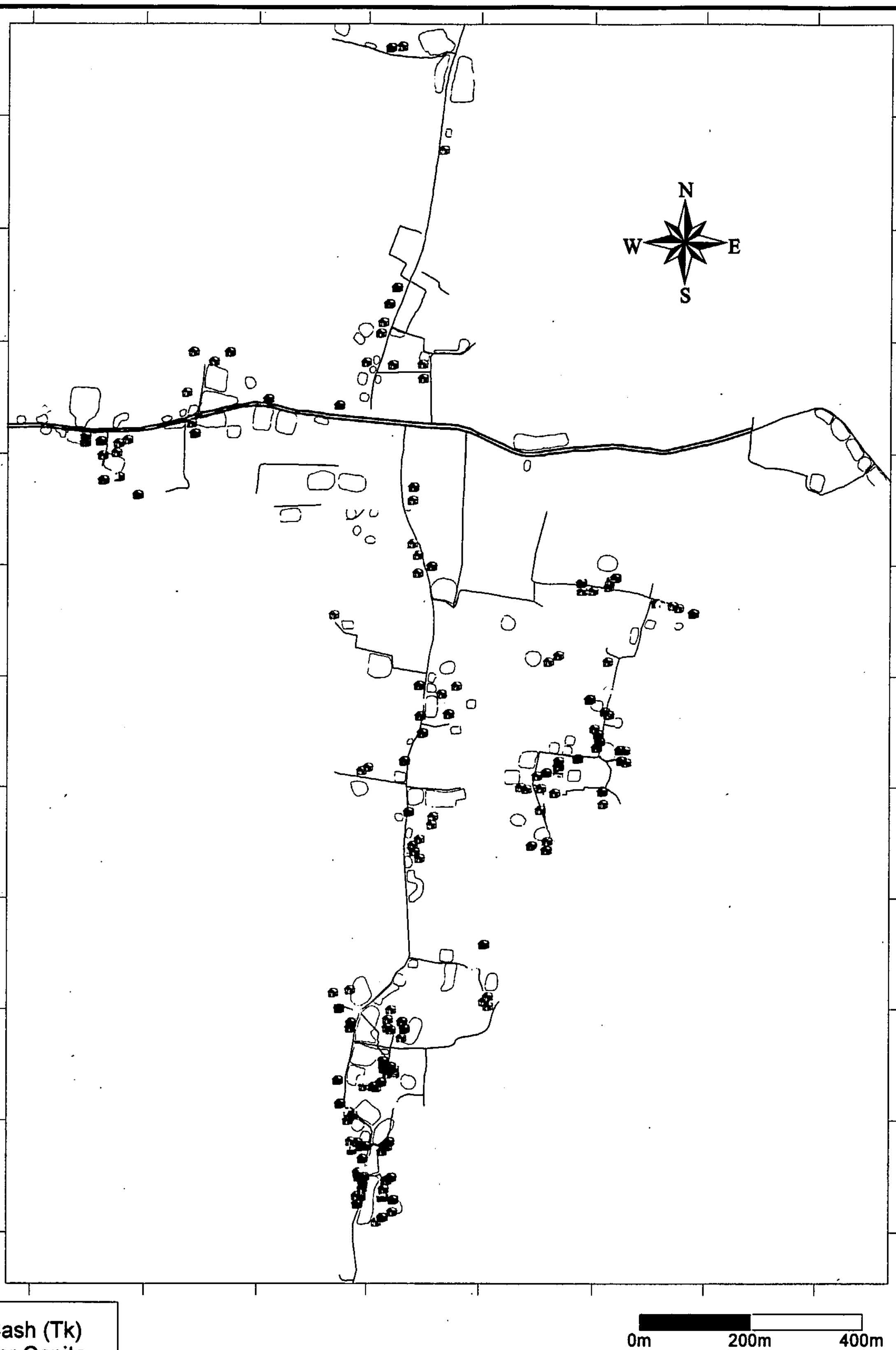


Figure: 6.4.24	Annual Cash Income per Capita in Bara Dudpatila Village

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



Annual Cash (Tk) Income per Capita

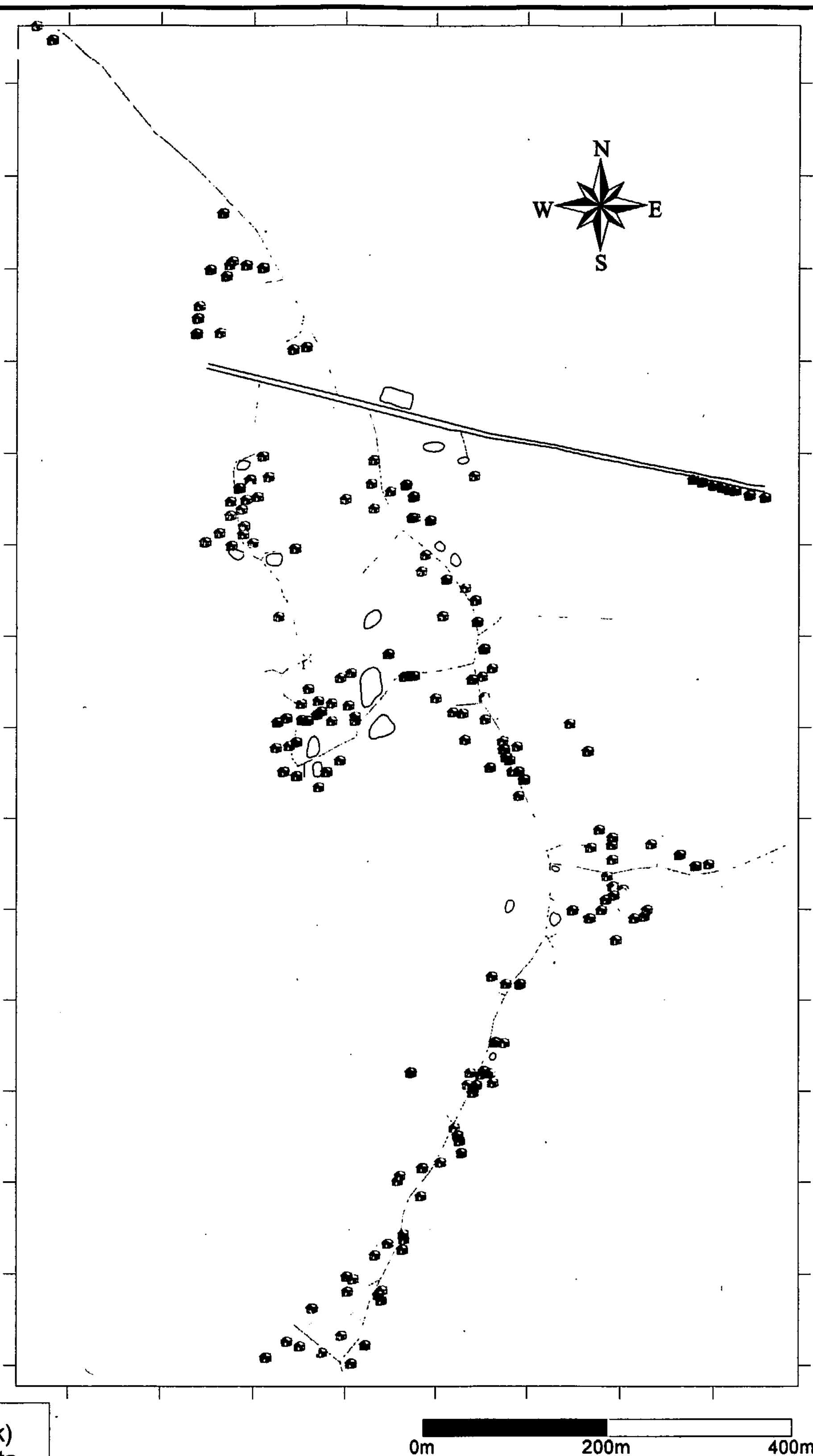
- 1000 to 2999
- 3000 to 4999
- 5000 to 6999
- 7000 to 8999
- 9000 to 10999
- 11000 to 50000

Figure: 6.4.25

Annual Cash Income per Capita in Rajnagar Bankabarsi

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



Annual Cash (Tk)
Income per Capita

- 1000 to 2999
- 3000 to 4999
- 5000 to 6999
- 7000 to 8999
- 9000 to 10999
- 11000 to 30000

Figure: 6.4.26	Annual Cash Income per Capita in Krishna Chandrapur

THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

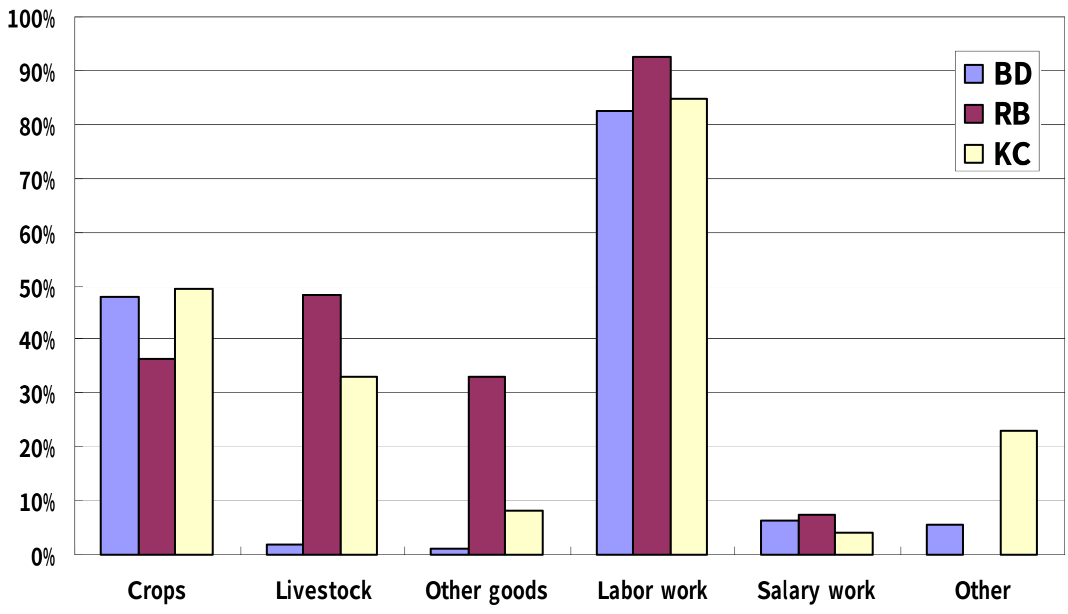


Figure 6.4.27 Ratio of Households by Source of Cash Income

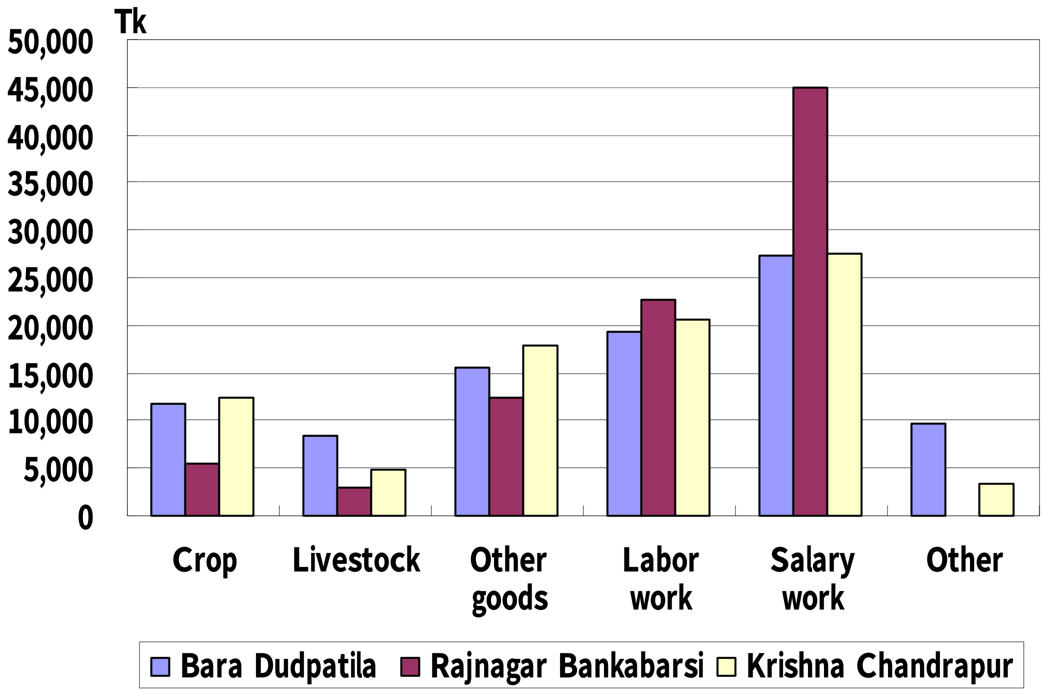


Figure 6.4.28 Average Annual Cash Income by Source

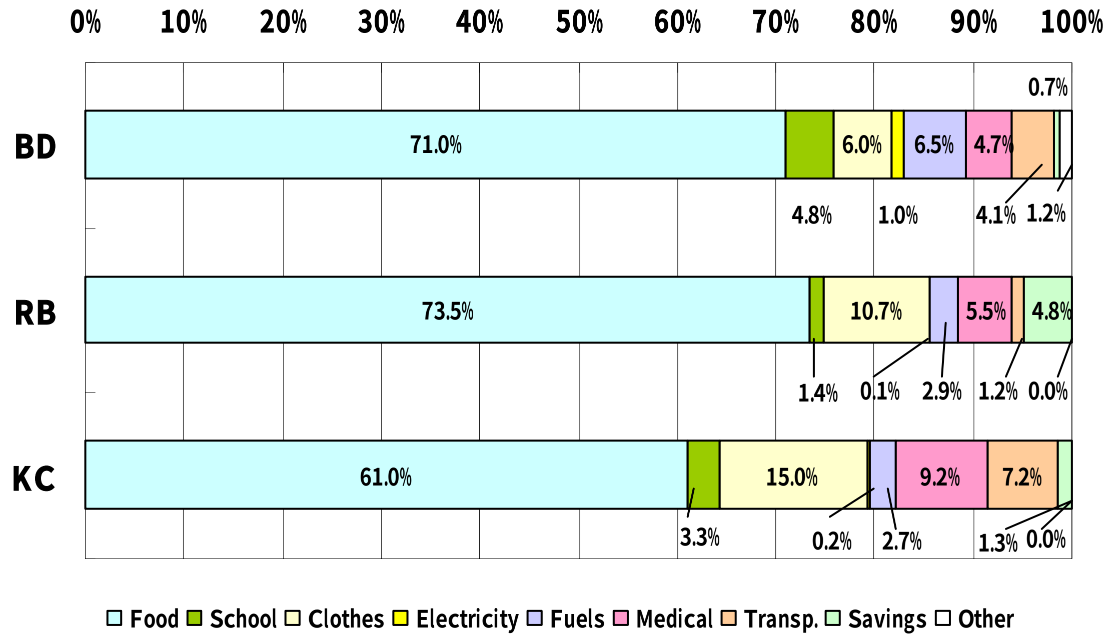
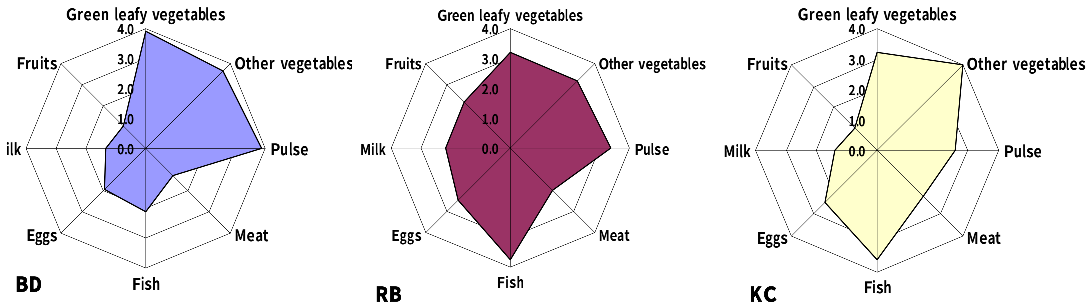
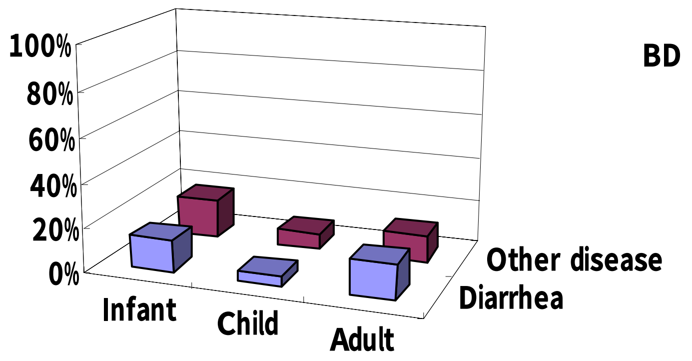


Figure 6.4.29 Average Household Monthly Expenditure

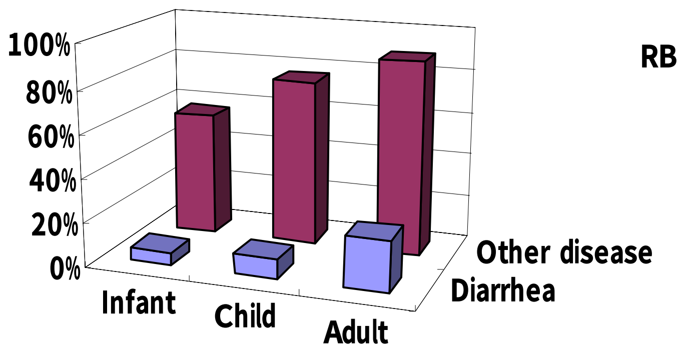


Frequency
4: Almost every day
3: More than once a week
2: More than once a month
1: Less than once a month

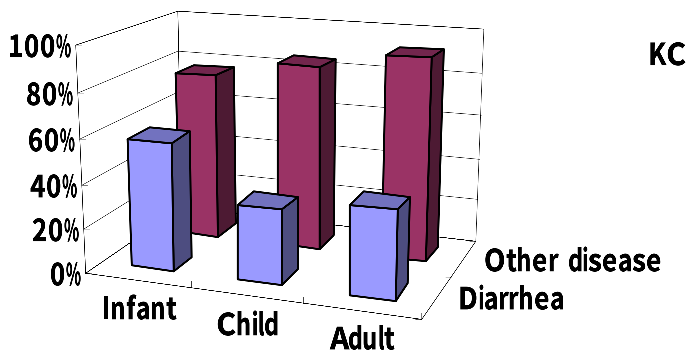
Figure 6.4.30 Frequency of Food Intake



	Infant	Child	Adult
Diarrhea	14%	4%	16%
Other disease	17%	7%	12%



	Infant	Child	Adult
Diarrhea	6%	9%	24%
Other disease	57%	76%	90%



	Infant	Child	Adult
Diarrhea	58%	34%	39%
Other disease	77%	85%	92%

Figure 6.4.31 Ratio of Households Having Sick Members by Age Group

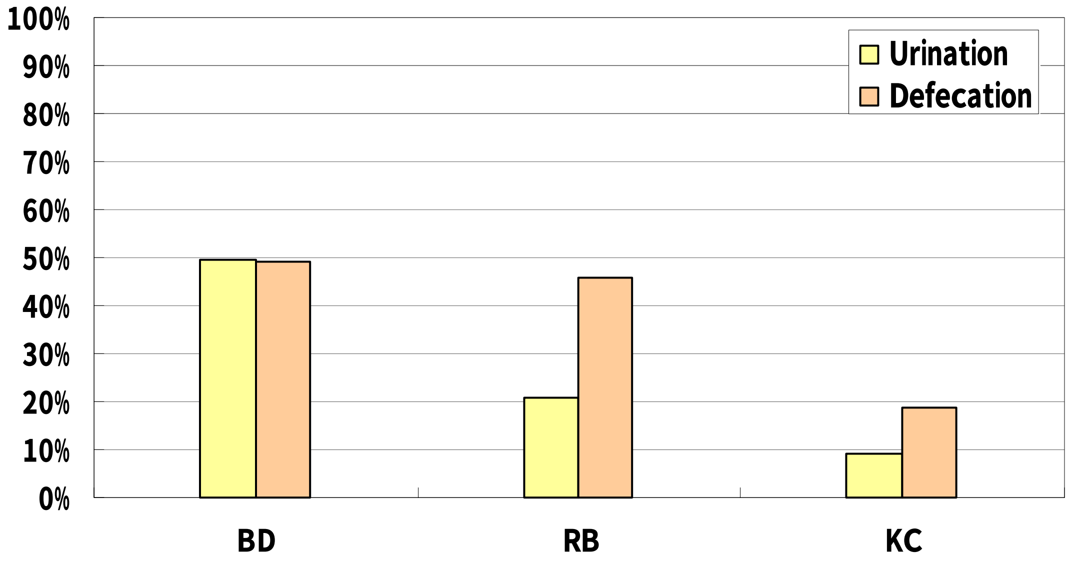


Figure 6.4.32 Ratio of Households Using Latrine

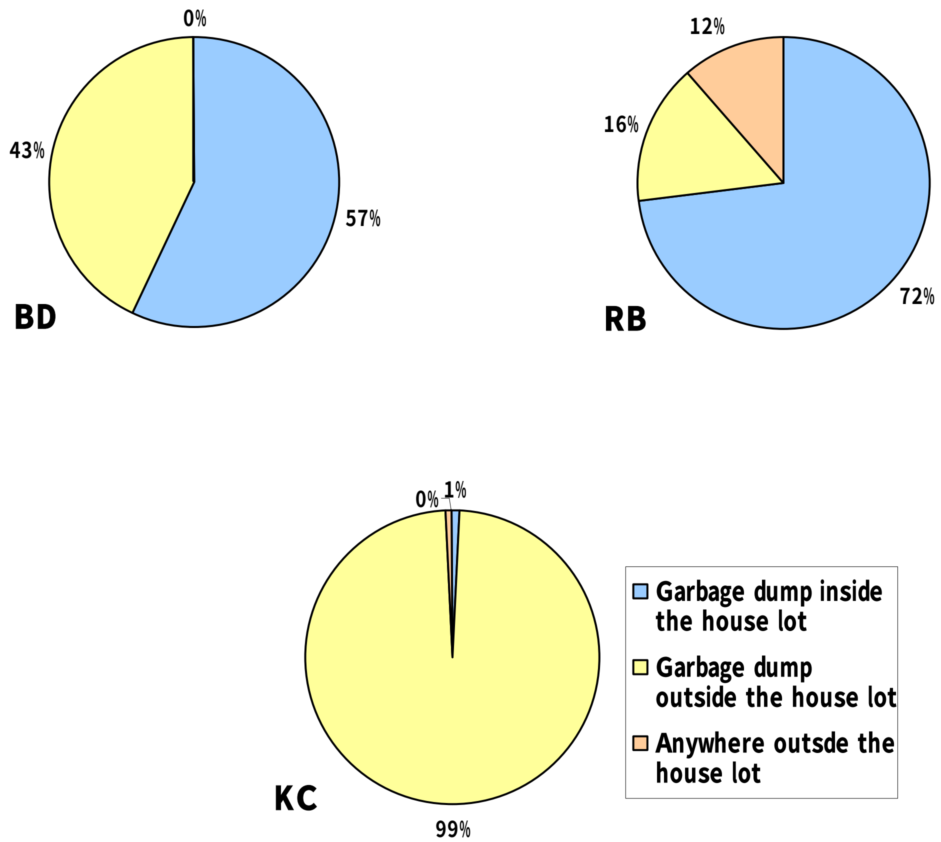


Figure 6.4.33 Ratio of Households by Garbage Dumping Site

Annex 6.4.1 Questionnaire for Interviews with Households

Basic Information

Village		ID #		House #	
Survey Date		Interviewer			
Name of Household Head					
Name of Interviewee					

	Question	Answer
General Information on the Household		
1	Could you tell us how many people are living in this house?	( )people
2	Please tell us household head's name. How old is s/he? Can s/he read and write Bengali? (Repeat the same questions about other family members and specify her/his relationship to the household head)	Record information on the attached Family Information Sheet
3	Does your family own the house (building per se)?	1. Yes 2. No
4	Does your family own land for the house?	1. Yes 2. No
5	Does your family own land for cultivation?	1.Yes → go to Q5-2 2.No → go to Q6
5-2	About how many acres of land does your family own?	About ( )acres
Domestic Water Use		
6	Who is mainly in charge of obtaining water in your family?	1. Husband 4. Daughter 2. Wife 5. Servant 3. Son 6. Other ( )
Please make the person in charge of obtaining water answer the Q7 to Q20 and Q28		
7	What is the main source of drinking water in your family?	1. Shallow well 4. Pond 2. Deep well 5. Rain water 3. River 6. Other( )
8	Who owns the main source of drinking water?	1. Your family 4. Government 2. Bari 5. Other( ) 3. Other villager
9	How many times do you usually go to the water source to get water every day?	( )times/day
10	About how many minutes do you need to get water from the water source per trip? (total collection time including waiting in a queue)	( )minutes/trip
11	About how many pots/buckets do you carry each time?	( )pots or buckets/time

	Question	Answer
12	How do you carry water pots/buckets from the water source to your house?	1. By hand 2. By cart 3. By rickshaw van 4. Other( )
13	Do you think the following sentences describe your situation? Please answer yes or no.	Situation / Yes / No 1. I have to wait in a long line in front of the water source to get water for most of the time. | | 2. The water pump is often out of order; I have to go further to fetch water. | | 3. It is uncomfortable that men sometimes tease me while I am on my way to/from the water source. | | 4. Because I have to carry heavy pots/buckets everyday, I feel pain in my body. | | 5. I have other problems related to water fetching: ( ) | |
14	About how many pots/ buckets of water does your family consume only for drinking in rainy season? How about in dry season? (Repeat the same question about two different kinds of cooking purposes)	Purpose / Rainy Season / Dry Season Drinking | | Cooking(consumed as food or drink) | | Cooking (used for washing dishes, pans, and utensils) | |
15	Please show us the water pot or bucket you imagined to answer Q 14.	Estimated size of the pot/bucket: ( )liter
16	In what container do you store water? Please show us the container.	Whether the container has a lid 1. Yes 2. No
17	Please show us how do you put water in your glass when you drink water?	1. Pour water from the container to the glass 2. Dip water with the glass 3. Dip water with a ladle or any kind of utensil 4. Other ( )
18	Do you boil water from tubewell before drinking?	1. Yes → go to Q19 2. No → go to Q18-2
18-2	What are the reasons of not boiling water before drinking? (Multiple Answer)	1. Tubewell water is safe from bacteria. 2. It takes time. 3. It consumes fuel. 4. Other ( )
19	Does your family drink pond water?	1.Yes → go to Q20 2.No → go to Q19-2
19-2	Did your family used to drink pond water in the past?	1. Yes → go to Q19-2-2 2. No → go to Q20

	Question	Answer
19-2-2	About how many years ago did your family stop drinking pond water?	About ( )years ago
20	Do you collect rainwater for drinking purpose?	1. Yes → go to Q21 2. No → go to Q20-2
20-2	What are the reasons of not collecting rainwater for drinking? (Multiple Answer)	1.It is easier to use tubewell water. 2.Do not know how to collect a large amount of rainwater. 3.Drinking rainwater is not sophisticated to do. 4.Other ( )
Arsenic Problems		
21	Have you heard about arsenic?	1.Yes 2.No
22	Have you heard about arsenicosis or arsenic poisoning?	1.Yes → go to Q23 2.No → explain its cause, symptom, and prevention method, then go to Q26
23	Do you know the symptoms of arsenicosis?	1.Yes → go to Q23-2 2.No → explain its symptom, and then go to Q24
23-2	What are the symptoms? (do not read answers)	1. Dark spots on skin 2. Hardening of palm and sole 3. Ulcer 4. Gangrene 5. Other ( )
24	Do you know the cause of arsenicosis?	1.Yes → go to Q24-2 2.No → explain its cause and go to Q25
24-2	What is the cause? (do not read answers)	1. Drinking arsenic contaminated water 2. Physical contact with patients of arsenic poisoning 3. Other ( )
25	Do you know how to prevent health injury due to arsenic poisoning?	1.Yes → go to Q25-2 2.No → explain prevention methods, and then go to Q26
25-2	What are the prevention methods? (do not read answers)	1. Do not drink arsenic contaminated water 2. Do not physically contact with patients of arsenic poisoning 3. Eat nutritious food 4. Take vitamin tablets 5. Other ( )
26	(Show the picture of the symptoms to the interviewee) If your family members show any of these symptoms, please tell us who does and how many years s/he has been having the symptom. Did s/he go to the doctor? How much does s/he need for the treatment per month?	Record the information on the attached Family Information Sheet.

<table>
<tr><th></th><th>Question</th><th colspan="3">Answer</th></tr>
<tr><td>27</td><td>Do you practice any of the followings to reduce arsenic concentration of tubewell water or to obtain arsenic safe water? Please answer either yes or no.</td><td colspan="3">1.Let water sit in a pot/bucket overnight
2.Use an arsenic removal pot
3.Put chemicals in a bucket to deposit arsenic
4.Use arsenic-safe wells
5.Harvest rain water
6.Boil pond/ river water
7.Other( )</td></tr>
<tr><td>28</td><td>If your drinking water is contaminated with arsenic, there are some ways to obtain arsenic safe drinking water. Using arsenic safe well is one of them. At present, you spend (answer to Q10) minutes per trip to obtain water. If there are arsenic safe wells, how many minutes are you willing to spend per trip to obtain arsenic-safe water?</td><td colspan="3">( )minutes/trip

*If the answer is less than that in Q10, inform the interviewee that she spend X minutes now, and then ask how many more minutes she is willing to spend.</td></tr>
<tr><td>29</td><td>If there is no arsenic safe well near your house, there are other ways to obtain arsenic safe water. These options are using an arsenic removal pot, harvesting rainwater, digging a deep tubewell, building a pond sand filter, or something like that. Of course you need to pay for the equipment and spend some time to maintain the equipment.
(1)How much are you willing to pay to obtain arsenic safe drinking water every day?
(2)How many minutes are you willing to spend for maintenance of the equipment to get arsenic safe water every day?</td><td colspan="3">(1)Expense to obtain arsenic safe water
( )Tk./day

(2)Time to maintain the equipment
( )minutes/day</td></tr>
<tr><td colspan="5">Economic Condition of the Household</td></tr>
<tr><td>30</td><td>During the past one year, did your family get cash income from selling crops (rice, vegetables, wheat, pulse, fruits, jute, etc.)?</td><td colspan="3">1.Yes → go to Q30-2
2.No → go to Q31</td></tr>
<tr><td rowspan="9">30-2</td><td rowspan="9">What crops did you sell? How many kilograms or pounds of the crop did you sell? How much money did you gain by selling each crop?</td><td>Name of Crop</td><td>Amount Sold(kg)</td><td>Total Money Gained(Tk)</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="2">Total</td><td></td></tr>
</table>

<table>
<tr><th></th><th>Question</th><th colspan="3">Answer</th></tr>
<tr><td>31</td><td>During the past one year, did your family get cash income from selling livestock (cow, goats, chicken, etc.) , milk, or eggs?</td><td colspan="3">1.Yes → go to Q31-2
2.No → go to Q32</td></tr>
<tr><td rowspan="9">31-2</td><td rowspan="9">What livestock did you sell? How many livestock did you sell? How much money did you gain by selling each livestock? (Repeat the same question about milk and eggs)</td><td>Name of Livestock</td><td>Number Sold</td><td>Total Money Gained(Tk)</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="2">Total</td><td></td></tr>
<tr><td>32</td><td>During the past one year, did your family get cash income from selling other goods such as fish, woods, seedlings, and handcrafts?</td><td colspan="3">1.Yes → go to Q32-2
2.No → go to Q33</td></tr>
<tr><td rowspan="9">32-2</td><td rowspan="9">Please tell us estimated cash income from selling other goods such as fish, woods, seedlings, and handcrafts.</td><td>Name of Goods</td><td>Number or Amount Sold</td><td>Total Money Gained(Tk)</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="2">Total</td><td></td></tr>
<tr><td>33</td><td>During the past one year, did your family get cash income from labor work (agriculture labor, rickshaw driver, construction worker, etc.)?</td><td colspan="3">1.Yes → go to Q33-2
2.No → go to Q34</td></tr>
<tr><td>33-2</td><td>Please tell us estimated cash income per month or year from labor work.</td><td colspan="3">( )Tk./ month
( )Tk./ year (calculate if not given)</td></tr>
<tr><td>34</td><td>During the past one year, did your family get cash income as salary worker (store clerk, government employee, office staff, etc.)?</td><td colspan="3">1.Yes → go to Q34-2
2.No → go to Q35</td></tr>
<tr><td>34-2</td><td>Please tell us estimated cash income per month or year as salary worker.</td><td colspan="3">( )Tk./ month
( )Tk./ year (calculate if not given)</td></tr>
<tr><td>35</td><td>During the past one year, did your family get cash income from other than labor work and salary work such as honorarium for professional services, land/house rent, gift, and remittance?</td><td colspan="3">1.Yes → go to Q35-2
2.No → go to Q36</td></tr>
<tr><td>35-2</td><td>Please tell us estimated cash income from other sources.</td><td colspan="3">( )Tk./ month
( )Tk./ year (calculate if not given)</td></tr>
</table>

<table>
<tr><th></th><th>Question</th><th colspan="3">Answer</th></tr>
<tr><td rowspan="13">36</td><td rowspan="13">During the past one year, how much did your family spend for the following items per month on average? If you are not sure about monthly expenditure for the item, please tell us annual estimates. (Calculate monthly expenditure based on the annual expenditure if not given)</td><td>Item</td><td>Monthly</td><td>(Annual)</td></tr>
<tr><td>Food</td><td></td><td></td></tr>
<tr><td>Water</td><td></td><td></td></tr>
<tr><td>School/education</td><td></td><td></td></tr>
<tr><td>Clothes</td><td></td><td></td></tr>
<tr><td>Electricity</td><td></td><td></td></tr>
<tr><td>Fuels</td><td></td><td></td></tr>
<tr><td>Doctor/medicines</td><td></td><td></td></tr>
<tr><td>Transportation</td><td></td><td></td></tr>
<tr><td>House rent</td><td></td><td></td></tr>
<tr><td>Savings</td><td></td><td></td></tr>
<tr><td>Other</td><td></td><td></td></tr>
<tr><td>Total</td><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="7">Health and Sanitary Condition of the Household</th></tr>
<tr><td rowspan="13">37</td><td rowspan="13">How often do your family members eat the following foods?

Almost everyday = 5+/week
More than once a week = 1+/week
More than once a month = 1+/m
Less frequently than once a month = Less frq.

Do you think household head eats enough amount of food every day? (Repeat the same question about other family members and record on the attached Family Information Sheet)</td><td></td><td>5+ / week</td><td>1+ / week</td><td>1+ / month</td><td>Less frq.</td></tr>
<tr><td>Rice</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Wheat</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Green leafy vegetables</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Other vegetables</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Beans</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Pulse</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Meat</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Fish</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Eggs</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Milk</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Fruits</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5"></td></tr>
<tr><td>38</td><td>During the past one year, did your family have diarrhea? Please tell us who had and how many times s/he had.
(Repeat the same question about other diseases)</td><td colspan="5">Record the information on the attached Family Information Sheet. For other diseases, also write down the name.</td></tr>
</table>

<table>
<tr><td rowspan="6">39</td><td rowspan="6">How is a sick male adult treated in your family when he looks very ill?
Please select one most likely option from the following:
1. Take to a hospital or a doctor.
2. Give a medicine and make rest at home.
3. Just make rest at home (no medicine).
4. Other (specify)
(Repeat the same question about others).</td><td></td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>Male adult</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Female adult</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Male child</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Female child</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">*If the answers are different between male adult and female adult, go to Q39-2</td></tr>
</table>

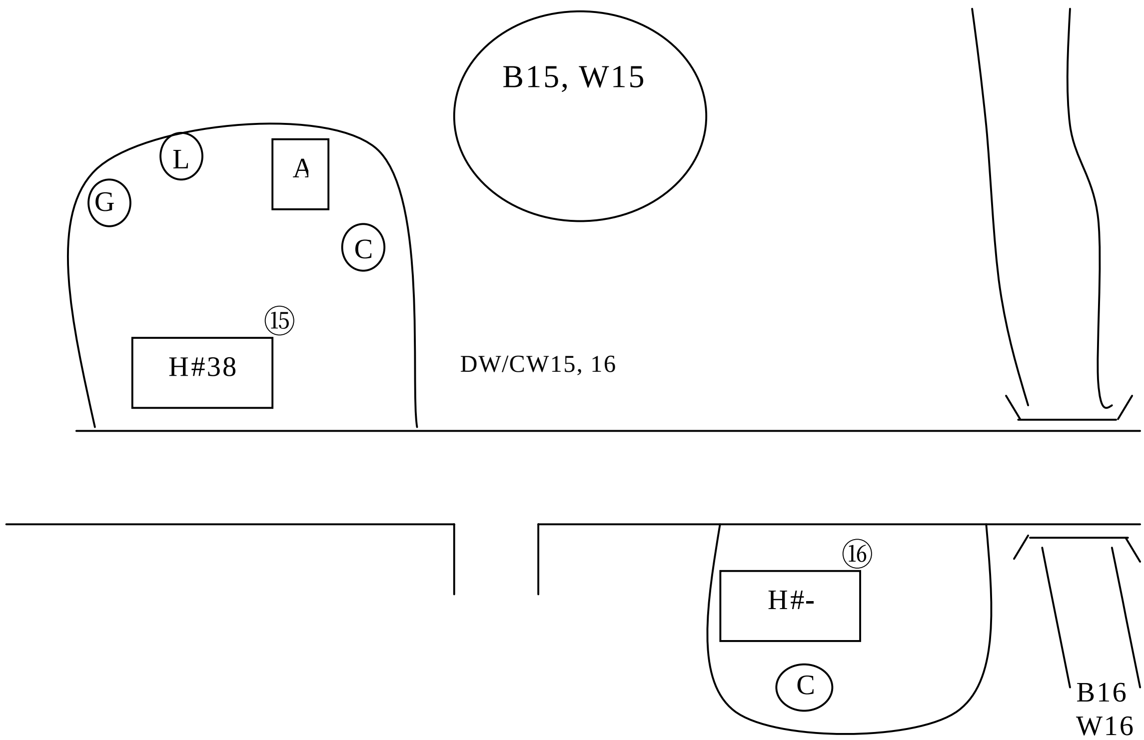
<table>
<tr><th></th><th>Question</th><th colspan="3">Answer</th></tr>
<tr><td>39-2</td><td>Why are male adult and female adult treated differently?
(Multiple Answer)</td><td colspan="3">1. Males earn money but females don't.
2. Females are not supposed to go out.
3. Doctors are usually males and females are not supposed to show their body to other men.
4. Other (   )</td></tr>
<tr><td rowspan="5">40</td><td rowspan="5">Where do your family members most often urinate? (Single Answer)
(Repeat the same question about defecation)</td><td></td><td>Urination</td><td>Defecation</td></tr>
<tr><td>1. Latrine</td><td></td><td></td></tr>
<tr><td>2. Pond/river</td><td></td><td></td></tr>
<tr><td>3. Anywhere outside of the house</td><td></td><td></td></tr>
<tr><td>4. Other</td><td></td><td></td></tr>
<tr><td>41</td><td>Where do your family members dump garbage?</td><td colspan="3">1. Garbage dump inside of the house lot
2. Garbage dump outside of the house lot
3. Anywhere outside of the house lot
4. Pond/river
5. Other (   )</td></tr>
</table>

Image Map of the Vicinity of the Interviewee's House

Indicate location of the followings on the supplied map:

- House lot boundary (a solid line)
- House (write down the house # in a rectangular and indicate ID# at the right corner)
- Wells (a black spot), ponds and rivers (follow the general legend)

  *Mark drinking water source with (DW+ID#), cooking water source (CW+ID#), bathing place (B+ID#), and washing place (W+ID#).
- Cooking place (a solid line circle and mark "C" inside)
- Garbage dump (a solid line circle and mark "G" inside)
- Latrine (a solid line circle with "L")
- Storage of agro-chemicals (a rectangular with "A")
- Neighboring houses, access and major roads, major buildings, ponds, trees, rice fields and other landmarks nearby



Family Information Sheet

Village		ID Number		House #	

	General Information(Q2)					Arsenicosis(Q26)				Q37	Diseases(Q38)				
											Diarrhea	Other			
	Name	Relationship *1	Sex (M/F)	Age	Read/ Write (Y/N)	Symp tom *2	Length of Suffer (Years)	Doctor (Y/N)	Costs/ month (Tk)	Enough Food? (Y/N)	# of times	Name of disease	#	Name of disease	#
1		Head													
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															
13															
14															
15															

***1 Input an appropriate number**
1.husband/wife
2.son/daughter
3.father/mother
4.(great)grandfather/grandmother
5.grand son/daughter
6.son/daughter in law
7.other relatives
8.other

***2 Input an appropriate number**
1.Dark spots on skin
2. Hardening of skin
3. Ulcer
4. Gangrene
5. Other (specify)

Annex 6.4.2 Estimates of Households in Model Rural Areas

(1) Definition of Households

A household is the minimum social unit in which its members live together and their daily expenses such as food and clothes are covered by one wallet. If there is a joint family in which its members live together but their daily expenses are covered by each of sub-families, it is not considered as a household.

(2) Estimated Numbers of Population and Households in the Model Rural Areas

Based on the existing information about number of households, population and average household size, JICA Study Team estimated number of households as follows:

District	Chuadanga	Jessore	Jhenaidah
Upazila	Damurhuda	Keshabpur	Maheshpur
Union	Howli	Panjia	Fatehpur
Mauza	Dudpatila	Rajnagar Bankabarsi	Chandpur
Village	Bara Dudpatila	Rajnagar Bankabarsi	Krishna Chandrapur
Population (1)	1678	1628	1001
Population (2)	1100	2447	1001
Population (3)	3600	3000	1000
Population (4)	2500	2700	1300
Estimated Population	3050	2700	1300
# of HHs(1)	296	319	190
# of HHs (2)	400	438	190
# of HHs (3)	538(5.67)	530(5.10)	249(5.23)
# of HHs (4)	570	-	120
Estimated # of HHs	500	480	250

Note: Population (1) is based on the information from *Population Census 1991*.

Population (2) is based on the information from JICA Expert report (2000).

Population (3) is based on the information from Socio-economic study on current conditions in rural areas carried out as a part of this study in June 2000.

Population (4) is based on the hearing from a villager upon JICA study team's visit in August 2000.

# of Households (1) is based on information from Population Census 1991.

# of Households (2) is based on information from JICA Expert report.

# of Households (3) is based on the estimated population and the average household size in each village from *Population Census 1991*. The numbers in the parenthesis are the average household size.

# of Households (4) is based on the hearing from a villager upon JICA study team's visit in August 2000.

Assuming that present population and number of households are larger than those in 1991, JICA Study Team used the following information for the estimation:

- For Bara Dudpatila, population is estimated as an average of information (3) and (4), and number of households (2) to (4).
- For Rajnagar Bankabarsi, population is estimated as an average of information (2) to (4), and number of households (2) and (3).
- For Krishna Chandrapur, information (4) is taken as population, and information (2) is taken as number of households.

6.5 Identification of Arsenicosis Patients

6.5.1 Preliminary Diagnosis of Arsenicosis Patients

During the socioeconomic study in the Model Rural Areas, the interviewers collected information on villagers who showed symptoms of arsenicosis. The JICA Study Team asked Dr. Faruquee of Asia Arsenic Network to train the interviewers on preliminary diagnosis of arsenicosis patients before the socioeconomic study. The interviewers recorded arsenic symptoms of probable patients while they were conducting interviews with 200 households in each Model Rural Area.

The interviewers found 27 probable patients in Bara Dudpatila (Chuadanga), 12 in Rajnagar Bankabarsi (Jessore), and 43 in Krishna Chandrapur (Jhenaidah).

6.5.2 Formal Diagnosis of Arsenicosis Patients

1) Diagnosis in Model Rural Areas

Making use of the information on arsenicosis symptoms of villagers collected by the interviewers during the socioeconomic study, the JICA Study Team arranged for the formal diagnosis of arsenicosis patients in Model Rural Areas by Dr. Faruquee in November 2000. Assisting NGOs informed the probable patients and other villagers in the Model Rural Areas of the patient diagnosis to be held at their villages, and villagers came to a diagnosis center tentatively set up in the village.

2) Arsenicosis Patients by Sex and Age

Dr. Faruquee diagnosed villagers who came to the diagnosis center and found 73 arsenicosis patients in Bara Dudpatila (Chuadanga), 23 in Rajnagar Bankabarsi (Jessore), and 45 in Krishna Chandrapur (Jhenaidah). Table 6.5.1 summarizes the number of arsenicosis patients by sex. More than 60% of the patients identified are male in each Model Rural Area.

Table 6.5.1 Number of Arsenicosis Patients by Sex

Model Rural Area	No. of Patients		
	Total	Male	Female
Bara Dudpatila (Chuadanga)	73	45 (62.6%)	28 (38.4%)
Rajnagar Bankabarsi (Jessore)	23	20 (85.0%)	3 (15.0%)
Krishna Chandrapur (Jhenaidah)	45	30 (66.7%)	15 (33.3%)
Total	141	95 (67.4%)	46 (32.6%)

Arsenicosis patients identified are in a wide age group; the youngest is 11 years old, and the eldest is 85 years old. Figure 6.5.1 shows the number of arsenicosis patients by age group in Model Rural Area. Although many villagers do not exactly know their age, the young people’s age is considered as relatively accurate because of school grade. The ratio of younger patients is high in Bara Dudpatila and Krishna Chandrapur while the age distribution of the patients is more even in Rajnagar Bankabarsi.

2) Stage of Arsenicosis

Melanosis, keratosis, and leukomelanosis are manifestations of arsenicosis on the skin (for descriptions of the manifestations, see Annex 6.5.1). In Bangladesh, the clinical features of arsenicosis are categorized as the following:

1st Stage: Melanosis, keratosis, conjunctivities, bronchitis, and gastro-enteritis

2nd Stage: Depigmentationi (leukomelanosis: raindrop pigmentation), hyperkeratosis, oedema (non-piting), peripheral neuropathy (early stage), and nephropathy (early stage)

3rd Stage: Hepatopathy (late stage), nephropathy (late stage), gangrene of the limbs, pre-cancerous skin lesions (Bowen's disease, actinic keratosis), and cancer

Most of the patients diagnosed in the Model Rural Areas are in the 1st and the 2nd stage, but one patient in Bara Dudpatila is in the 3rd stage. Figure 6.5.2 shows the number of arsenicosis patients by stage. Although the number of arsenicosis patients in Rajnagar Bankabarsi is the lowest among the three villages, the ratio of the patients in the 2nd and the 3rd stage is the highest.

6.5.3 Tube wells Used by Arsenicosis Patients

1) Location of Tube wells Used by Arsenicosis Patients

Arsenicosis patients drink water from arsenic contaminated wells, but some patients were reportedly drinking tube well water whose arsenic concentration is below the Bangladesh standard (0.05mg/l). The assisting NGOs collected information on the identification number of the tube wells used by the arsenic patients; the tube wells were numbered upon the water sampling in October[1] 2000. Figure 6.5.3, 6.5.4, and 6.5.6 show the tube wlls used by arsenicosis patients and their arsenic concentration analyzed by the atomic absorption spectrophotometer.

In Bara Dudpatila, the arsenicosis patients used to drink water from tube wlls that are located in the center of the village where a high arsenic concentration in tube well water has been observed. Among the 73 patients, three were drinking water from the tube wells whose arsenic concentration was below 0.05mg/l as of October and December 2000. Because the arsenic concentration of tube well water varies by time, and because water was sampled after the serious flood in October 2000, the arsenic concentration of the tube wells might not reflect the

[1] Some of the tubewells were sampled again in December 2000.

annual average arsenic concentration. Moreover, due to the flood, many houses in Bara Dudpatila were inundated and reconstructed after the retreat of the water; some of the villagers may have relocated to a different area. Therefore, further investigation of the patients' history of drinking water is needed in order to discuss the relationship between the tube wells and arsenicosis patients in Bara Dudpatila.

In Rajnagar Bankabarsi, distribution of the tube wells used by arsenic patients resembles that of shallow tube well users (see Figure 6.4.19 and Figure 6.5.4). Tube wells used by arsenicosis patients are located in the southern part of the village where shallow tube well users are concentrated. In the southern para, 14 patients have been found, which is more than 60% of the patients in the village.

In Krishna Chandrapur, the tube wells used by arsenicosis patients are located along the road dividing the village, and high concentration of the tube wells can be seen in one para at the middle part of the village. Within the para, 37 patients have been found, which is more than 80% of the patients in the village. There are two tube wells that 9 and 8 patients drink water from respectively.

2) Arsenic Concentration of Tube wells Used by Arsenicosis Patients

Although the drinking water sources of the arsenicosis patients reported by the assisting NGOs have not been double checked, there seems a relationship between the arsenic concentration in tube well water and the drinking water source of the patients; the higher the ratio of tube wells whose users have been found to be arsenicosis patients. Figure 6.5.6 shows the ratio of tube wells used by arsenicosis patients to total tube wells in the same range of arsenic concentration among the 360 tube wells in the Model Rural Area. The ranges are 0.01mg/l interval up to 0.1mg/l and 0.1mg/l interval up to 1.0mg/l. After confirming the history of drinking water of the patients, the relationship will be analyzed again.

6.5.4 Characteristics of Arsenicosis Patients

There is a difference in the ratio of arsenicosis patients to the total village population at risk among the three Model Rural Areas. Table 6.5.2 shows the estimated population at risk and the actual number of arsenicosis patients in each Model Rural Area. The population at risk was estimated by multiplying the total population by the ratio of tube wells whose arsenic concentration is equal to or over 0.05mg/l, which is the Bangladeshi standard. For some of the tube wells whose arsenic concentration was measured twice (October and December 2000), if either result is equal to or over 0.05mg/l, the tube well is categorized as arsenic contaminated.

Table 6.5.2 Population at Risk of Arsenicosis

	Bara Dudpatila	Rajnagar Bankabarsi	Krishna Chandrapur
# of TW	172	73	115
# of TW (0.05mg/l≦As)	116 (67.4%)	71 (98.6%)	93 (80.9%)
Average As concentration	0.20mg/l	0.48mg/l	0.30mg/l
Median As concentration	0.10mg/l	0.51mg/l	0.17mg/l
Estimated population	2,300	1,800	1,000
Population at risk	1,550	1,775	809
# of Arsenicosis patients	73	23	45
Ratio of patients to population at risk	0.047	0.013	0.056

Although the average arsenic concentration of the tube wells in Rajnagar Bankabarsi is the highest among the three Model Rural Areas, the ratio of arsenicosis patients to total population at risk is the lowest. There may be several factors explaining the difference in the prevalence of arsenicosis among the three villages.

1) Arsenic Safe Water

The diagnosis of arsenicosis patients was held late November 2000; four months had passed since the DPHE tube well was installed in Rajnagar Bankabarsi in July 2000. Because cessation of arsenic contaminated water is the best way to cure arsenicosis, changing the water source from a shallow tube well to the DPHE deep tube well may have improved symptoms of arsenicosis patients who were in the 1st stage, and consequently they were not diagnosed as a patient. In addition, more than 60% of the households in Rajnagar Bankabarsi let water sit in a pot overnight (see Figure 6.4.17); they started this practice at the beginning of 2000 based on the recommendation by JICA experts. On the other hand, in Bara Dudpatila there was no arsenic safe water source confirmed, and no household interviewed practices letting water sit in a pot overnight. In Krishna Chandrapur, some households follow the practice, but the ratio is lower than in Rajnagar Bankabarsi. The villagers' effort to reduce arsenic in water and obtain arsenic safe water may have helped them to prevent arsenicosis.

2) Diet Rich in Protein

Diet rich in protein helps methylation of inorganic arsenic in the body. When the average frequency of protein rich food intake such as fish and meat in the three Model Rural Areas is compared, villagers in Rajnagar Bankabarsi eat fish more often than those in Bara Dudpatila (see Figure 6.4.30).

6.5.5 Treatment and Management of Patients

Upon the diagnosis of the arsenicosis patients, patients were told to drink arsenic safe water and take nutritious food. In addition, based on the symptoms of the patients, vitamin A, E, C tablets were provided to 85 out of the 142 patients.

During October 2000, water from all the tube wells in the Model Rural Areas was sampled and tested with the AAN field kit. Based on the results of the field kit test, tube wells whose arsenic concentration is over 0.5 mg/l were painted with red so that villagers can identify wells highly contaminated with arsenic. Water samples were analyzed with the atomic absorption spectrophotometer (AAS) in the JICA Study Team laboratory to confirm arsenic concentration. More precise information on the arsenic concentration of tube wells based on the analysis by the AAS will be provided to villagers, and tube wells will be painted based on the level of arsenic contamination.

In addition, arsenic removal plants and deep tube wells have been installed in the Model Rural Areas to provide arsenic safe water. In Bara Dudpatila, although the improved deep tube wells drilled by the JICA Study Team are not in service as of February 24, 2001, arsenic removal plants such as a double bucket system, passive sedimentation plants, and activated alumina plants (see Chapter 7 for details) have been installed and used by the villagers. All the patients in Bara Dudpatila are now using one of the arsenic removal plants. In Rajnagar Bankabarsi, all the arsenicosis patients are now drinking water from either the DPHE deep tube well or the improved deep wells drilled by the JICA Study Team. The information on drinking water source of the arsenicosis patients in Krishna Chandrapur has not been collected yet.

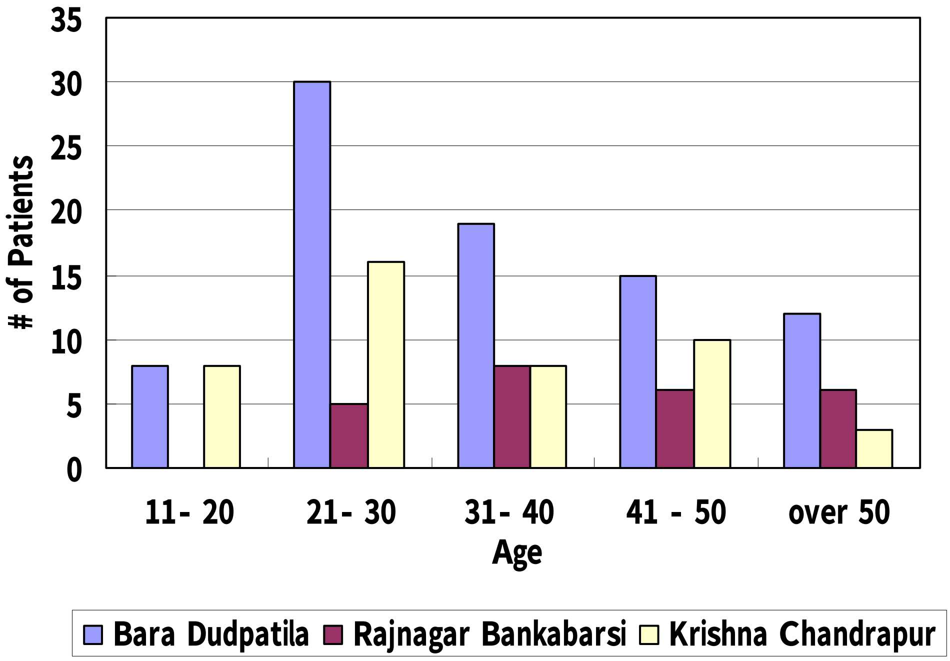


Figure 6.5.1 Number of arsenicosis patients by age

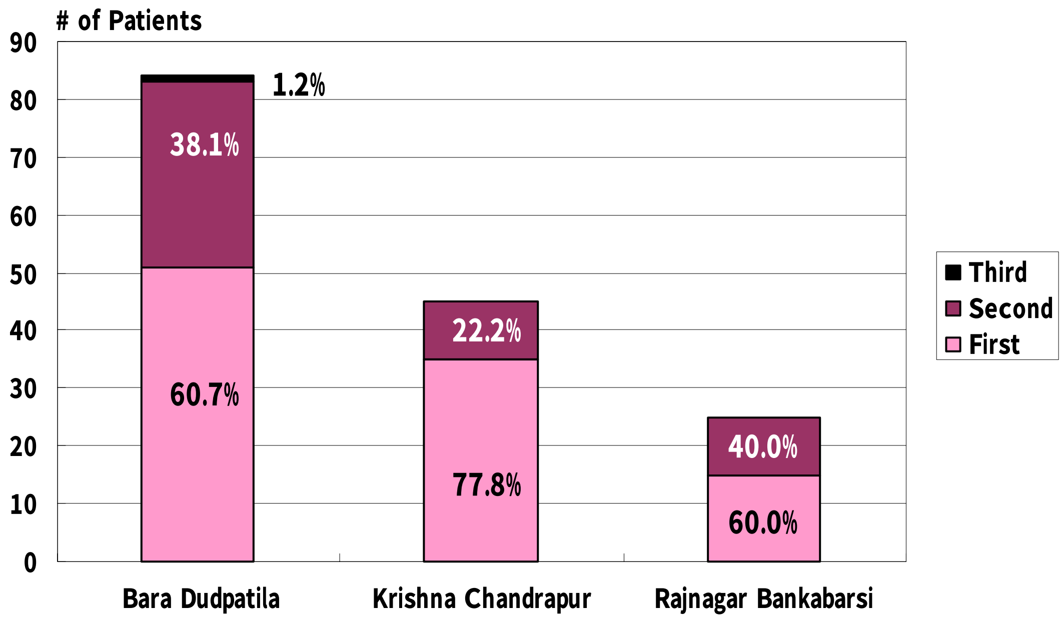
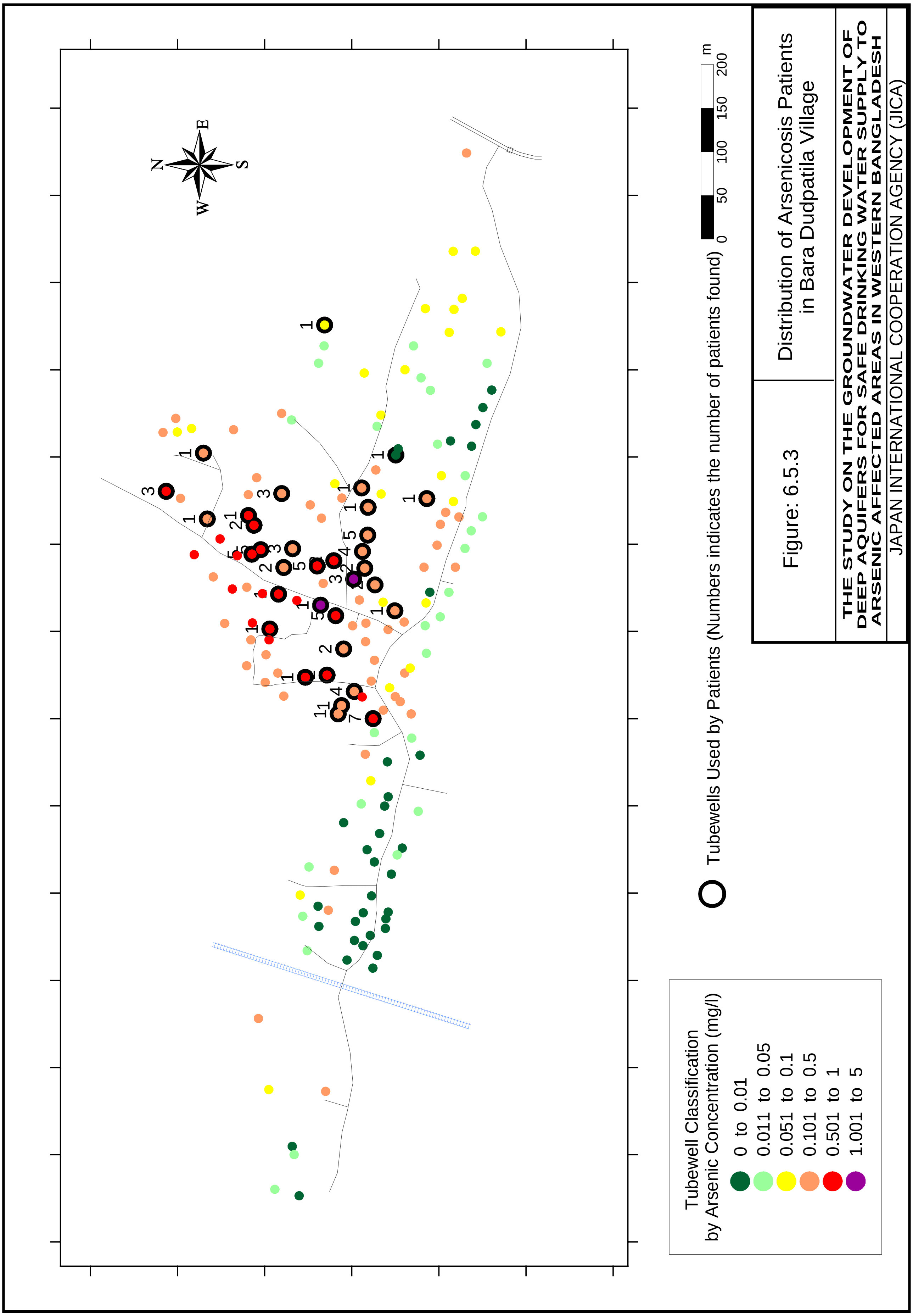
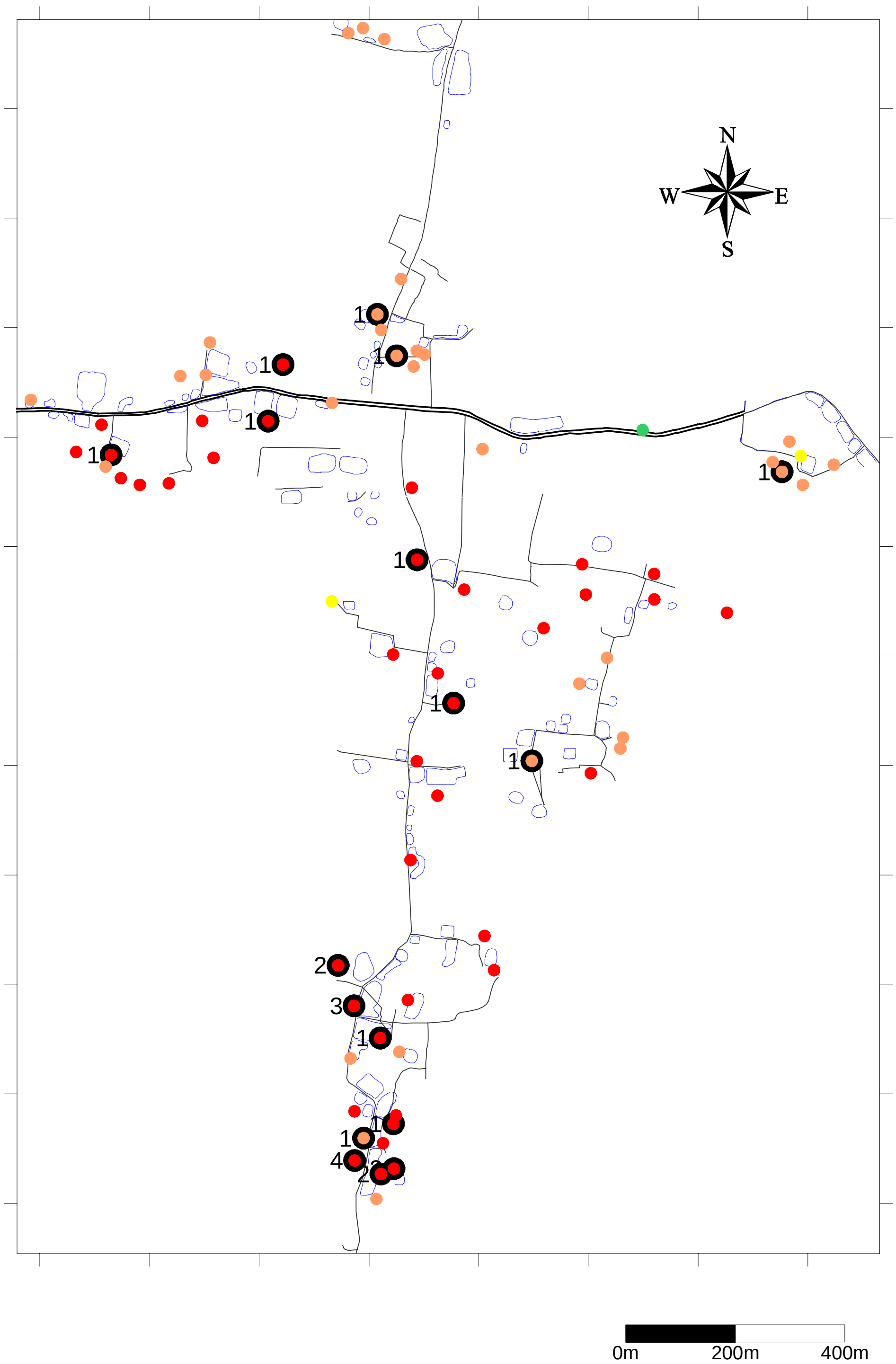


Figure 6.5.2 Number of Arsenicosis Patients by Stage


N
E
S
W
Tubewells Used by Patients (Numbers indicates the number of patients found)
0 50 100 150 200 m
Tubewell Classification
by Arsenic Concentration (mg/l)
0 to 0.01
0.011 to 0.05
0.051 to 0.1
0.101 to 0.5
0.501 to 1
1.001 to 5
Figure: 6.5.3
Distribution of Arsenicosis Patients
in Bara Dudpatila Village
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF
DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO
ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

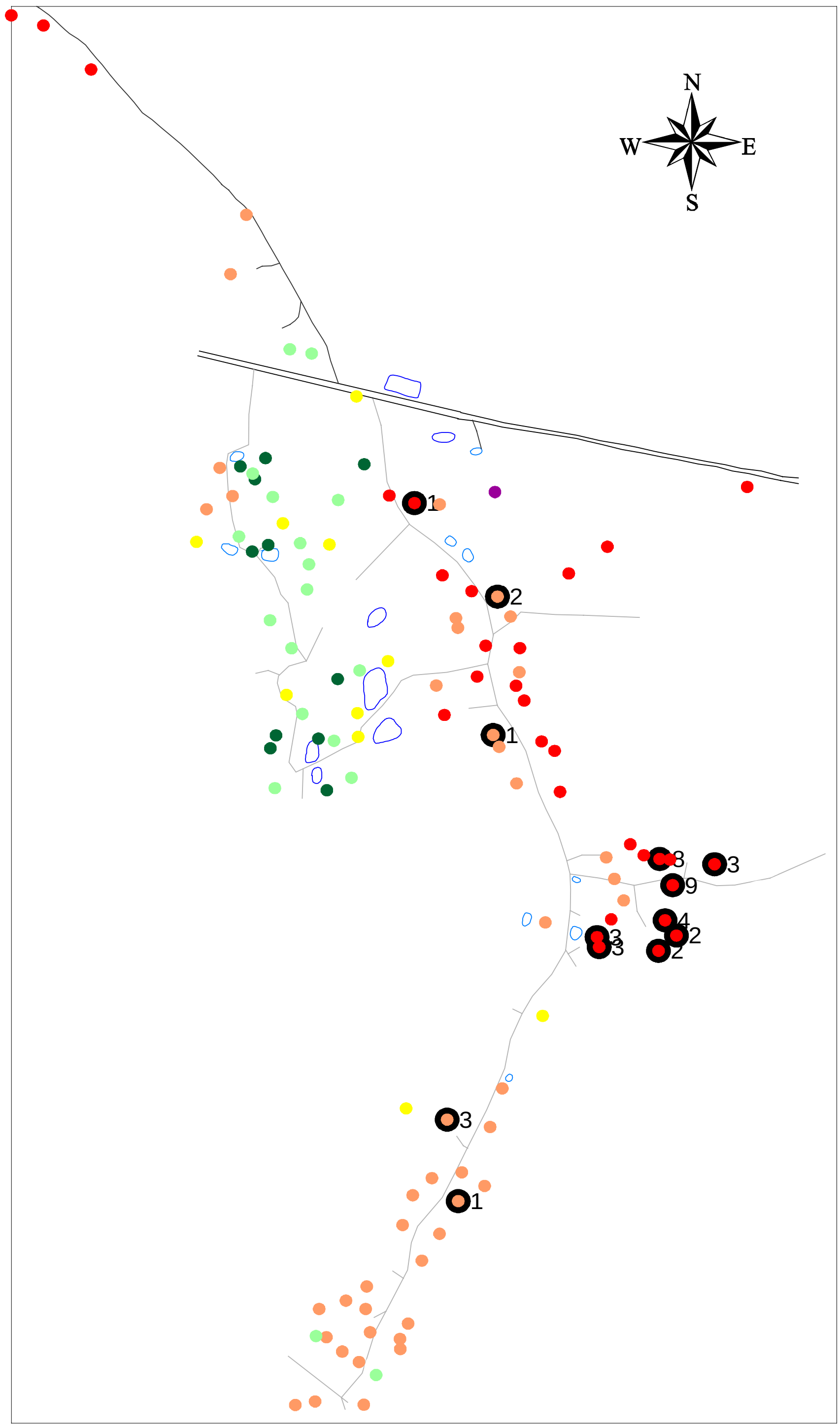


Tubewell Classification
by Arsenic Concentration (mg/l)

- 0 to 0.01
- 0.011 to 0.05
- 0.051 to 0.1
- 0.101 to 0.5
- 0.501 to 1
- 1.001 to 5

Tubewell Used by Patients (Number indicates the number of patients found)

Figure: 6.5.4	Distribution of Arsenicosis Patients in Rajnagar Bankabarsi
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	



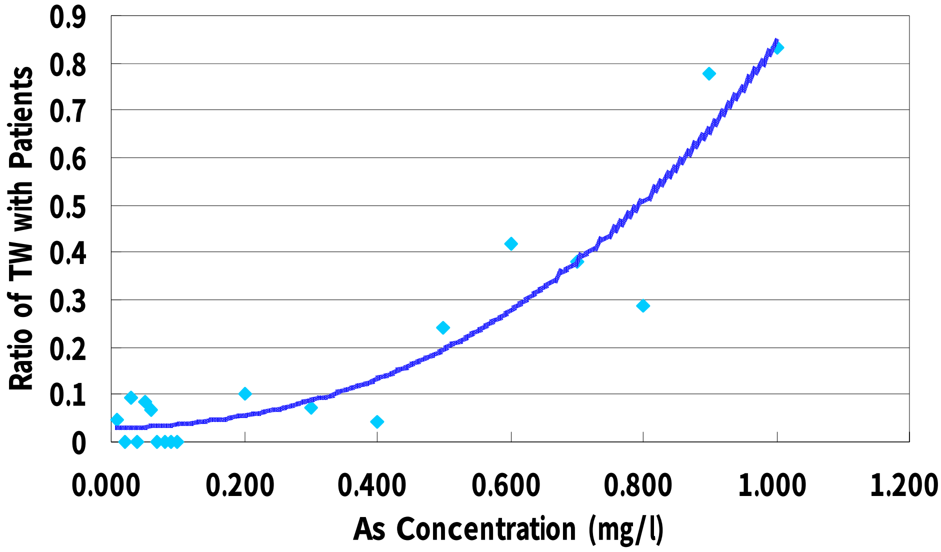
Tubewell Used by Patients (Number indicates the number of patients found)

Tubewell Classification
by Arsenic Concentration (mg/l)

- 0 to 0.01
- 0.011 to 0.05
- 0.051 to 0.1
- 0.101 to 0.5
- 0.501 to 1
- 1.001 to 5

0m 200m 400m

Figure: 6.5.5	Distribution of Arsenicosis Patients in Krishna Chandrapur
THE STUDY ON THE GROUNDWATER DEVELOPMENT OF DEEP AQUIFERS FOR SAFE DRINKING WATER SUPPLY TO ARSENIC AFFECTED AREAS IN WESTERN BANGLADESH	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	



Notes: Tube wells are categorized into 20 ranges by arsenic concentration of the water (0.01mg/l interval up to 0.1mg/l and 0.1mg/l interval up to 1.0mg/l).

Figure 6.5.6 Ratio of the tube wells used by arsenicosis patients to the total number of tube wells whose arsenic concentration is in a corresponding arsenic concentration range

Annex 6.5.1 Major Skin Manifestations of Arsenicosis

Symptom	Description
Melanosis	Diffuse or spotted blacking or darkening of the skin due to deposition of black pigment (melanin) in the skin and mucous membrane due to stimulation of melanocyte. Mild – Blackening of the skin (melanosis), thinly distributed in palm, trunk, gum, tongue, lips etc. (both spotted and diffuse). Moderate – Melanosis densely affecting gum, palm and trunk (spotted and diffuse) with leucomelanosis (rain drop depigmentation). Severe – Melanosis densely and extensively affecting gum, palm, trunk and whole body with leucomelanosis.
Leukomelanosis	Depigmentation in hyper pigmented area characterized by whitish or pallor patch like raindrop due to exhaust melanocyte.
Keratosis	Hardening and thickening of the skin due to increased keratinization. Mild – Just palpable keratosis (spotted and diffuse) but clearly visible affecting palm and sole in a scattered manner. Moderate – Palpable and visible keratosis affecting palm and sole. Severe – Wart-like keratosis on hands, legs, and feet.

6.6 Community Activities in the Model Rural Areas

6.6.1 Community Organization

1) Set Up of Community Organization

Upon the selection of the Model Rural Area, the JICA Study Team encouraged villagers to form a community organization to lead community activities related to arsenic problems. The community organization organizes meetings to discuss arsenic problems in general and functions as a focal point to contact villagers in the Model Rural Area when the JICA Study Team asks villagers opinions on selecting sites for drilling, installation of arsenic removal equipment, and core boring in the Model Rural Areas. The JICA Study Team requested, through DPHE District Executive Engineers, Union Parishad Members and the social elite in the Model Rural Areas to mobilize villagers to form a community organization comprised of approximately 20 members (half are male and the other half are female). To form the community organization, the JICA Study Team will do the following for each Model Rural Area :

- Before the community organization is formed, invite Dr. M. H. Faruquee, Arsenic and Environmental Health Consultant, to each Model Rural Area to talk about arsenic problems in Bangladesh and other villages' efforts to tackle arsenic problems in order to raise awareness of arsenic problems among villagers
- designate one local NGO to assist villagers to form and run the community organization

Dr. Faruquee has been a member of Asia Arsenic Network, a Japanese NGO assisting arsenic affected areas to identify arsenic condition of tube wells, diagnose and treat arsenic patients, and provide arsenic safe water. He has a rich experience in diagnosing and treating patients and educating people about the cause and prevention methods of arsenicosis.

General information on the three local NGOs that are assisting the Model Rural Areas is summarized in Table 6.6.1.

Table 6.6.1 NGOs Assisting the Model Rural Areas

Name of NGO	ATMABISWAS	KMMS (Kapatakha Memorial Mohila Shangsta)	AID (Action In Development)
Model Rural Area	Bara Dudpatila, Damruhda, Chuadanga	Rajnagar Bankabarsi, Keshabpur, Jessore	Krishna Chandrapur, Maheshpur, Jhenaidah
Representative of NGO	Mr. Md. Akramul Haque Biswas	Ms. Sufia Parvinshikha	Mr. Tarikul Islam Palash
Year of Establishment	1991	1995	1992
Number of staff	Full time Part time	Full time 46 Part time 2	Full time 27 Part time 7
Location	Chuadanga Sadar, Chuadanga	Keshabpur Union, Jessore	Jhenaidah Sadar Jhenaidah

Their experiences relevant to assisting the Model Rural Areas are:

ATMABISWAS

- Assisted two villages (Takpara, Benagari) to set up an Arsenic Prevention Committee
- Advised villagers to take vegetables and distribute plants for villagers to grow
- Helped villagers to raise income by fishery in ditch (Benagari)
- Assisted Asia Arsenic Network to diagnose arsenic patients and distribute medicine
- Assisted villagers to establish a fund to help arsenic patients
- Conducted an arsenic test of tube wells (Takpara)

KMMS

- Conducted an arsenic test of tube wells in three villages (Habaspol, Mulgram, Bhagati)
- Formed a village committee in Rajnagar Bankabarsi as a part of the school program (elected officials and villagers know the staff of KMMS)

AID

- Assisted one village (Achintanagor) to set up Arsenic Prevention Committee
- Assisted Asia Arsenic Network to diagnose arsenic patients and distribute medicine
- Conduct arsenic test of tubewells

A community organization to tackle arsenic problems has been set up in each Model Rural Area as in Table 6.6.2.

Table 6.6.2 Community Organization in the Model Rural Area

Model Rural Area	Bara Dudpatila, Damruhda, Chuadanga	Rajnagar Bankabarsi, Keshabpur, Jessore	Krishna Chandrapur, Maheshpur, Jhenaidah
Date of Establishment	September 22, 2000	October 10, 2000	September 21, 2000
Number of members	20 (Male 11, Female 9)	20 (Male 10, Female 10)	19 (Male 9, Female 10)

2) Activities Lead by Community Organization

The community organizations have led several activities in each Model Rural Area. Their activities are summrized in Tables 6.3.3 to 6.3.5.

Table 6.6.3 Community Activities in Bara Dudpatila (Chuadanga)

Date	Activity	Attendants
Oct. 10, 2000	Community organization meeting 1.Arsenic contamination of tubewells in Bara Dudpatila 2.Report of the socioeconomic condition in Bara Dudpatila	20 members and one from NGO
Oct 16, 2000	Community organization meeting 1. Damages by the flood 2. Relief of victims from JICA Study Team	18 members
Oct 30, 2000	Community organization meeting 1. JICA Study Team's plan on arsenic removal plants 2. Selection of trainees for the training on awareness raising activity	18 members

Table 6.6.4 Community Activities in Rajnagar Bankabarsi (Jessore)

Date	Activity	Attendants
Oct. 15, 2000	Community meeting 1. Dissemination of information about arsenic, it's sources and health effects through drinking arsenic contaminated water, and ways to obtain arsenic safe water by the assisting NGO staff 2. JICA Study Team's plan on digging three deep tubewells	19 villagers
Oct. 16, 2000	Community meeting 1. Site selection for three deep tubewells dug by JICA Study Team 2. Dissemination of information about importance of water on lives, health effects of arsenic intake through drinking water, it's consequences and it's probable solution by the assisting NGO staff	34 villagers
Oct. 18, 2000	Community meeting 1.Dissemination of information about the situation of asrsenic problems in Bangladesh, health effects of arsenic intake through drinking water, it's consequences, and sources of arsenic by the assisting NGO staff	54 villagers
Nov. 28, 2000	Community meeting 1.Importance of awareness raising activity	11 villagers
Nov. 29, 2000	Community meeting 1. Report of the training on awareness raising activity	23 villagers

Table 6.6.5 Community activities in Krishna Chandrapur (Jhenaidah)

Date	Activity	Attendants
Dec. ?, 2000	Community meeting 1.Benefits of using arsenic removal plants	17 villagers

6.6.2 Raising Awareness of Arsenic Problems

1) Awareness of Arsenic Problems in the Study Area

Correct understanding of a problem is the basis of solving the problem and the source of enthusiasm for action. DPHE and UNICEF carried out a communication campaign through mass media in 2000; in addition, articles on arsenic problems such as causes and symptoms of arsenicosis and patients' stories frequently appear in newspapers. The results of the socioeconomic study in the 260 villages in the study area carried out in June and July 2000 show that more than half of village leaders know symptoms of arsenic poisoning. Although village leaders in the 19 villages reported that arsenic patients have been found in their villages, only 11 villages have taken actions to tackle arsenic problems. Although arsenic patients have been found in the Model Rural Areas, no community action has been taken.

2) Training on Awareness Raising Activity in the Model Rural Area

JICA Study Team trained representatives of the Model Rural Areas and the assisting NGOs on awareness raising activity so that they can educate villagers about arsenic problems and mobilize them to take actions against arsenic problems. The training on raising awareness of arsenic was held as follows and the training program is summarized in Table 6.6.6.

Date: November 5, 2000
Venue: Banshte Shikha, Jessore
Participants: Total 15 (Two villagers from each Model Rural Area and three from each assisting NGO)

Table 6.6.6 Training Program on Raising Awareness of Arsenic

Topics	Contents
A. Overview of arsenic contamination of groundwater	1. Geographical perspective: Bangladesh and the world - Information from newspapers - Information from government and NGOs - Situation in Bangladesh and the world (by map) 2. Current status of arsenic contamination of groundwater in Bangladesh - History of arsenic problem in Bangladesh - Arsenic contamination level of groundwater - Population at risk - Districts and tubewells affected - Numbers of identified patients 3. Involvement of different organizations in arsenic mitigation and research in Bangladesh JICA, NIPSOM, AAN, UNICEF, WHO, World Bank, DCH, BRAC, etc.
B. Introduction on arsenic	1. What is arsenic? - Physical and chemical characteristics of arsenic - Geological compounds of arsenic - Types of arsenic (inorganic & organic) 2. Toxicity of arsenic 3. Arsenic in the environment including arsenic cycle 4. Use of arsenic 5. Definition of safe drinking water (permissible level of arsenic, WHO guideline value and the Bangladeshi standard) 6. Risk of cancer from arsenic in drinking water
C. Source of arsenic in water and the environment	1. Possible sources of arsenic in the environment 2. Source of arsenic in groundwater in Bangladesh 3. Current hydro-geological hypothesis of arsenic contamination of groundwater

D. Effects of arsenic	1. Arsenic in biosphere (impacts on plants) 2. Bio-transformation and pathogenesis 3. Toxicity (acute and chronic) 4. Chronic effects of arsenic on human health 5. Clinical feature (stages of arsenicosis in Bangladesh) 6. Identification of arsenicosis at community level 7. Treatment and management of arsenicosis (arsenic safe water and role of vitamin A, E & C and vitamin rich food)
D. Prevention of arsenicosis	1. Outline of prevention 2. Methods of arsenic removal from water 3. Options for arsenic safe water (use of surface water, rainwater harvesting, pond sand filter, sanitary dug well, two bucket system, aeration or passive sedimentation, activated aluminum method, distillation by solar energy)
E. Community mobilization and community participation	1. Social problem due to arsenic contamination of groundwater 2. Community mobilization (developmental change in social life through awareness raising) 3. Community participation (in planning, implementation, financing, and maintenance) 4. Role of village representatives, NGOs, village committee, femals 5. Flip chart 6. Use of the flip chart

2) Communication Material

Because the average literacy rate is less than 30% in the study area[1], visual and oral communication are considered to most fit the local condition in order to disseminate information on arsenic problems. The JICA Study Team asked Dr. Faruquee of Asia Arsenic Network to develop a communication material containing information on symptoms, cause, and prevention methods of arsenicosis. He wrote up a story about a rickshaw driver who is suffering from arsenicosis, and a local artist drew pictures for the story. The story and pictures were integrated into flip charts; the flip charts are used for a picture-story show (see Annex 6.6.1).

3) Awareness Raising Activities in the Model Rural Area

The awareness raising activities by the trainees from the Model Rural Areas are summarized in Table 6.6.7. Before the awareness raising activities by the trainees, information on arsenicosis was disseminated to those who did not know the said information during the socioeconomic study carried out in September and October 2000. When an interviewee answered “no” to the questions asking about knowledge of arsenicosis and its symptoms, cause, and prevention methods, the interviewer informed the interviewee of the correct information.

The follow-up interviews with villagers in the Model Rural Areas to see effectiveness of the awareness raising activities is being conducted by the assisting NGOs. The results will be analyzed and integrated into the draft final report.

[1] Adult literacy rate is 20.1% in Chuadanga, 25.6% in Jessore, and 19.3% in Jhenaidah.

Table 6.6.7 Awareness Raising Activity in Model Rural Area

Model Rural Area	Bara Dudpatila, Damruhda, Chuadanga	Rajnagar Bankabarsi, Keshabpur, Jessore	Krishna Chandrapur, Maheshpur, Jhenaidah
Duration of Activity	After November 5 to present	After November 5 to present	One week after November 5 to present
Way of a picture-story show	Holding small gatherings (about 15 times)	Door to door visit and holding small gatherings (about 10 times)	Door to door visit and holding small gatherings

Reference

Research and Computing Services Private Limited (2000): *Main Report UNICEF Communication Campaign on Arsenic Mitigation in Four Upazilas*.

Annex 6.6.1 Communication Material

A story used for a picture-story show in the Model Rural Areas is described below, followed by the accompanying pictures.

Story of Karim Miah

Karim Miah is a rickshaw van driver. His wife's name is Shakhina Bibi. They have six children. Shakhina Bibi works in a neighboring rich family's house. They were leading a happy life. The last few months Karim Miah and Shakhina Bibi have been suffering from physical weakness as well as some skin problems, such as blackening of the skin and hardening of the palms and soles. Now Shakhina Bibi cannot do her job. Karim Miah also cannot earn money as before. They went to the local village doctors and kaviraj for their treatment, but they got no result. Karim Miah is thinking that his weakness is due to his wife (it is due to illiteracy, superstition and prejudice). Now Karim Miah cannot decide what he has to do with his wife. Divorce his wife or send her to her parents' house? This created gradual disharmony in their family.

One day the local family health worker (Shilpi Apa) came to the village on her regular monthly visit and arranged a village meeting as usual. This time, however, she talked about a new topic, "arsenic." Karim Miah and Shakhina Bibi attended the meeting to get some solution for their physical problem.

Shilpi Apa listened to them about their problems in detail. According to their skin manifestations she diagnosed the problem as arsenicosis. To confirm her diagnosis, she asked Karim Miah about their source of drinking and cooking water. Yes, Karim Miah and his family have been using water for all purposes from their neighbor's tube well for last five years. Shilpi Apa then checked the tube well water for arsenic with a field kit supplied by the Thana health complex and detected arsenic in the water more than the permissible level as she learned.

Then she discussed the problem not only with Karim Miah and his family but also with his neighbors. She advised them to take surface water after proper boiling. She also advised them to take vitamin rich fruits and vegetables and medical care from the health complex.

Accordingly, Karim Miah and his wife went to the health complex for their treatment. A doctor prescribed some vitamins for them.

After one month Shilpi Apa again visited the village and met with Karim Miah and Shakhina.

They are improving.

After three months, Shilpi Apa again came to the village and found that there was marked improvement of their physical condition. Then Shilpi Apa told them that following her advice is what saved their lives. Otherwise they would have suffered from so many health problems including cancer. Now peace and harmony returned to the house of Karim Miah and Shakhina.

By this time Shilpi Apa informed the villagers that a Japanese group is working on the arsenic problem in Bangladesh. They are researching some arsenic safe water options for the arsenic affected areas, such as sealed deep tube wells and arsenic removal plants (community and household based).

CHAPTER 7

HOME PAGE PREPARATION

CHAPTER 7 HOME PAGE PREPARATION

In the First Phase of the Study, preparatory work for constructing the home page were made both in Japan and Bangladesh. The home page will present the summarized results of the Study according to the progress of actual activities.

In this chapter, the home page that was made based on the Inception Report of the Study is described.

7.1 Structure of Home Page

The menu of the home page was prepared as shown in Figure 7.1.1

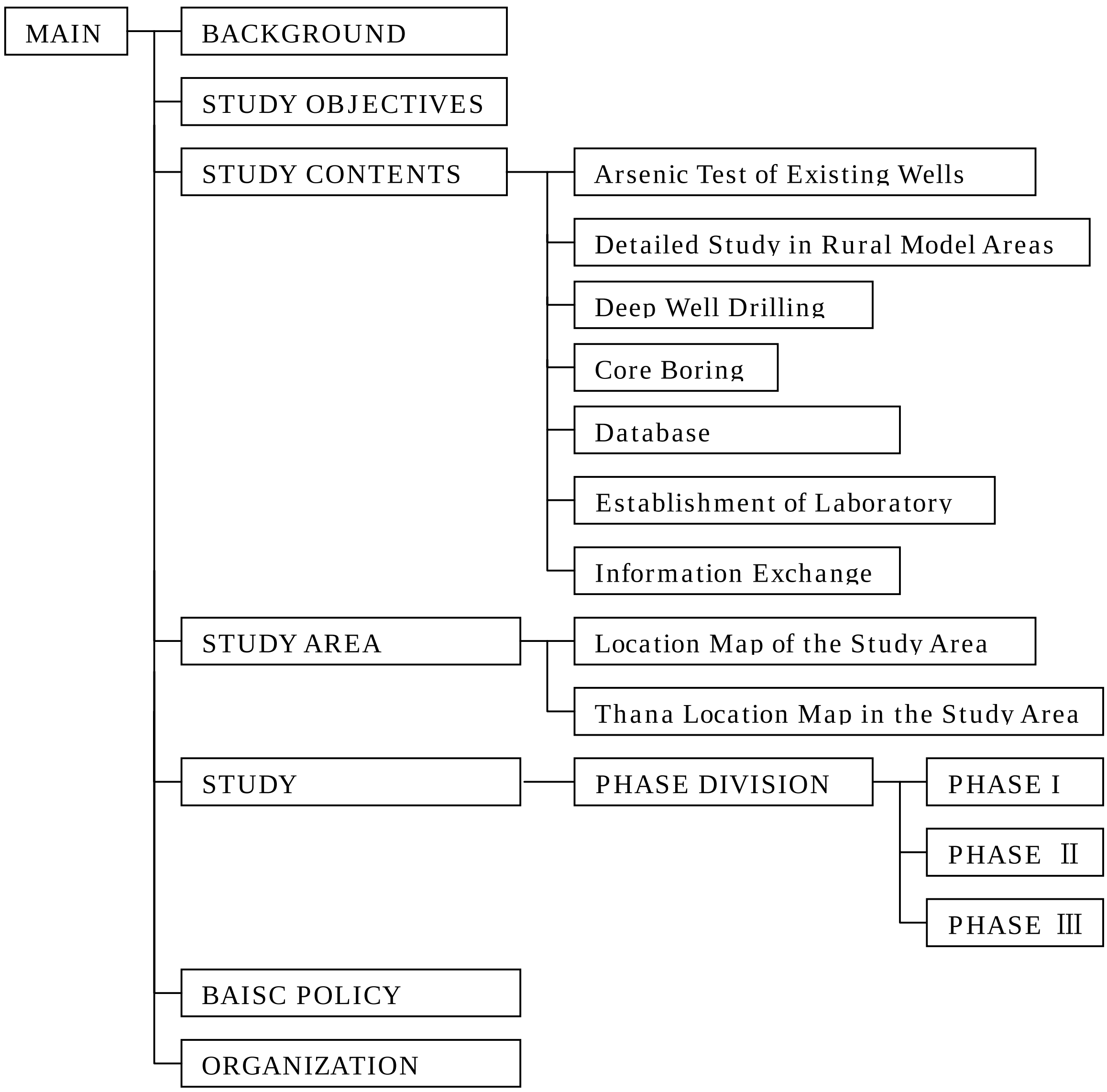


Figure 7.1.1 Structure of Home Page Based on the Inception Report

7.2 Contents of Home Page

7.2.1 Main Page

The home page has an opening page, which has an index on the left side. The index is fixed on the left side and appears permanently by the frame function. When the user clicks on a particular item in the index, the specified page will appear on the right side.

Figure 7.2.1 shows the main page that will appear when the user opens the home page. The photograph on the main page shows the building of the DPHE Jessore Office where the Study Team Office is located.

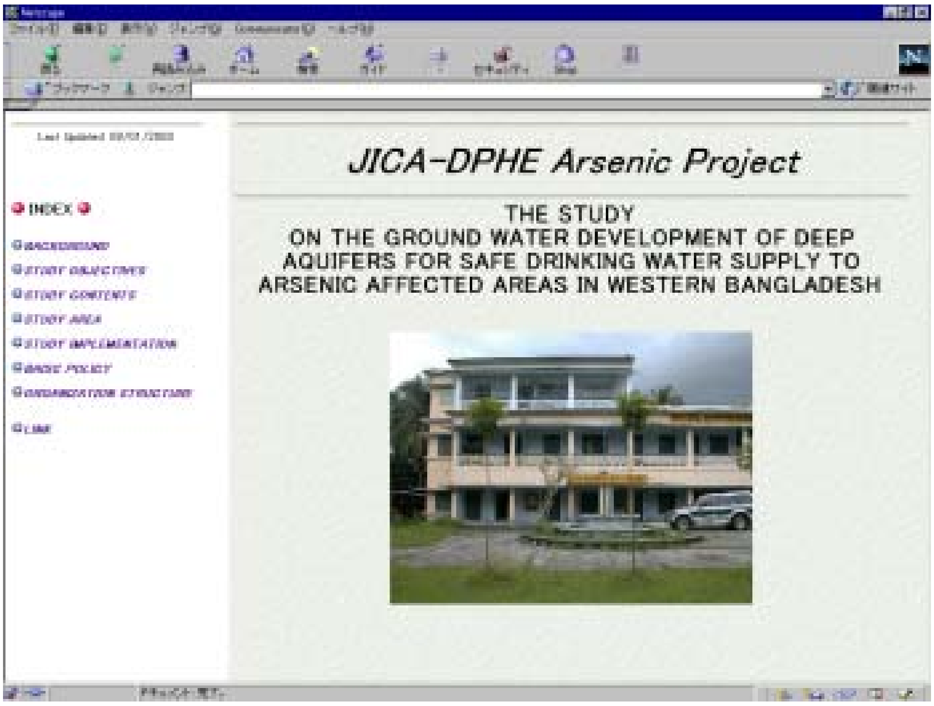


Figure 7.2.1 Opening Page

7.2.2 Page for Background of the Study

When the user clicks on "BACKGROUND" in the Index on the left, the page for the Background of the Study will appear on the right side of the screen as shown in Figure 7.2.2. The user can easily understand the background of the study and a brief history of arsenic mitigation activities in Bangladesh.

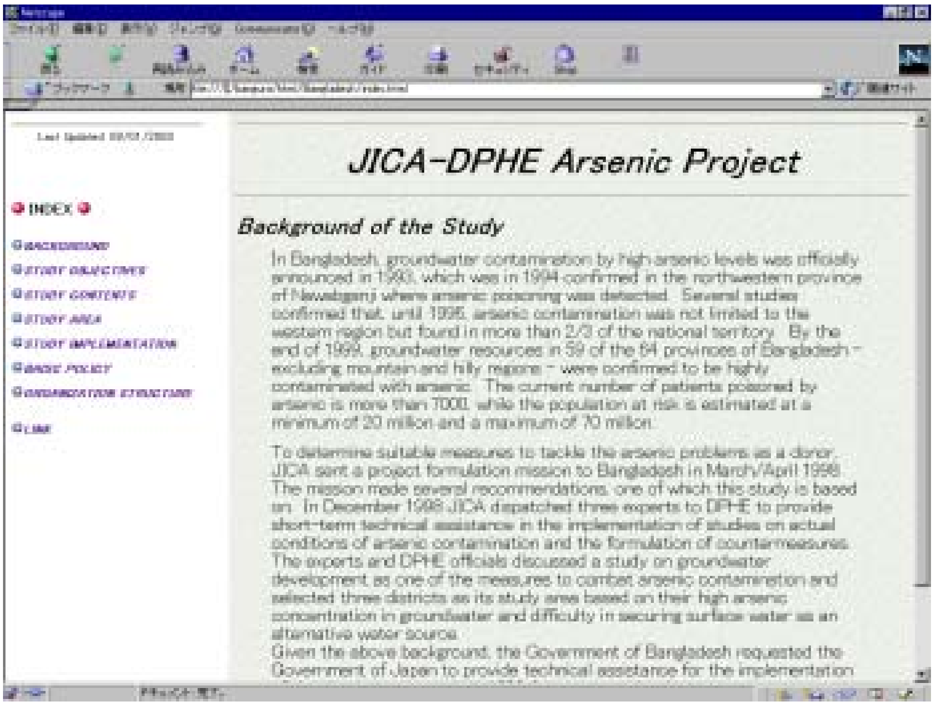


Figure 7.2.2 Page for Background of the Study

7.2.3 Page for Objectives of the Study

When the user clicks on "STUDY OBJECTIVES" in the index, the Objectives of the Study based on the S/W signed in December 1999 are shown on the right side of the screen as shown in Figure 7.2.3.

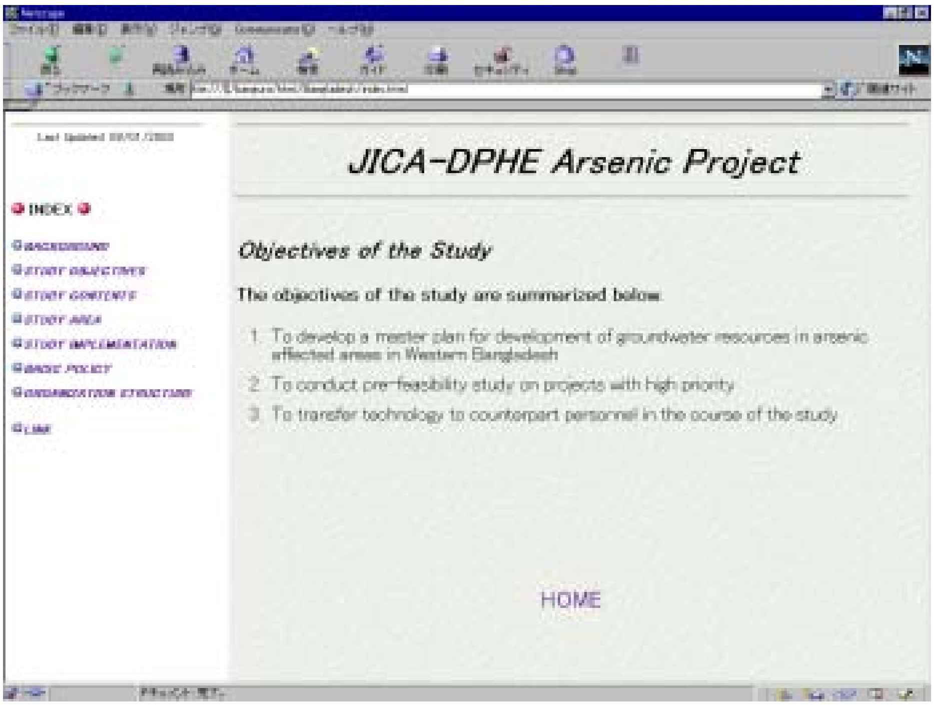


Figure 7.2.3 Page for Study Objectives

7.2.4 Page for Main Activities of the Study

An outline of the Study activities is mentioned here. The user can proceed to his/her page of interest by clicking on the corresponding study activity.

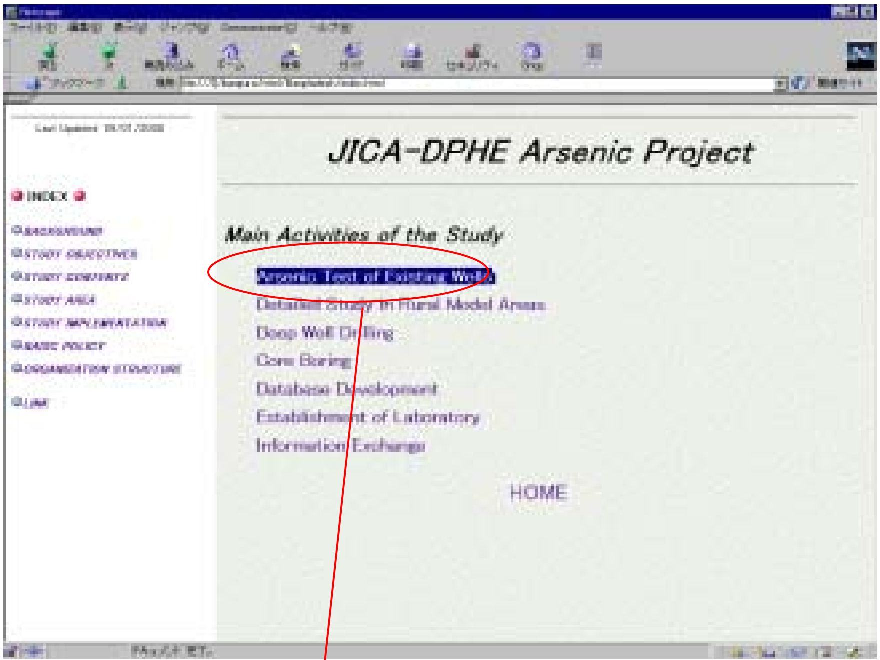


Figure 7.2.4 Page for Main Activities of the Study

Figure 7.2.5 Page for Arsenic Test of Existing Wells

7.2.5 Page for Study Area

This page introduces the Study Area. The thumbnail figures were prepared for users to guide them to the images of the next page. When the user clicks on the thumbnail in Figure 7.2.6, a large-sized Study Area map will appear on the screen as shown in Figure 7.2.7.

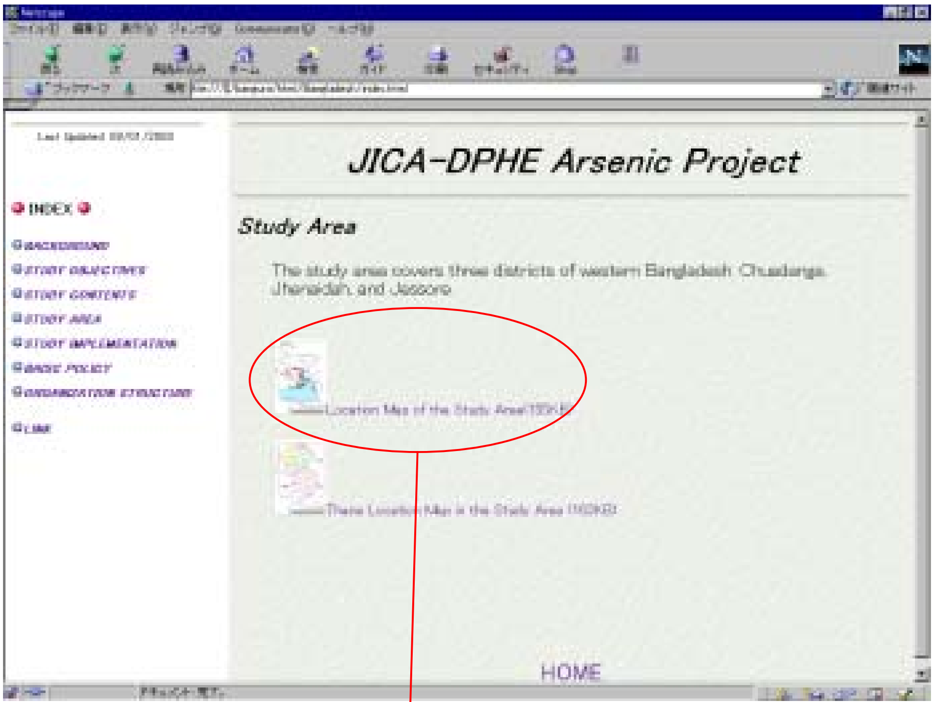


Figure 7.2.6 Selection Page for the Study Area Map

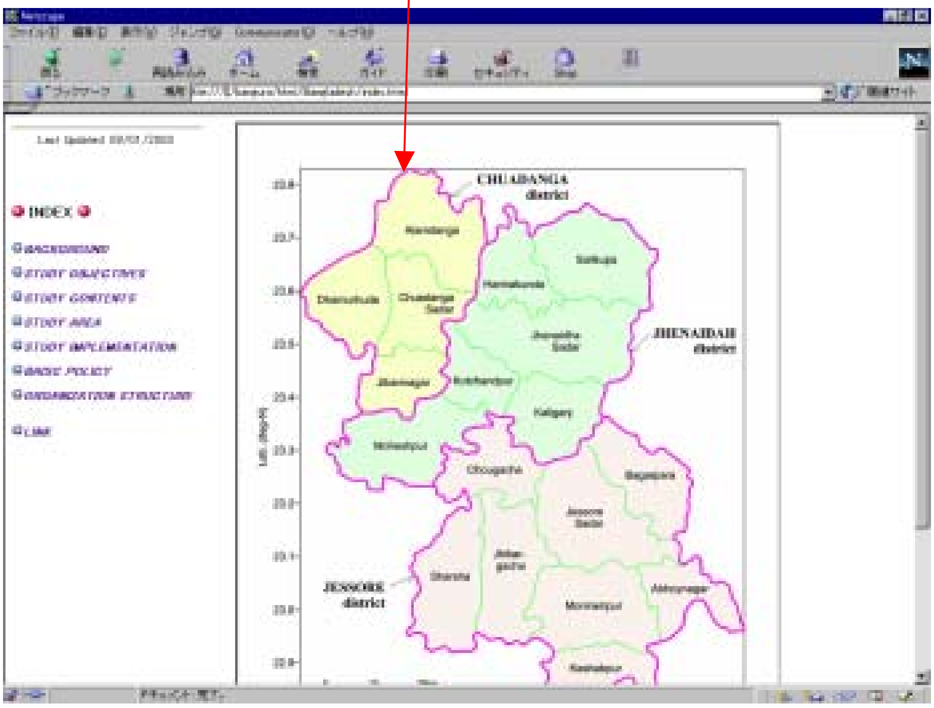


Figure 7.2.7 Enlarged Study Area Map in the Home Page

7.2.6 Page for Study Implementation

This page explains the implementation of the Study by phase. When the user clicks on a particular phase, a more detailed explanation will appear on the display as shown in Figures 7.2.8 and 7.2.9.

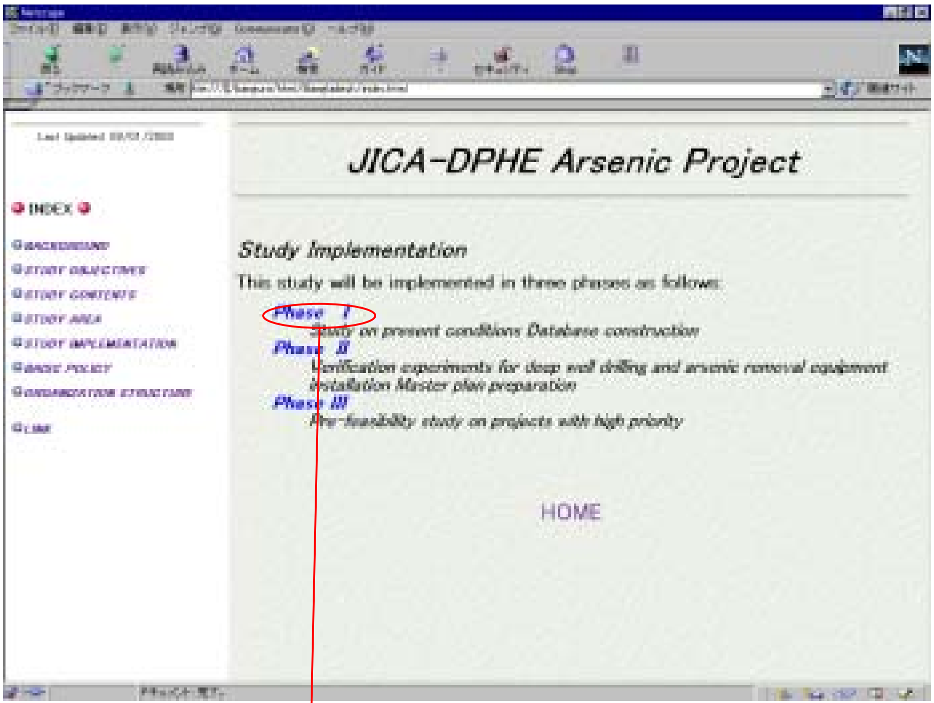


Figure 7.2.8 Page for Study Implementation

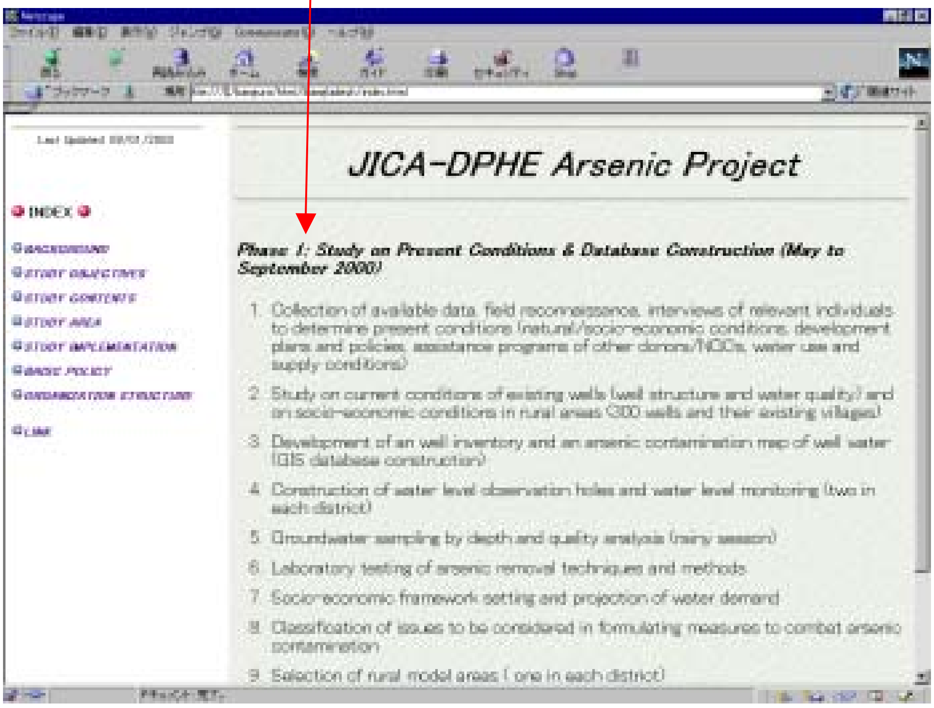


Figure 7.2.9 Page for Explanation of Study in Phase I

7.2.7 Page for Basic Policy

This page introduces the basic policies of the Study considering the actual situations of the arsenic problem in Bangladesh.

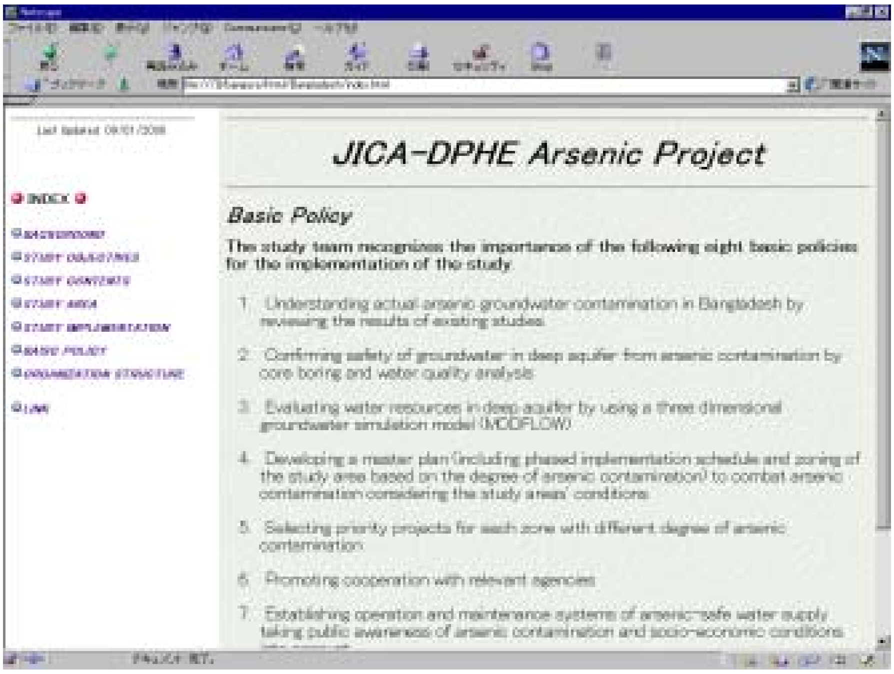


Figure 7.2.10 Page for Basic Policy

7.2.8 Page for Organization of the Study

This page introduces the organization of the Study.

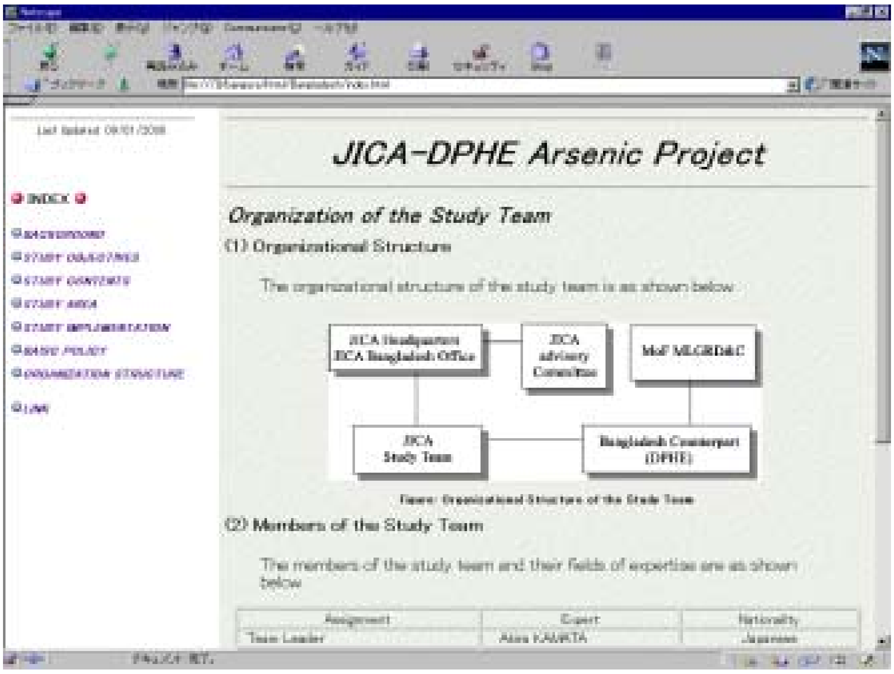


Figure 7.2.11 Page for Organization of the Study

7.2.9 Links

The home page has a page for links where the user can move to his/her sites of interest on the Internet related to arsenic issues by clicking on the name of the home pages or organizations. The Study Team will make the necessary arrangements to contact existing arsenic related home pages or organizations to exchange the home page addresses.

7.3 Renewal of Home Page

The Study Team is ready to disclose the home page mentioned above. The home page specialist of the Study Team has already contacted several Internet companies to open the home page.

In November 2000, the home page will be publicized using a Bangladeshi provider. Our own domain name of the home page is also being prepared. After publicizing the initial home page describing the contents of the Inception Report, the Study Team will prepare to publicize the contents of this Progress Report on the home page. The Study Team and DPHE counterparts will discuss the contents of the home page. The Study Team will also conduct technical transfers to the DPHE counterparts in the course of home page preparations