(3) Adequate Durability

Preference will be given to adequate durability of wearing parts even though the price of the pump may be considerably higher. Wearing parts should last for 2-months at least in actual operation, otherwise employment of manual operated pumps in the rural area will become meaningless.

The average discharge capacity of the pump is 500 to 1,300ℓ/hr which is enough to supply water for a population of 330 to 860 per day on the basis of a daily operation of 10 hours and 15ℓ of the design level.

Pump Specifications

| | | |
|---|---|---|
| a) Model | Shallow type | Deep type |
| b) Depth (M) | 1 - 50 | 20 - 70 |
| C) Average output (L/H) | 800 - 1,100 | 50 - 1,300 |
| d) Min. diameter of borehole (mm) | 76 (3in.) | 100 (4in.) |
| e) Discharge pipe | Polyethylene | Polyethylene |
| - Size (mm) | 18 x 26 | 20 x 32 |
| - Weight (kg/m) | 0.25 | 0.27 |

### 4.9.3 Pump Outlet

In order to protect well water from contamination by surface drainage or waste, an elevated concrete platform will be placed over the well with a simple drainage ditch around it. A fence will also be installed to prevent intrusion by livestock.

A typical arrangement of such facilities is shown in FIG. IV-8.

### 4.9.4 Rainfall Storage Unit

The rainfall storage unit is designed to supplement insufficiencies in the main water source during the dry season, from June through August. The unit is particularly advantageous when it is installed in districts where ground water is not available at a reasonable depth. Standard capacity of the unit is designed to supply 100 families (with 5 members each) with $30m^3$ of drinking water per month (10ℓ/family/day).

Estimation of available rainfall is as described below.

(1) Available Rainfall

More than 2mm of daily rainfall is assumed to be collected and stored in the tank, even considering several kinds of losses such as evaporation and runoff. Rainfall records in 1974 were used in estimation as the total rainfall in that year was 955mm, which is close to the average value (969mm) during the past 11 years, from 1973 to 1983. Rainfall in 1974, also represents the typical rainfall pattern in the project area as shown in FIG. IV-9.

(2) Design Rainfall

Yearly rainfall variation must be considered in order to design the surface area of collecting yards and the capacity of reservoirs. Based on investigation of rainfall for 11 years from 1973 through 1983, the variation factor was determined as 85%. Design value of rainfall can be calculated as follows:

$$\text{Design rainfall} = (\text{rainfall in 1974}) \times (1 - \frac{\text{unavailability \%}}{100} \times 0.85)$$

(3) Design Capacity of the Facilities

The size of the collecting yard and the reservoir is designed at $500m^2$ and $100m^2$, respectively. The collecting yard will have an annual capacity of $373m^3$ of rain water while the reservoir will provide approximately $30m^3$ of water year-round which will be stored monthly throughout the year. The lowest storage level will be $13.7m^3$ in September and will recover to $112.6m^3$ in May.

(4) Principles of Collection and Reservoir Design

The collecting yard of $500m^2$ can be divided into a few small yards, depending on the topographical conditions at each site and these small yards will be connected with covered ditches or pipes to a reservoir. Around the collecting yard, fences and drainage ditches will be placed so as to keep the surface of the yard clean. In some places, existing unpaved roads or other spaces can be used by covering the surface with concrete. Elevated places are preferable for the installation of the collecting yard.

The reservoir should be a closed type and may be constructed of stone or bricks, which are inexpensive. The inside wall should be waterproofed.

TABLE IV-1

**ESTIMATED POPULATION IN 1990**

Commune : BIRENGA

| NAME OF SECTOR | AREA ($km^2$) | POPULATION | 1983 DENSITY ($hab/km^2$) | NO. OF FAMILIES | SIZE OF FAMILY | AVERAGE GROWTH RATE (78-83) | ESTIMATED POPULATION | 1990 DENSITY ($hab/km^2$) | SIZE OF FAMILY |
|---|---|---|---|---|---|---|---|---|---|
| 1. BARE | 37.1 | 1,897 | 51.5 | 635 | 2.99 | N.A. | 2,333 | 62.9 | 3.67 |
| 2. BIRENGA | 32.7 | 2,087 | 63.8 | 767 | 2.72 | N.A. | 2,567 | 78.5 | 3.35 |
| 3. GAHARA | 72.7 | 5,436 | 74.8 | 990 | 5.49 | N.A. | 6,686 | 92.0 | 6.75 |
| 4. GAHULIRE | 13.5 | 2.765 | 204.8 | 455 | 6.08 | N.A. | 3,401 | 259.9 | 7.47 |
| 5. GASHONGORA | 38.3 | 4,193 | 109.5 | 414 | 10.13 | N.A. | 5,157 | 134.6 | 12.46 |
| 6. KIBAYA | 8.3 | 2.967 | 357.5 | 412 | 7.20 | N.A. | 3.649 | 439.6 | 8.86 |
| 7. KIBARA | 15.4 | 3.406 | 221.2 | 353 | 9.65 | N.A. | 4,189 | 272.0 | 11.87 |
| 8. KIBIMBA | 16.7 | 2,947 | 176.5 | 358 | 8.23 | N.A. | 3,624 | 217.0 | 10.12 |
| 9. KIBUNGO | 14.4 | 2,998 | 208.2 | N.A. | N.A. | N.A. | 3,687 | 256.0 | N.A. |
| 10. MATONGO | 28.8 | 4.396 | 152.6 | 534 | 8.23 | N.A. | 5,406 | 187.7 | 10.12 |
| 11. NDAMIRA | 11.0 | 2,349 | 213.5 | 467 | 5.03 | N.A. | 2,889 | 262.6 | 6.19 |
| 12. SAKARA | 22.7 | 3,866 | 170.2 | 774 | 6.14 | N.A. | 4,755 | 209.5 | 6.14 |
| TOTAL | 311.6 | 39,307 | 126.1 | N.A. | N.A. | 3.0 | 48,343 | 155.1 | N.A. |

TABLE IV-1

**ESTIMATED POPULATION IN 1990**

Commune : KABARONDO

| NAME OF SECTOR | AREA ($km^2$) | POPULATION | 1983 DENSITY ($hab/km^2$) | NO. OF FAMILIES | SIZE OF FAMILY | AVERAGE GROWTH RATE (78-83) | ESTIMATED POPULATION | 1990 DENSITY ($hab/km^2$) | SIZE OF FAMILY |
|---|---|---|---|---|---|---|---|---|---|
| 1. BISENGA | 19.8 | 2,104 | 106.3 | 476 | 4.42 | 5.02 | 2,619 | 132.3 | 5.50 |
| 2. CYINZOVU | 10.8 | 2,418 | 223.9 | 484 | 5.00 | 3.54 | 3,010 | 278.7 | 6.22 |
| 3. KABARONDO | 15.0 | 2,101 | 140.1 | 301 | 6.98 | 2.88 | 2,616 | 174.4 | 8.69 |
| 4. MURAMA | 21.0 | 1,461 | 69.6 | 284 | 5.14 | 1.80 | 1,819 | 86.6 | 6.04 |
| 5. NKANBA | 12.7 | 2,955 | 232.7 | 628 | 4.71 | 2.48 | 3,679 | 289.7 | 5.86 |
| 6. RUBIRA | 6.7 | 2,296 | 342.7 | 362 | 6.34 | 1.78 | 2,859 | 426.7 | 7.90 |
| 7. RUKIRA | 6.0 | 1,963 | 327.2 | 350 | 5.61 | 3.26 | 2,444 | 407.3 | 6.98 |
| 8. RUNDA | 11.7 | 2,908 | 248.6 | 616 | 4.72 | 3.38 | 3.621 | 309.5 | 5.88 |
| 9. RURAMIRA | 15.8 | 2,866 | 181.4 | 612 | 4.68 | 2.50 | 3,568 | 225.8 | 5.83 |
| 10. RUSERA | 9.6 | 1,875 | 195.3 | 480 | 3.91 | 5.16 | 2,334 | 243.1 | 4.86 |
| 11. RUYONZA | 8.5 | 2,238 | 263.3 | 349 | 6.41 | 2.36 | 2,786 | 327.8 | 7.98 |
| 12. SHYANDA | 36.3 | 2,346 | 64.6 | 315 | 7.45 | 5.46 | 2,921 | 80.5 | 9.27 |
| TOTAL | 173.9 | 27,531 | 158.3 | 5,257 | 5.24 | 3.18 | 34,276 | 197.1 | 6.52 |

TABLE IV-1

**ESTIMATED POPULATION IN 1990**

Commune : KAYONZA

| NAME OF SECTOR | AREA ($km^2$) | POPULATION | 1983 DENSITY ($hab/km^2$) | NO. OF FAMILIES | SIZE OF FAMILY | AVERAGE GROWTH RATE (78-83) | ESTIMATED POPULATION | 1990 DENSITY ($hab/km^2$) | SIZE OF FAMILY |
|---|---|---|---|---|---|---|---|---|---|
| 1. GASOGI | 15.0 | 2,738 | 182.5 | 543 | 5.04 | 2.86 | 2,968 | 197.9 | 5.47 |
| 2. KAYONZA | 13.5 | 3,247 | 240.5 | 530 | 6.13 | 0.86 | 3,520 | 260.7 | 6.64 |
| 3. MBARABUTURO | 10.0 | 1,982 | 198.2 | 365 | 5.43 | 1.80 | 2,149 | 214.9 | 5.89 |
| 4. MUSUMBA | 20.2 | 2,454 | 121.5 | 324 | 7.57 | 1.16 | 2,660 | 131.7 | 8.21 |
| 5. NYAMIRAMA | 19.6 | 3,524 | 179.8 | 298 | 11.8 | -5.00 | 3,820 | 194.9 | 12.8 |
| 6. RUTARE | 13.1 | 2,410 | 184.0 | 354 | 6.81 | -0.50 | 2,613 | 199.5 | 7.38 |
| 7. RWINDWAVU | 99.4 | 4,784 | 48.1 | 557 | 8.59 | 10.46 | 5,186 | 52.2 | 9.31 |
| 8. SHYOGO | 7.5 | 2,621 | 349.5 | 409 | 6.41 | 1.00 | 2,841 | 378.8 | 6.95 |
| TOTAL | 198.3 | 23,760 | 119.8 | 3,380 | 7.03 | 1.16 | 25,757 | 129.9 | 7.62 |

TABLE IV-1

**ESTIMATED POPULATION IN 1990**

Commune : KIGARAMA

| NAME OF SECTOR | AREA ($km^2$) | POPULATION | 1983 DENSITY ($hab/km^2$) | NO. OF FAMILIES | SIZE OF FAMILY | AVERAGE GROWTH RATE (78-83) | ESTIMATED POPULATION | 1990 DENSITY ($hab/km^2$) | SIZE OF FAMILY |
|---|---|---|---|---|---|---|---|---|---|
| 1. FUKWE | 5.0 | 3,744 | 748.8 | 552 | 6.78 | 3.02 | 5,136 | 1,072.2 | 9.30 |
| 2. GASETSA | 22.5 | 2,436 | 108.3 | 553 | 4.41 | 5.82 | 3,342 | 148.5 | 6.04 |
| 3. GSHANDA | 15.6 | 2,622 | 168.1 | 451 | 5.81 | 3.98 | 3,597 | 230.6 | 7.98 |
| 4. KARABE I | 16.0 | 2,473 | 154.6 | 638 | 3.88 | 6.56 | 3,393 | 212.1 | 5.32 |
| 5. KARARE II | 68.8 | 4,156 | 60.4 | 908 | 4.58 | 6.48 | 5,701 | 82.9 | 6.28 |
| 6. KARABERANGUF | 30.8 | 3,366 | 109.3 | 691 | 4.87 | 4.92 | 4,618 | 149.9 | 6.68 |
| 7. KANSANA | 18.3 | 3,462 | 189.2 | 573 | 6.04 | 3.34 | 4,749 | 259.5 | 8.29 |
| 8. REMERA | 16.7 | 2,327 | 139.3 | 506 | 4.60 | 5.72 | 3.192 | 191.1 | 6.31 |
| 9. RUBONA | 22.5 | 5,389 | 239.5 | 625 | 8.62 | 3.08 | 7.393 | 328.6 | 11.83 |
| 10. RURENGA | 20.8 | 2,168 | 104.2 | 615 | 3.53 | 6.32 | 2,874 | 143.0 | 4.84 |
| 11. VUMUE | 22.5 | 3,454 | 153.2 | 672 | 5.14 | 3.96 | 4,738 | 210.6 | 7.05 |
| TOTAL | 159.5 | 35,597 | 137.2 | 6,784 | 5.25 | 4.62 | 48,833 | 188.2 | 7.20 |

TABLE IV-1

## ESTIMATED POPULATION IN 1990

Commune : MUGESERA

| NAME OF SECTOR | AREA ($km^2$) | POPULATION | 1983 DENSITY ($hab/km^2$) | NO. OF FAMILIES | SIZE OF FAMILY | AVERAGE GROWTH RATE (78-83) | ESTIMATED POPULATION | 1990 DENSITY ($hab/km^2$) | SIZE OF FAMILY |
|---|---|---|---|---|---|---|---|---|---|
| 1. CYIZIHIZA | 9.8 | 2,919 | 297.9 | 506 | 5.77 | 3.78 | 3,785 | 386.7 | 7.49 |
| 2. GATARE | 16.3 | 3,015 | 185.0 | 538 | 5.60 | 3.33 | 3,915 | 240.2 | 7.28 |
| 3. KAGASHI | 21.7 | 3,537 | 163.0 | 587 | 6.03 | 3.78 | 4,585 | 211.6 | 7.82 |
| 4. KARENBO | 5.4 | 2,092 | 387.4 | 299 | 7.00 | 4.40 | 2,716 | 503.0 | 9.08 |
| 5. KIBARE | 8.8 | 3,444 | 391.4 | 483 | 7.13 | 3.75 | 4,472 | 508.2 | 9.26 |
| 6. KIBILIZA I-II | 20.6 | 5,143 | 249.7 | 815 | 6.31 | 2.53 | 6.677 | 324.1 | 8.19 |
| 7. KIRANBO | 10.6 | 2,454 | 231.5 | 327 | 7.50 | 4.13 | 3,186 | 300.6 | 9.74 |
| 8. KIKABUYE | 8.5 | 3.427 | 403.2 | 653 | 5.25 | 3.63 | 4,450 | 523.5 | 6.81 |
| 9. MATONGO | 5.2 | 2.583 | 496.7 | 422 | 6.12 | 3.95 | 3,354 | 645.0 | 7.95 |
| 10. NUGARA | 11.0 | 2,895 | 263.2 | 459 | 6.31 | 4.35 | 3,759 | 341.7 | 8.19 |
| 11. NYANGE | 20.2 | 2,085 | 103.2 | 462 | 4.51 | 5.33 | 2,707 | 134.0 | 5.86 |
| 12. SANGAZA | 16.3 | 2,839 | 174.2 | 502 | 5.66 | 4.03 | 3,686 | 226.1 | 7.34 |
| 13. SHYWA | 8.3 | 2,691 | 324.2 | 419 | 6.42 | 3.50 | 3,494 | 421.0 | 8.34 |
| 14. ZAZA | 7.7 | 2,385 | 309.7 | 329 | 7.25 | 5.20 | 3,094 | 401.8 | 9.40 |
| TOTAL | 170.4 | 41,509 | 243.6 | 6,801 | 6.10 | 3.80 | 53,880 | 316.3 | 7.92 |

TABLE IV-1
(6 of 11)

## ESTIMATED POPULATION IN 1990

Commune : MUHAZI

| NAME OF SECTOR | AREA ($km^2$) | POPULATION | 1983 DENSITY ($hab/km^2$) | NO. OF FAMILIES | SIZE OF FAMILY | AVERAGE GROWTH RATE (78-83) | ESTIMATED POPULATION | 1990 DENSITY ($hab/km^2$) | SIZE OF FAMILY |
|---|---|---|---|---|---|---|---|---|---|
| 1. GATI | 15.0 | 3.286 | 219.1 | 700 | 4.69 | 2.70 | 4,050 | 270.0 | 5.79 |
| 2. GISHALI | 12.5 | 3,910 | 312.8 | 722 | 5.42 | 2.27 | 4,819 | 385.5 | 6.67 |
| 3. KARABE | 10.6 | 3,025 | 285.4 | 402 | 7.52 | 7.17 | 3,728 | 351.7 | 9.27 |
| 4. KITAZIGURWA | 10.6 | 2,395 | 222.5 | 466 | 5.06 | 2.0 | 2,907 | 274.2 | 6.24 |
| 5. MUKARANGE | 7.9 | 2,219 | 280.5 | 438 | 5.07 | 3.00 | 2.735 | 36.2 | 6.24 |
| 6. MUNYIGINYA | 8.1 | 2,577 | 318.1 | 522 | 4.94 | 2.10 | 3,176 | 392.1 | 6.08 |
| 7. MURANBI | 15.0 | 3,129 | 208.6 | 525 | 5.96 | 3.13 | 3,856 | 257.1 | 7.34 |
| 8. NKOMANGWA | 8.8 | 2,271 | 258.1 | 457 | 4.97 | 1.63 | 2,799 | 318.7 | 6.12 |
| 9. NYANGATOVU | 12.1 | 2,700 | 223.1 | 504 | 5.36 | 3.30 | 3.327 | 275.0 | 6.60 |
| 10. NYARUBUYE | 8.5 | 2,810 | 330.6 | 512 | 5.49 | 3.37 | 3.463 | 407.4 | 6.76 |
| 11. NYARUGALI | 8.3 | 2,399 | 289.1 | 525 | 4.57 | 2.17 | 2,956 | 356.1 | 5.63 |
| 12. RUHUNDA | 11.5 | 2,814 | 244.7 | 538 | 5.23 | 2.70 | 3,468 | 301.6 | 6.45 |
| TOTAL | 128.9 | 33,499 | 259.9 | 6.311 | 5.31 | 3.30 | 41,284 | 320.3 | 6.54 |

TABLE IV-1

**ESTIMATED POPULATION IN 1990**

Commune : RUKARA

| NAME OF SECTOR | AREA ($km^2$) | POPULATION | 1983 DENSITY ($hab/km^2$) | NO. OF FAMILIES | SIZE OF FAMILY (78-83) | AVERAGE GROWTH RATE | ESTIMATED POPULATION | 1990 DENSITY ($hab/km^2$) | SIZE OF FAMILY |
|---|---|---|---|---|---|---|---|---|---|
| 1. GAHINI | 27.1 | 5,111 | 188.6 | 521 | 9.81 | 1.70 | 5,803 | 214.1 | 11.14 |
| 2. KAWANGIRE | 17.9 | 3,492 | 195.1 | 553 | 6.31 | 1.47 | 3,965 | 221.5 | 7.17 |
| 3. KIYENZI | 15.6 | 3,355 | 215.1 | 331 | 10.14 | 1.33 | 3,809 | 244.2 | 11.51 |
| 4. NYANKABUNGO | 31.9 | 2,663 | 83.5 | 340 | 7.83 | 1.77 | 3,809 | 244.2 | 11.51 |
| 5. NYAWERA | 44.6 | 3,809 | 85.4 | 350 | 10.88 | 1.70 | 4,325 | 97.0 | 12.35 |
| 6. RUKARA | 47.5 | 6,049 | 127.4 | 745 | 8.12 | 2.10 | 6.868 | 144.6 | 9.22 |
| 7. RWIMISHINYA | 22.5 | 4,609 | 204.8 | 638 | 7.22 | 1.60 | 5,233 | 232.6 | 8.208 |
| 8. RYAMANYONI | 63.8 | 2,454 | 38.5 | 377 | 6.51 | 3.33 | 2,786 | 43.7 | 7.39 |
| TOTAL | 270.9 | 31,542 | 116.4 | 3,855 | 8.18 | 1.83 | 35,811 | 132.2 | 9.29 |

TABLE IV-1

**ESTIMATED POPULATION IN 1990**

Commune : RUKIRA

| NAME OF SECTOR | AREA ($km^2$) | POPULATION | 1983 DENSITY ($hab/km^2$) | NO. OF FAMILIES | SIZE OF FAMILY | AVERAGE GROWTH RATE (78-83) | ESTIMATED POPULATION | 1990 DENSITY ($hab/km^2$) | SIZE OF FAMILY |
|---|---|---|---|---|---|---|---|---|---|
| 1. GASHIRU | 31.7 | 3,245 | 102.4 | 505 | 6.43 | N.A. | 4,609 | 145.4 | 9.13 |
| 2. GITUKU | 24.8 | 3,057 | 123.3 | 483 | 6.33 | N.A. | 4,324 | 175.1 | 8.99 |
| 3. GITWE | 33.5 | 3,552 | 106.0 | 477 | 7.45 | N.A. | 5,045 | 150.6 | 10.58 |
| 4. MUBANGO | 15.4 | 3,466 | 225.0 | 611 | 5.67 | N.A. | 4,923 | 319.7 | 8.06 |
| 5. MURAMA | 11.7 | 3,134 | 268.0 | 565 | 5.55 | N.A. | 4,451 | 380.4 | 7.88 |
| 6. MUSHIKIRI | 58.1 | 2,997 | 51.6 | 459 | 6.53 | N.A. | 4,257 | 73.3 | 9.27 |
| 7. NUTARUKA | 36.9 | 2,310 | 62.6 | 458 | 5.04 | N.A. | 3,281 | 88.9 | 7.16 |
| 8. RUGARAMA | 30.8 | 2,171 | 70.5 | 367 | 5.92 | N.A. | 3,083 | 100.1 | 8.40 |
| 9. RURAMA | 14.6 | 3,151 | 215.8 | 572 | 5.51 | N.A. | 4,475 | 306.5 | 7.82 |
| 10. RURENGE | 15.8 | 3,261 | 206.4 | 642 | 5.08 | N.A. | 4,632 | 293.2 | 7.21 |
| TOTAL | 273.3 | 30,344 | 111.0 | 5,139 | 5.00 | 5.14 | 43,098 | 157.7 | 8.39 |

TABLE IV-1

**ESTIMATED POPULATION IN 1990**

Commune : RUSUMO

| NAME OF SECTOR | AREA ($km^2$) | POPULATION | 1983 DENSITY ($hab/km^2$) | NO. OF FAMILIES | SIZE OF FAMILY | AVERAGE GROWTH RATE (78-83) | ESTIMATED POPULATION | 1990 DENSITY ($hab/km^2$) | SIZE OF FAMILY |
|---|---|---|---|---|---|---|---|---|---|
| 1. GATURE | 74.6 | 6,088 | 81.6 | N.A. | N.A. | 3.36 | 8,341 | 111.8 | 8.69 |
| 2. GISENBI | 47.1 | 2,346 | 49.8 | 512 | 4.58 | 2.38 | 3,214 | 68.2 | 6.28 |
| 3. KANKOBWA | 267.5 | 4,225 | 15.8 | 722 | 5.85 | 5.92 | 5,788 | 21.6 | 8.02 |
| 4. KIGARAMA | 135.6 | 5,711 | 42.1 | 753 | 7.58 | 4.84 | 7,824 | 57.7 | 10.39 |
| 5. KIGINA | 65.0 | 5,296 | 81.5 | 876 | 6.05 | 4.24 | 7,256 | 111.6 | 8.28 |
| 6. KIRFHF | 50.6 | 4,792 | 94.7 | 902 | 5.31 | 4.88 | 6,565 | 129.7 | 7.28 |
| 7. MUSAZA | 86.5 | 6,509 | 75. | N.A. | N.A. | 4.34 | 8,917 | 103.1 | 8.69 |
| 8. NYABITARE | 42.1 | 3,177 | 75.5 | 408 | 7.79 | 4.06 | 4,353 | 103.4 | 10.67 |
| 9. NYAMUGALI | 114.8 | 3,614 | 31.5 | N.A. | N.A. | 3.76 | 4,951 | 43.1 | 8.69 |
| 10. NYARUBUYE | 85.0 | 5,214 | 61.3 | 723 | 7.12 | 7.68 | 7,143 | 84.0 | 9.88 |
| TOTAL | 968.8 | 46,972 | 48.5 | N.A. | N.A. | 4.60 | 64,352 | 66.4 | 8.69 |

TABLE IV-1

**ESTIMATED POPULATION IN 1990**

Commune : RUTONDE

| NAME OF SECTOR | AREA ($km^2$) | POPULATION | 1983 DENSITY ($hab/km^2$) | NO. OF FAMILIES | SIZE OF FAMILY | AVERAGE GROWTH RATE (78-83) | ESTIMATED POPULATION | 1990 DENSITY ($hab/km^2$) | SIZE OF FAMILY |
|---|---|---|---|---|---|---|---|---|---|
| 1. KADUHA | 18.1 | 3,267 | 180.2 | 558 | 5.85 | 6.90 | 4,201 | 232.1 | 7.53 |
| 2. KIGABIRO | 3.8 | 3,417 | 899.2 | 406 | 8.42 | 1.88 | 4,401 | 1,158 | 10.84 |
| 3. NKUNGU | 12.1 | 2,866 | 236.9 | 501 | 5.72 | 7.36 | 3,691 | 305.0 | 7.37 |
| 4. NSINDA | 9.0 | 2,731 | 303.4 | 216 | 12.6 | 8.86 | 3,517 | 390.8 | 16.28 |
| 5. NYARUSANCE | 11.7 | 3,161 | 270.2 | 500* | 6.32* | 4.80 | 4,071 | 347.9 | 8.14 |
| 6. RUTONDE | 15.8 | 3,273 | 207.2 | 551 | 5.94 | 10.60 | 4,215 | 266.8 | 7.65 |
| 7. RWERU | 8.3 | 3,235 | 389.8 | 700 | 4.62 | 0.46 | 4.166 | 501.9 | 5.95 |
| 8. RWIKUBO | 11.9 | 3,022 | 254.0 | 597 | 5.06 | -1.48** | 3,892 | 327.1 | 6.52 |
| 9. SOVU | 13.3 | 2,759 | 207.4 | 491 | 5.62 | 0.02 | 3,553 | 267.1 | 7.24 |
| TOTAL | 104.0 | 27,726 | 266.6 | 4,520* | 6.13 | 3.68 | 35,707 | 343.3 | 7.90* |

TABLE IV-1

**ESTIMATED POPULATION IN 1990**

Commune : SAKE

| NAME OF SECTOR | AREA ($km^2$) | POPULATION | 1983 DENSITY ($hab/km^2$) | NO. OF FAMILIES | SIZE OF FAMILY | AVERAGE GROWTH RATE (78–83) | ESTIMATED POPULATION | 1990 DENSITY ($hab/km^2$) | SIZE OF FAMILY |
|---|---|---|---|---|---|---|---|---|---|
| 1. GITUZA | 19.8 | 2,830 | 142.9 | 415 | 6.82 | 7.08 | 3,625 | 183.1 | 8.73 |
| 2. MABUGA I | 11.0 | 2,228 | 202.5 | 374 | 5.96 | 2.88 | 2,854 | 259.5 | 7.63 |
| 3. MABUGA II | 10.4 | 2,295 | 220.7 | 378 | 6.07 | 3.44 | 2,940 | 282.7 | 7.78 |
| 4. MBUYE | 28.5 | 3,031 | 106.4 | 856 | 3.54 | 3.36 | 3,883 | 136.2 | 4.54 |
| 5. MURWA | 60.0 | 3,541 | 59.0 | 52 | 6.78 | 7.06 | 4,536 | 75.6 | 8.69 |
| 6. NGOMA | 14.4 | 2,228 | 154.7 | 536 | 4.16 | 1.42 | 2,854 | 198.2 | 5.32 |
| 7. NSHILI I | 13.3 | 2,641 | 198.6 | 496 | 5.32 | 4.30 | 3,383 | 254.4 | 6.82 |
| 8. NSHILI II | 9.6 | 2,263 | 235.7 | 219 | 10.33 | 2.10 | 2,899 | 302.0 | 13.24 |
| 9. RUBAGO | 14.0 | 3,315 | 236.8 | 518 | 6.40 | 2.60 | 4,246 | 303.3 | 8.20 |
| 10. RUKUMBELI | 126.5 | 3,320 | 125.3 | 589 | 5.64 | 2.28 | 4,252 | 160.5 | 7.21 |
| 11. RUYEMA I | 4.6 | 1,731 | 376.3 | 300 | 5.77 | 3.98 | 2,217 | 482.0 | 7.39 |
| 12. RUYEMA II | 5.6 | 1,604 | 286.4 | 344 | 4.66 | 4.80 | 2,054 | 366.8 | 5.97 |
| 13. SHOLI | 23.8 | 3,091 | 129.9 | 348 | 12.46 | 2.68 | 3,959 | 166.3 | 11.38 |
| TOTAL | 241.5 | 34,118 | 141.3 | 5,895 | 5.79 | 3.60 | 43,702 | 181.0 | 7.41 |

TABLE IV-2

**SUMMARY OF DESIGN WATER DEMAND**

| COMMUNE | POPULATION IN 1990 | ESTIMATED DAILY WATER DEMAND (GROSS) ($m^3/d$) | % OF DEMAND COVERED BY SPRING | DESIGN DAILY WATER DEMAND ($m^3/d$) |
|---|---|---|---|---|
| BIRENGA | 48,343 | 1,807.7 | 54.9 | 490.6 |
| KABARONDO | 34,276 | 771.2 | 53.6 | 357.8 |
| KAYONZA | 25,757 | 579.5 | 25.1 | 434.0 |
| KIGARAMA | 48,833 | 1,098.7 | 50.9 | 539.5 |
| MUGESERA | 53,880 | 1,212.0 | 60.7 | 476.3 |
| MUHAZI | 41,284 | 928.9 | 6.3 | 870.4 |
| RUKARA | 35,811 | 805.7 | 11.1 | 716.3 |
| RUKIRA | 43,098 | 969.7 | 29.7 | 681.7 |
| RUSUMO | 64,352 | 1,447.9 | 45.9 | 783.3 |
| RUTONDE | 35,707 | 803.4 | 76.0 | 192.8 |
| SAKE | 43,702 | 903.3 | 28.6 | 702.1 |

TABLE IV-5

**HYDROGEOLOGICAL CONDITIONS OF THE AQUIFER AT EACH TEST BORING SITE**

| No. | Location (Secteur) | Basement | Overburden | Aquifer | Topography | Type |
|---|---|---|---|---|---|---|
| 1. | KAYONZA (RWINKWAVU) | quartzite/schist (dominant schist) | clay/thick sand and gravel with boulders | quartzite (confined/ unconfined) | wide valley flanvial fan | $S_1$ + $D_1$ |
| 2. | KABARONDO (KABARONDO) | quartzite/schist (dominant quartzite) | clay/thick sand and gravel with boulders | quartzite (confined) | narrow valley colluvial | $D_2$ |
| 3. | RUKIRA (RURENGE) | quartzite/schist (dominant schist) | clay/thick sand and gravel | quartzite (confined) | wide valley marsh | $S_1$ + $D_1$ |
| 4. | RUSUMO (KIGINA) | quartzite/schist (dominant quartzite) | clay/thick sand and gravel | quartzite (confined) | narrow valley steeply inclined layer | $D_1$ |
| 5. | KIGARAMA (GASETZA) | quartzite/schist (dominant schist) | clay/thick sand and gravel | quartzite (confined/ unconfined) | wide valley alluvial | $S_2$ + $D_1$ |
| 6. | SAKE (SHOLI) | granite | thin clay layer | granite/ weathered layer (confined) | terraced hills hill side | $D_3$ |
| 7. | BIRENGA (BIRENGA) | quartzite/schist (dominant quartzite) | clay/thin sand and gravel | quartzite (confined) | narrow valley mountainside | $D_2$ |

TABLE IV-6

**SUMMARY OF TEST BORING RESULTS**

| No. | Location (Sector) | Well Depth (m) | Strainer Depth (m) | Pump Depth (m) | Water Level (m) | Yield ($m^3/h$) | Comment |
|---|---|---|---|---|---|---|---|
| 1. | KAYONZA (RWINKWAVU) | 48.85 | 36-42 | 25 | 9.40 | 15.0 | Foot pedal pump (now in use) Potential for use of $S_1$-$D_2$ power pump in future |
| 2. | KABARONDO (KABARONDO) | 43.50 | 30-42 | 40 | 19.50 | 2.0 | Foot pedal pump (now in use) $D_2$ type |
| 3. | RUKIRA (RURENGE) | 42.00 | 30-36 | 32.5 | 22.18 | 2.0 | Foot pedal pump (now in use) $S_1$-$D_2$ type |
| 4. | RUSUMO (KIGINA) | 46.00 | - | - | - | no water | $D_1$ type |
| 5. | KIGARAMA (GASETZA) | 54.85 | 45-51 | 25 | 11.41 | 12.0 | Foot pedal pump (now in use) Potential for use of $S_2$-$D_1$ power pump in future |
| 6. | SAKE (SHOLI) | 58.00 | - | - | - | no water | Bored through weathered granite zone bedrock but did not strike water |
| 7. | BIRENGA (BIRENGA) | 58.00 | 34-52 | 40 | 33.8 | 2.4 | Foot pedal pump (now in use) $D_2$ type |

TABLE IV-8

**WATER QUALITY TEST RESULTS**

| Items \ Water Source | Nyakora River (1) | Kodilidimba River Rugazi: I (2) | Sendaya River Rugazi: I (3) | Rwinkwavu Pond (4) | Kadilidimba River Nkondo West (5) |
|---|---|---|---|---|---|
| Date of Analysis | Aug.23,'85 | Aug.26,'85 | Sep.26,'85 | Sep.24,'85 | Oct.10,'85 |
| $NO_2$ - N | 0ppm | 0ppm | 0.05ppm | | 0ppm |
| $NO_3$ - N | 0 | 0 | 2.0 | 0 | 0 |
| $NH_4$ - N | 0.8 | 0 | 0.5 | 0 | 0 |
| Cl | 115 | 140 | 100 | 130 | 150 |
| $Cr^{6+}$ | 0 | 0 | 0 | 0 | 0 |
| Cu | 0 | 0 | 0 | 0 | 0 |
| $Fe^T$ | 0 | 1.0 | 0.5 | 0 | 0 |
| Zn | 0 | 0 | 0.5 | 0 | 0 |
| pH | 8.0pH | 7.0pH | 7.0pH | 7.0pH | 7.5pH |
| COD | > 20 | > 20 | > 20 | 20 | 5 |
| $CaCO_3$ | 255 | 150 | 50 | 140 | 150 |
| Colon Bactisille | ++ | ++ | ++ | ++ | ++ |
| Other Bacteria | ++ | ++ | ++ | ++ | ++ |
| Tervidity | >10° | >10° | >10° | >10° | 5° |
| Temperature | 20°C | 16°C | 17°C | 20°C | 20°C |

TABLE IV-8

**WATER QUALITY TEST RESULTS**

| Water Source / Items | Kabilizi Rurenge (6) | Ruvuvu Gasetsa (7) | "Kano" Kayonza (8) | "Kano" Rutonde Ngungu (9) | Public Faucet near Somirwa Hospital (10) |
|---|---|---|---|---|---|
| Date of Analysis | Sep.7,'85 | Sep.24,'85 | Aug.26,'85 | Sep.24,'85 | Sep.24,'85 |
| $NO_2$ - N | 0ppm | 0ppm | 0ppm | 0ppm | 0ppm |
| $NO_3$ - N | 0 | 0 | 0 | 0 | 0 |
| $NH_4$ - N | 0.4 | 0 | 0 | 0 | 1.0 |
| Cl | 50 | 110 | 80 | 140 | 135 |
| $Cr^{6+}$ | 0 | 0 | 0 | 0 | 0 |
| Cu | 0.5 | 0 | 0 | 0 | 0 |
| $Fe^T$ | 0.5 | 0 | 0 | 0 | 0.5 |
| Zn | 0 | 0 | 0.5 | 0 | 0 |
| pH | 7.0pH | 8.0pH | 6.0pH | 5.5pH | 8.5pH |
| COD | > 20 | > 20 | 15 | 5 | 10 |
| $CaCO_3$ | 105 | 110 | 150 | 100 | 130 |
| Colon Bactisille | ++ | ++ | - | - | ++ |
| Other Bacteria | ++ | ++ | + | + | ++ |
| Tervidity | > 10° | > 10° | 0° | 0° | > 10° |
| Temperature | 19°C | 20°C | 16°C | 17°C | 20°C |

TABLE IV-8

**WATER QUALITY TEST RESULTS**

| Water Source / Items | Nyankora Test Well No.1 (11) | Kabarondo Test Well No.2 (12) | Rukira Test Well No.3 (13) | Kigarama Test Well No.4 (14) | Birenga Test Well No.5 (15) |
|---|---|---|---|---|---|
| Date of Analysis | Aug.23,'85 | Aug.23,'85 | Sep.25,'85 | Sep.12,'85 | Oct.25,'85 |
| $NO_2$ - N | 0ppm | 0ppm | 0ppm | 0ppm | 0ppm |
| $NO_3$ - N | 0 | 0 | 0 | 0 | 0 |
| $NH_4$ - N | 0 | 0 | 0 | 0 | 0 |
| Cl | 75 | 90 | 75 | 85 | 75 |
| $Cr^{6+}$ | 0 | 0 | 0 | 0 | 0 |
| Cu | 0 | 0 | 0 | 0 | 0.5 |
| $Fe^T$ | 0 | 0.2 | 0.2 | 0 | 0.2 |
| Zn | 0 | 0 | 0.5 | 0 | 0 |
| pH | 7.0pH | 6.5pH | 6.0pH | 6.0pH | 7.5pH |
| COD | 0 | 0 | 0 | 0 | 0 |
| $CaCO_3$ | 125 | 150 | 50 | 45 | 50 |
| Colon Bactisille | - | - | - | - | - |
| Other Bacteria | - | - | - | - | - |
| Tervidity | 0° | 0° | 0° | 0° | 0° |
| Temperature | 17°C | 18°C | 21°C | 22°C | 20°C |

TABLE IV-9

**WATER SUPPLY DISTRICTS**

| Commune | No. of Sector | No. of Cellules | No. of Water Supply Districts | | | |
|---|---|---|---|---|---|---|
| | | | Ideal Program | | Working Program | |
| | | | Wells | R.F.S Units | Wells | R.F.S Units |
| 1. Birenga | 12 | 59 | 57 | 41 | 3 | 2 |
| 2. Kabarondo | 12 | 60 | 32 | 19 | 12 | 1 |
| 3. Kayonza | 8 | 38 | 18 | 4 | 15 | 1 |
| 4. Kigarama | 11 | 66 | 39 | 17 | 19 | 1 |
| 5. Mugesera | 15 | 75 | 59 | 4 | 0 | 1 |
| 6. Muhazi | 12 | 66 | 40 | 0 | 25 | 1 |
| 7. Rukara | 8 | 52 | 27 | 0 | 24 | 1 |
| 8. Rukira | 10 | 58 | 41 | 18 | 16 | 1 |
| 9. Rusumo | 10 | 99 | 69 | 49 | 17 | 1 |
| 10. Rutonde | 9 | 51 | 38 | 20 | 2 | 1 |
| 11. Sake | 13 | 70 | 69 | 14 | 3 | 1 |
| TOTAL | 120 | 694 | 489 | 186 | 136 | 12 |

TABLE IV-10

## SUMMARY OF WATER SUPPLY PLAN FOR COMMUNE

| Zone | No. of Communes | No. of Sectors | No. of Cellules | Population (1983) | Population Served (1990) | Water Demand (ℓ/d) | Discharge Supplied (ℓ/d) | No. of Wells Required | Type of Wells |
|---|---|---|---|---|---|---|---|---|---|
| I. | 2 | 2 | 3 | 2,752 | 3,187 | 71,708 | 80,000 | 1 | D1 (Electric pump) |
| II. | 3 | 6 | 13 | 7,831 | 8,714 | 130,710 | 130,000 | 13 | D1 (Manual pump) |
| III. | 3 | 6 | 18 | 6,324 | 11,754 | 176,310 | 180,000 | 18 | " |
| IV. | 4 | 13 | 40 | 20,144 | 26,247 | 393,705 | 400,000 | 40 | " |
| | Subtotal | | | 37,051 | 49,467 | 703,912 | 720,000 | 72 | |
| V. | 1 | 2 | 7 | 3,823 | 5,239 | 78,585 | 80,000 | 8 | D1 |
| VI. | 2 | 6 | 17 | 9,355 | 12,952 | 194,280 | 180,000 | 18 | D1 |
| VII. | 1 | 5 | 19 1/ | 3,496 | 4,786 | 71,790 | 180,000 | 18 | D1 |
| VIII. | 1 | 1 | 5 | 1,534 | 2,101 | 31,515 | 50,000 | 5 | S1 |
| IX. | 1 | 3 | 11 2/ | 3,252 | 4,455 | 66,825 | 110,000 | 11 | S1 |
| X. | 1 | 6 | 13 | 10,062 | 12,368 | 185,520 | 160,000 | 16 | D1 |
| XI. | 1 | 6 | 18 3/ | 12,528 | 15,399 | 230,985 | 240,000 | 24 | S1 |
| XII. | 1 | 6 | 14 | 7,596 | 9,864 | 147,960 | 140,000 | 14 | S1 |
| | Subtotal | | | 51,646 | 67,164 | 1,007,460 | 1,140,000 | 114 | |
| | Total | | | 88,697 | 116,631 | 1,711,372 | 1,860,000 | 186 | |

Note: 1/ 11 cellules have no population data
2/ 5 - " -
3/ 1 - " -

TABLE IV-11

## WATER SUPPLY PLAN (ZONE I) ELECTRIC PUMP SYSTEM

Zone I.

| No. | Communes | Sectors | Cellules | Population (1983) | Population Served (1990) | Water Demand (ℓ/d) | Spring Supply (ℓ/d) | Discharge Supplied (ℓ/d) | No. of Wells Required | Type of Wells |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Kayonza | Rwinkwavu | Mukoyoyo | 1,572 | 1,703 | 38,318 | 0 | 80,000 | 1 | D1 |
| 2. | | | Gishanda | 722 | 856 | 19,260 | 0 | - | (electric pump) | |
| 3. | Kigarama | Kabare II | Gishanda | 458 | 628 | 14,130 | 47,692 | - | - | |
| | Total | | | 2,752 | 3,187 | 71,708 | 47,692 | 80,000 | 1 | D1 |

Note: For daily water consumption per capita, 22.5ℓ/h/day is applied. (En ce qui concerne le debit journalier per haitant, 22.5ℓ/j/h est utilizé)

TABLE IV-11

## WATER SUPPLY PLAN (ZONE II) ELECTRIC PUMP SYSTEM

Zone II.

| No. | Communes | Sectors | Cellules | Population (1983) | Population Served (1990) | Water Demand (ℓ/d) | Spring Supply (ℓ/d) | Discharge Supplied (ℓ/d) | No. of Wells Required | Type of Wells |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Kabarondo | Shyanda | Gisunzu | N.A. | (667) | (10,005) | 0 | 10,000 | 1 | D1 |
| 2. | | | Nyakagezi | 887 | 843 | 12,645 | 0 | 10,000 | 1 | " |
| 3. | | Kabarondo | Rugazi I | 370 | 460 | 6,900 | 0 | 10,000 | 1 | " |
| 4. | | | Cyabajwa | 398 | 459 | 6,885 | 15,033 | 10,000 | 1 | " |
| 5. | | | Kabarondo | 537 | 669 | 10,035 | 23,328 | 10,000 | 1 | " |
| 6. | | Cyinzovu | Rugazi II | 450 | 559 | 8,385 | 0 | 10,000 | 1 | " |
| 7. | | | Rurenge | 500 | 622 | 9,330 | 30,585 | 10,000 | 1 | " |
| 8. | | Bisenga | Muko | 486 | 605 | 9,075 | 0 | 10,000 | 1 | " |
| 9. | | | Rulenge | 486 | 605 | 9,075 | 0 | 10,000 | 1 | " |
| 10. | | | Nyakanazi | 402 | 500 | 7,500 | 0 | 10,000 | 1 | " |
| 11. | Kigarama | Remera | Kamvumba | 644 | 883 | 13,245 | 19,180 | 10,000 | 1 | " |
| 12. | Kayonza | Rwinkwavu | Nkondo | 936 | 1,014 | 15,210 | 0 | 10,000 | 1 | " |
| 13. | | | Cyabajwa | 765 | 828 | 12,420 | 0 | 10,000 | 1 | " |
| | Total | | | 6,324 | 8,714 | 130,710 | 88,126 | 130,000 | 13 | |

TABLE IV-11

**WATER SUPPLY PLAN (ZONE III) ELECTRIC PUMP SYSTEM**

Zone III.

| No. | Communes | Sectors | Cellules | Population (1983) | Population Served (1990) | Water Demand (ℓ/d) | Spring Supply (ℓ/d) | Discharge Supplied (ℓ/d) | No. of Wells Required | Type of Wells |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Birenga | Sakara | Gahama | 664 | 816 | 12,240 | 91,756 | 10,000 | 1 | D1 |
| 2. | | | Kabahushi | 419 | 515 | 7,725 | 11,588 | 10,000 | 1 | " |
| 3. | | Kibara | Nyamugali | 772 | 949 | 14,235 | 0 | 10,000 | 1 | " |
| 4. | Rukira | Murama | Mutara | 660 | 937 | 14,055 | 0 | 10,000 | 1 | " |
| 5. | | | Nyagasozi | 677 | 961 | 14,415 | 39,398 | 10,000 | 1 | " |
| 6. | | | Rukizi | 427 | 606 | 9,090 | 0 | 10,000 | 1 | " |
| 7. | | | Tonero | 366 | 520 | 7,800 | 0 | 10,000 | 1 | " |
| 8. | | | Nyakabanga | 344 | 488 | 7,320 | 0 | 10,000 | 1 | " |
| 9. | | Rurenge | Ntara | 345 | 490 | 7,350 | 0 | 10,000 | 1 | " |
| 10. | | | Kizenga | 528 | 749 | 11,235 | 0 | 10,000 | 1 | " |
| 11. | | | Ruzinga I | 360 | 605 | 9,075 | 0 | 10,000 | 1 | " |
| 12. | | | Ruzinga II | 376 | 511 | 7,665 | 0 | 10,000 | 1 | " |
| 13. | | | Nyakazinga | 457 | 648 | 9,720 | 0 | 10,000 | 1 | " |
| 14. | | | Ruvuzi II | 411 | 533 | 7,995 | 0 | 10,000 | 1 | " |
| 15. | | | Rugombe | 356 | 504 | 7,560 | 0 | 10,000 | 1 | " |
| 16. | | Mubago | Nyagateme | 669 | 588 | 8,820 | 0 | 10,000 | 1 | " |
| 17. | Rusumo | Gatore | Rurenge I | N.A. | (667) | (10,005) | 0 | 10,000 | 1 | " |
| 18. | | | Rurenge II | N.A. | (667) | (10,005) | 0 | 10,000 | 1 | " |
| | Total | | | 7,831 | 11,754 | 176,310 | 142,742 | 180,000 | 18 | |

TABLE IV-11

**WATER SUPPLY PLAN (ZONE IV) ELECTRIC PUMP SYSTEM**

Zone IV.

| No. | Communes | Sectors | Cellules | Population (1983) | Population Served (1990) | Water Demand (ℓ/d) | Spring Supply (ℓ/d) | Discharge Supplied (ℓ/d) | No. of Wells Required | Type of Wells |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Kigarama | Gasetsa | Murukore | 445 | 610 | 9,150 | 0 | 10,000 | 1 | D1 |
| 2. | | | Kurutari | 445 | 610 | 9,150 | 0 | 10,000 | 1 | " |
| 3. | | | Mundekwe | 520 | 712 | 10,680 | 0 | 10,000 | 1 | " |
| 4. | | | Gikomero | 348 | 477 | 7,155 | 0 | 10,000 | 1 | " |
| 5. | | Rurenge | Sata | 409 | 561 | 8,415 | 0 | 10,000 | 1 | " |
| 6. | | Kaberangwe | Rugese | 648 | 888 | 13,320 | 0 | 10,000 | 1 | " |
| 7. | | | Bugarama | 657 | 901 | 13,515 | 0 | 10,000 | 1 | " |
| 8. | Kabarondo | Rundu | Gisoro | 712 | 887 | 13,305 | 0 | 10,000 | 1 | " |
| 9. | | Rukira | Mashya | 303 | 446 | 6,690 | 0 | 10,000 | 1 | " |
| 10. | | | Ngatare | 292 | 362 | 5,430 | 0 | 10,000 | 1 | " |
| 11. | | | Murambi | 438 | 544 | 8,160 | 0 | 10,000 | 1 | " |
| 12. | | | Agasharu | 438 | 544 | 8,160 | 0 | 10,000 | 1 | " |
| 13. | | | Buhoro | 438 | 544 | 8,160 | 0 | 10,000 | 1 | " |
| 14. | | Ruramira | Abiyahuzi | 627 | 781 | 11,715 | 0 | 10,000 | 1 | " |
| 15. | | Nkamba | Cyemo | 513 | 638 | 9,570 | 0 | 10,000 | 1 | " |
| 16. | | | Mabuga | 782 | 972 | 14,580 | 23,846 | 10,000 | 1 | " |
| 17. | Rutonde | Nkungu | Matabe | 578 | 744 | 11,160 | 0 | 10,000 | 1 | " |
| 18. | | | Rushangari | 572 | 737 | 11,055 | 33,696 | 10,000 | 1 | " |
| 19. | | | Rudashya | 572 | 737 | 11,055 | 0 | 10,000 | 1 | " |
| 20. | | | Kabuye | 583 | 751 | 11,265 | 0 | 10,000 | 1 | " |
| 21. | | | Nyagakombe | 561 | 722 | 10,830 | 6,739 | 10,000 | 1 | " |
| 22. | | Kaduha | Kabare | 644 | 828 | 12,420 | 0 | 10,000 | 1 | " |

Zone IV.

| No. | Communes | Sectors | Cellules | Population (1983) | Population Served (1990) | Water Demand (ℓ/d) | Spring Supply (ℓ/d) | Discharge Supplied (ℓ/d) | No. of Wells Required | Type of Wells |
|---|---|---|---|---|---|---|---|---|---|---|
| 23. | | | Gishike | 573 | 737 | 11,055 | 175,789 | 10,000 | 1 | D1 |
| 24. | | | Kangabo | 515 | 662 | 9,930 | 6,739 | 10,000 | 1 | " |
| 25. | | | Kababero | 509 | 655 | 9,825 | 112,492 | 10,000 | 1 | " |
| 26. | | | Rwimbago | 509 | 655 | 9,825 | 51,840 | 10,000 | 1 | " |
| 27. | | | Kamamana | 515 | 662 | 9,930 | 0 | 10,000 | 1 | " |
| 28. | | Rweru | Mubuga | 407 | 523 | 7,845 | 0 | 10,000 | 1 | " |
| 29. | | | Kinganzwa | 402 | 517 | 7,755 | 9,331 | 10,000 | 1 | " |
| 30. | | | Gatare | 411 | 529 | 7,935 | 0 | 10,000 | 1 | " |
| 31. | | | Rwisange | 411 | 529 | 7,935 | 3,628 | 10,000 | 1 | " |
| 32. | | | Kabazeyi | 365 | 470 | 7,050 | 55,987 | 10,000 | 1 | " |
| 33. | | | Kanyegera | 402 | 517 | 7,755 | 0 | 10,000 | 1 | " |
| 34. | | Sovu | Nyabishunzi | 399 | 651 | 9,765 | 41,990 | 10,000 | 1 | " |
| 35. | | | Rushangara | 461 | 593 | 8,895 | 112,492 | 10,000 | 1 | " |
| 36. | | | Rugobagoba | 550 | 644 | 9,660 | 0 | 10,000 | 1 | " |
| 37. | Mugesera | Kabilizi I | Rwakayango | 631 | 819 | 12,285 | 24,364 | 10,000 | 1 | " |
| 38. | | | Kalibu | 631 | 819 | 12,285 | 68,947 | 10,000 | 1 | " |
| 39. | | | Kashekashi | 536 | 696 | 10,440 | 76,956 | 10,000 | 1 | " |
| 40. | | Kabilizi II | Gashekasheke | 442 | 573 | 8,595 | 11,404 | 10,000 | 1 | " |
| | Total | | | 20,144 | 26,247 | 393,705 | 766,240 | 400,000 | 40 | |

TABLE IV-11

**WATER SUPPLY PLAN (ZONE V)**

Zone V.

| No. | Communes | Sectors | Cellules | Population (1983) | Population Served (1990) | Water Demand (ℓ/d) | Spring Supply (ℓ/d) | Discharge Supplied (ℓ/d) | No. of Wells Required | Type of Wells |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Kigarama | Kabare II | Murugunga | 591 | 810 | 12,150 | 0 | 10,000 | 1 | D1 |
| 2. | | | Cyarubare | 458 | 628 | 9,420 | 0 | 10,000 | 1 | " |
| 3. | | | Rubimba | 403 | 552 | 8,280 | 0 | 10,000 | 1 | " |
| 4. | | | Bara | 518 | 709 | 10,635 | 0 | 10,000 | 1 | " |
| 5. | | | Rushenyi | 522 | 715 | 10,725 | 0 | 10,000 | 1 | " |
| 6. | | | Gitara | 495 | 678 | 10,170 | 0 | 10,000 | 1 | " |
| 7. | | Rubona | Nyagatovu | 836 | 1,147 | 17,205 | 0 | 20,000 | 2 | " |
| | Total | | | 3,823 | 5,239 | 78,585 | 0 | 80,000 | 8 | |

TABLE IV-11

**WATER SUPPLY PLAN (ZONE VI)**

Zone VI.

| No. | Communes | Sectors | Cellules | Population (1983) | Population Served (1990) | Water Demand ($\ell$/d) | Spring Supply ($\ell$/d) | Discharge Supplied ($\ell$/d) | No. of Wells Required | Type of Wells |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Rukira | Mushikili | Bisagara | 771 | 1,093 | 16,395 | 0 | 20,000 | 2 | D1 |
| 2. | | | Gatongo | 699 | 991 | 14,865 | 0 | 10,000 | 1 | " |
| 3. | | | Rwamuhigi | 470 | 667 | 10,005 | 0 | 10,000 | 1 | " |
| 4. | | Gitwe | Rusenyi | 648 | 920 | 13,800 | 0 | 10,000 | 1 | " |
| 5. | Rusumo | Kirehe | Bugarura | 542 | 742 | 11,130 | 0 | 10,000 | 1 | " |
| 6. | | | Kirehe | 579 | 793 | 11,895 | 0 | 10,000 | 1 | " |
| 7. | | | Kaduha | 584 | 800 | 12,000 | 114,048 | 10,000 | 1 | " |
| 8. | | | Rurenge | 489 | 669 | 10,035 | 0 | 10,000 | 1 | " |
| 9. | | | Gacumu | 515 | 706 | 10,590 | 0 | 10,000 | 1 | " |
| 10. | | | Mubuga | 377 | 516 | 7,740 | 0 | 10,000 | 1 | " |
| 11. | | Kigina | Ruhanga | 605 | 828 | 12,420 | 41,990 | 10,000 | 1 | " |
| 12. | | | Rugando | 605 | 828 | 12,420 | 0 | 10,000 | 1 | " |
| 13. | | | Rugarama | 605 | 828 | 12,420 | 0 | 10,000 | 1 | " |
| 14. | | Nyabitare | Rwagitura | 506 | 693 | 10,395 | 0 | 10,000 | 1 | " |
| 15. | | | Rusarabaga | 506 | 693 | 10,395 | 13,996 | 10,000 | 1 | " |
| 16. | | Nyarubuye | Kagabiro | 470 | 652 | 9,780 | 0 | 10,000 | 1 | " |
| 17. | | | Mareba | 384 | 533 | 7,995 | 0 | 10,000 | 1 | " |
| | Total | | | 9,355 | 12,952 | 194,280 | 170,034 | 180,000 | 18 | |

TABLE IV-11

**WATER SUPPLY PLAN (ZONE VII)**

Zone VII.

| No. | Communes | Sectors | Cellules | Population (1983) | Population Served (1990) | Water Demand (ℓ/d) | Spring Supply (ℓ/d) | Discharge Supplied (ℓ/d) | No. of Wells Required | Type of Wells |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Rusumo | Gatore | Rwabutazi | N.A. | - | - | 0 | 10,000 | 1 | D1 |
| 2. | | | Cyunuzi | N.A. | - | - | 0 | 10,000 | 1 | " |
| 3. | | | Nyamiryaango | N.A. | - | - | 0 | 10,000 | 1 | " |
| 4. | | | Kurugarika | N.A. | - | - | 0 | 10,000 | 1 | " |
| 5. | | | Kamemo | N.A. | - | - | 0 | 10,000 | 1 | " |
| 6. | | | Muganza | N.A. | - | - | 0 | 10,000 | 1 | " |
| 7. | | Kirehe | Mukaziba | 425 | 582 | 8,730 | 0 | 10,000 | 1 | " |
| 8. | | | Rutobagu | 664 | 910 | 13,650 | 0 | 10,000 | 1 | " |
| 9. | | | Murugando | 308 | 422 | 6,330 | 0 | 10,000 | 1 | " |
| 10. | | | Nyabukokora | 308 | 422 | 6,330 | 0 | 10,000 | 1 | " |
| 11. | | Musaza | Rugarama | N.A. | - | - | 0 | 10,000 | 1 | " |
| 12. | | | Nyagahama | N.A. | - | - | 0 | 10,000 | 1 | " |
| 13. | | | Kumurambi | N.A. | - | - | 0 | 10,000 | 1 | " |
| 14. | | | Nkwandi | N.A. | - | - | 29,548 | 10,000 | 1 | " |
| 15. | | Kigarama | Kigarama | 508 | 696 | 10,440 | 0 | 10,000 | 1 | " |
| 16. | | Kigina | Buhwaga | 442 | 604 | 9,060 | 11,923 | 10,000 | 1 | " |
| 17. | | | Bugarura | 448 | 612 | 9,180 | 32,140 | 10,000 | 1 | " |
| 18. | | | Nyakibande | 393 | 538 | 8,070 | 0 | 10,000 | 1 | " |
| | Total | | | 3,496 | 4,786 | 71,790 | 73,611 | 18,000 | 18 | " |

Note: Rusumo/Gatore & Musasa have no data of No. of families. (total 11 cellules)

TABLE IV-11

**WATER SUPPLY PLAN (ZONE VIII)**

Zone VIII.

| No. | Communes | Sectors | Cellules | Population (1983) | Population Served (1990) | Water Demand (ℓ/d) | Spring Supply (ℓ/d) | Discharge Supplied (ℓ/d) | No. of Wells Required | Type of Wells |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Rusumo | Gisenyi | Kigonge | 256 | 351 | 5,265 | 0 | 10,000 | 1 | S1 |
| 2. | | | Gisenyi | 334 | 458 | 6,870 | 0 | 10,000 | 1 | " |
| 3. | | | Mahama | 266 | 364 | 5,460 | 0 | 10,000 | 1 | " |
| 4. | | | Mwoga | 339 | 464 | 6,960 | 0 | 10,000 | 1 | " |
| 5. | | | Mwizinga | 339 | 464 | 6,960 | 0 | 10,000 | 1 | " |
| | Total | | | 1,534 | 2,101 | 31,515 | 0 | 50,000 | 5 | |

TABLE IV-11

**WATER SUPPLY PLAN (ZONE IX)**

Zone IX.

| No. | Communes | Sectors | Cellules | Population (1983) | Population Served (1990) | Water Demand ($\ell$/d) | Spring Supply ($\ell$/d) | Discharge Supplied ($\ell$/d) | No. of Wells Required | Type of Wells |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Rusumo | Kigarama | Kiyanzi | 652 | 893 | 13,395 | 0 | 10,000 | 1 | S1 |
| 2. | | | Kiremera | 652 | 893 | 13,395 | 0 | 10,000 | 1 | " |
| 3. | | | Kimesho | 546 | 748 | 11,220 | 0 | 10,000 | 1 | " |
| 4. | | | Nyacyerera | 394 | 540 | 8,100 | 23,328 | 10,000 | 1 | " |
| 5. | | | Gishenyi | 576 | 789 | 11,835 | 0 | 10,000 | 1 | " |
| 6. | | | Cyanya | 432 | 592 | 8,880 | 0 | 10,000 | 1 | " |
| 7. | | Musaza | Gatwe | N.A. | - | - | 93,312 | 10,000 | 1 | " |
| 8. | | | Kagera | N.A. | - | - | 0 | 10,000 | 1 | " |
| 9. | | | Gikenke | N.A. | - | - | 0 | 10,000 | 1 | " |
| 10. | | Gatore | Mukiha | N.A. | - | - | 0 | 10,000 | 1 | " |
| 11. | | | Rubona | N.A. | - | - | 0 | 10,000 | 1 | " |
| | Total | | | 3,252 | 4,455 | 66,825 | 116,640 | 110,000 | 11 | |

Note: Rusumo/Musaza & Gatore have no data of No. of families. (total 5 cellules)

TABLE IV-11

**WATER SUPPLY PLAN (ZONE X)**

**Zone X.**

| No. | Communes | Sectors | Cellules | Population (1983) | Population Served (1990) | Water Demand (ℓ/d) | Spring Supply (ℓ/d) | Discharge Supplied (ℓ/d) | No. of Wells Required | Type of Wells |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Birenga | Sakara | Nyagataba | 788 | 970 | 14,550 | 0 | 10,000 | 1 | D1 |
| 2. | | | Kukarambi | 549 | 675 | 10,125 | 0 | 10,000 | 1 | " |
| 3. | | | Kukarenge | 564 | 693 | 10,395 | 0 | 10,000 | 1 | " |
| 4. | | Kibara | Nyamirindi | 1,312 | 1,614 | 24,210 | 0 | 20,000 | 2 | " |
| 5. | | | Nyagasozi | 1,322 | 1,626 | 24,390 | 0 | 20,000 | 2 | " |
| 6. | | Gahulire | Itambiro | 736 | 903 | 13,545 | 57,542 | 10,000 | 1 | " |
| 7. | | | Rugenge | 553 | 679 | 10,185 | 8,812 | 10,000 | 1 | " |
| 8. | | Bare | Muzingira | 395 | 484 | 7,260 | 0 | 10,000 | 1 | " |
| 9. | | | Rurenge | 395 | 484 | 7,260 | 188,679 | 10,000 | 1 | " |
| 10. | | Gashongora | Kabagera | 608 | 747 | 11,205 | 0 | 10,000 | 1 | " |
| 11. | | | Rwimondo | 1,520 | 1,869 | 28,035 | 0 | 20,000 | 2 | " |
| 12. | | | Nyagasenyi | 1,013 | 1,246 | 18,690 | 36,288 | 10,000 | 1 | " |
| 13. | | Gahara | Nyakagezi | 307 | 378 | 5,670 | 6,839 | 10,000 | 1 | " |
| | Total | | | 10,062 | 12,368 | 185,520 | 298,060 | 160,000 | 16 | |

TABLE IV-11

## WATER SUPPLY PLAN (ZONE XI)

Zone XI.

| No. | Communes | Sectors | Cellules | Population (1983) | Population Served (1990) | Water Demand (ℓ/d) | Spring Supply (ℓ/d) | Discharge Supplied (ℓ/d) | No. of Wells Required | Type of Wells |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Birenga | Gashongora | Butezi | N.A. | - | - | 0 | 10,000 | 1 | S1 |
| 2. | | Gahara | Mugogo | 988 | 1,215 | 18,225 | 0 | 20,000 | 2 | " |
| 3. | | | Taraye | 631 | 776 | 11,640 | 0 | 10,000 | 1 | " |
| 4. | | | Muhamba | 686 | 843 | 12,645 | 0 | 10,000 | 1 | " |
| 5. | | | Murangara | 368 | 452 | 6,780 | 0 | 10,000 | 1 | " |
| 6. | | | Butanga | 631 | 776 | 11,640 | 0 | 10,000 | 1 | " |
| 7. | | Bare | Mutendeli | 362 | 444 | 6,660 | 27,993 | 10,000 | 1 | " |
| 8. | | | Karenge | 372 | 444 | 6,660 | 0 | 10,000 | 1 | " |
| 9. | | Matongo | Mukona | 872 | 1,072 | 16,080 | 10,368 | 10,000 | 1 | " |
| 10. | | | Kibaro | 1,202 | 1,477 | 22,155 | 0 | 20,000 | 2 | " |
| 11. | | | Karwema | 1,300 | 1,598 | 23,970 | 0 | 20,000 | 2 | " |
| 12. | | | Nyagasozi | 1,021 | 1,254 | 18,810 | 0 | 20,000 | 2 | " |
| 13. | | Kibimba | Kinyonzo | 839 | 1,032 | 15,480 | 235,353 | 10,000 | 1 | " |
| 14. | | | Rugarama | 1,037 | 1,275 | 19,125 | 0 | 20,000 | 2 | " |
| 15. | | | Tunduti | 1,070 | 1,315 | 19,725 | 0 | 20,000 | 2 | " |
| 16. | | Birenga | Karenge | 275 | 338 | 5,070 | 0 | 10,000 | 1 | " |
| 17. | | | Rusebeya | 413 | 509 | 7,635 | 0 | 10,000 | 1 | " |
| 18. | | | Kazo | 471 | 579 | 8,685 | 10,368 | 10,000 | 1 | " |
| | Total | | | 12,528 | 15,399 | 230,985 | 400,986 | 240,000 | 24 | |

Note: Bironga/Gashongora has no data of No. of families.

## TABLE IV-11

## WATER SUPPLY PLAN (ZONE XII)

Zone XII.

| No. | Communes | Sectors | Cellules | Population (1983) | Population Served (1990) | Water Demand (ℓ/d) | Spring Supply (ℓ/d) | Discharge Supplied (ℓ/d) | No. of Wells Required | Type of Wells |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Sake | Ruyema I | Mizibili | 577 | 739 | 11,085 | 29,548 | 10,000 | 1 | S1 |
| 2. | | | Ruyema | 577 | 739 | 11,085 | 0 | 10,000 | 1 | " |
| 3. | | Ruyema II | Rubumba | 303 | 399 | 5,985 | 0 | 10,000 | 1 | " |
| 4. | | Ngoma | Giseso | 270 | 468 | 7,020 | 0 | 10,000 | 1 | " |
| 5. | | Nshili II | Nyagasani | 671 | 860 | 12,900 | 122,342 | 10,000 | 1 | " |
| 6. | | | Kabare | 795 | 1,019 | 15,285 | 0 | 10,000 | 1 | " |
| 7. | | | Karenge | 795 | 1,019 | 15,285 | 38,361 | 10,000 | 1 | " |
| 8. | | Mbuye | Kigoma | 315 | 404 | 6,060 | 0 | 10,000 | 1 | " |
| 9. | | | Mubaha | 726 | 930 | 13,950 | 0 | 10,000 | 1 | " |
| 10. | | | Akabande | 655 | 839 | 12,585 | 0 | 10,000 | 1 | " |
| 11. | | Murwa | Jarama | 570 | 729 | 10,935 | 0 | 10,000 | 1 | " |
| 12. | | | Irarire | 359 | 460 | 6,900 | 0 | 10,000 | 1 | " |
| 13. | | | Ihanika | 468 | 599 | 8,985 | 0 | 10,000 | 1 | " |
| 14. | | | Kiryama | 515 | 660 | 9,900 | 0 | 10,000 | 1 | " |
| | Total | | | 7,596 | 9,864 | 147,960 | 190,251 | 140,000 | 14 | |

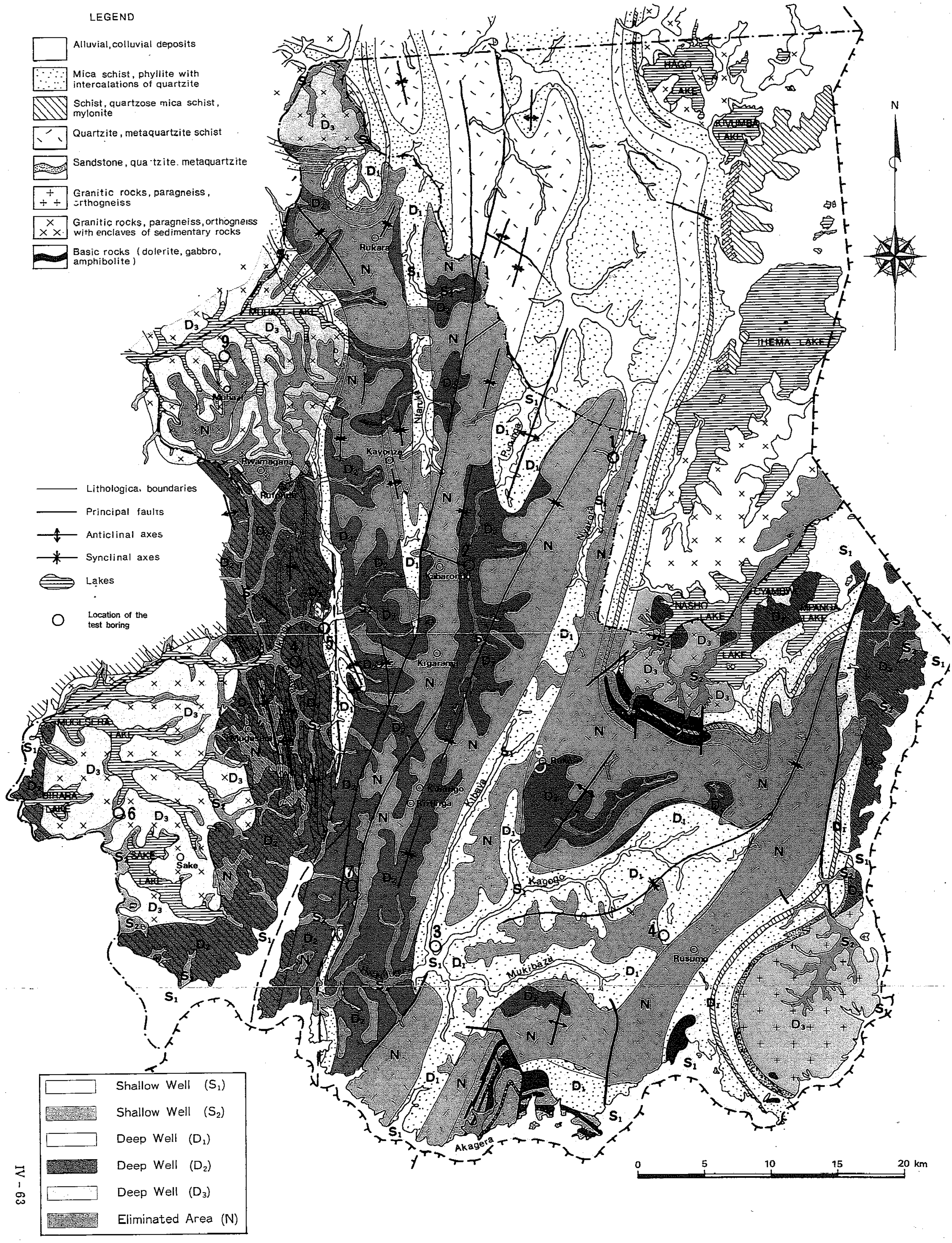



Fig. IV-1 Classification of Water Sources(well types)

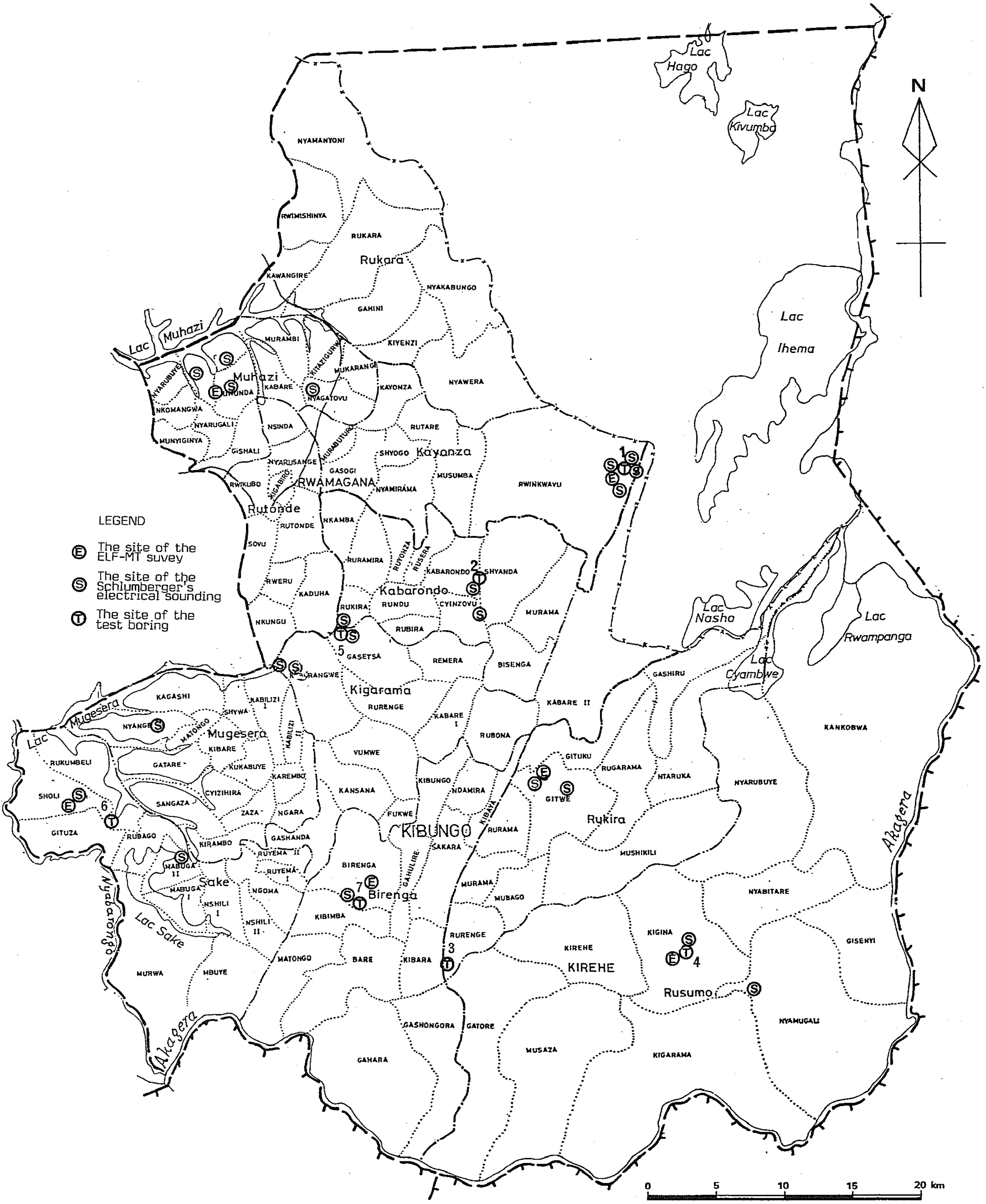



Fig. IV-2 Location of Geophysical Groundwater Survey and Test Boring Sites

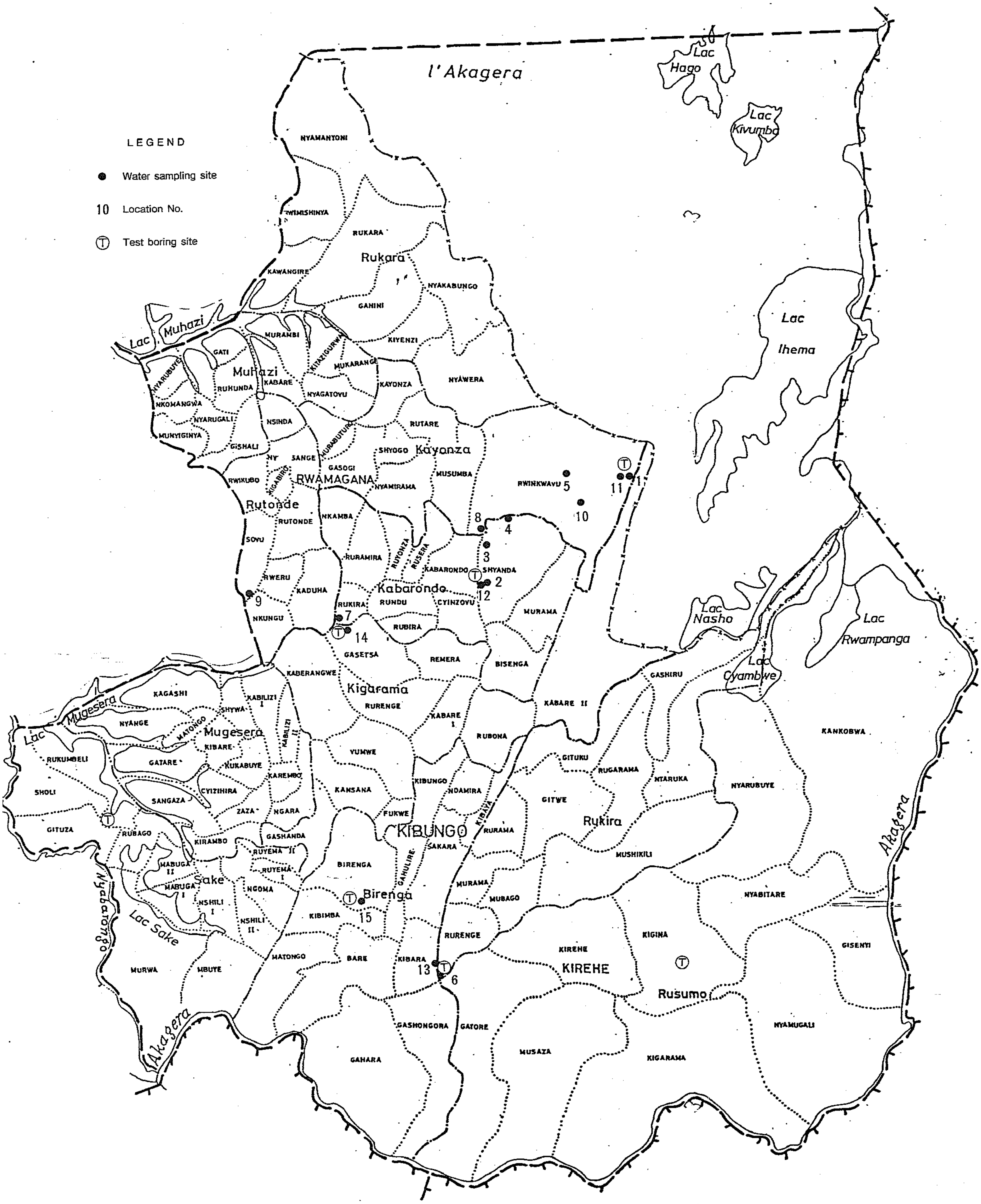



Fig. IV-7 Location Map of Water Quality Test

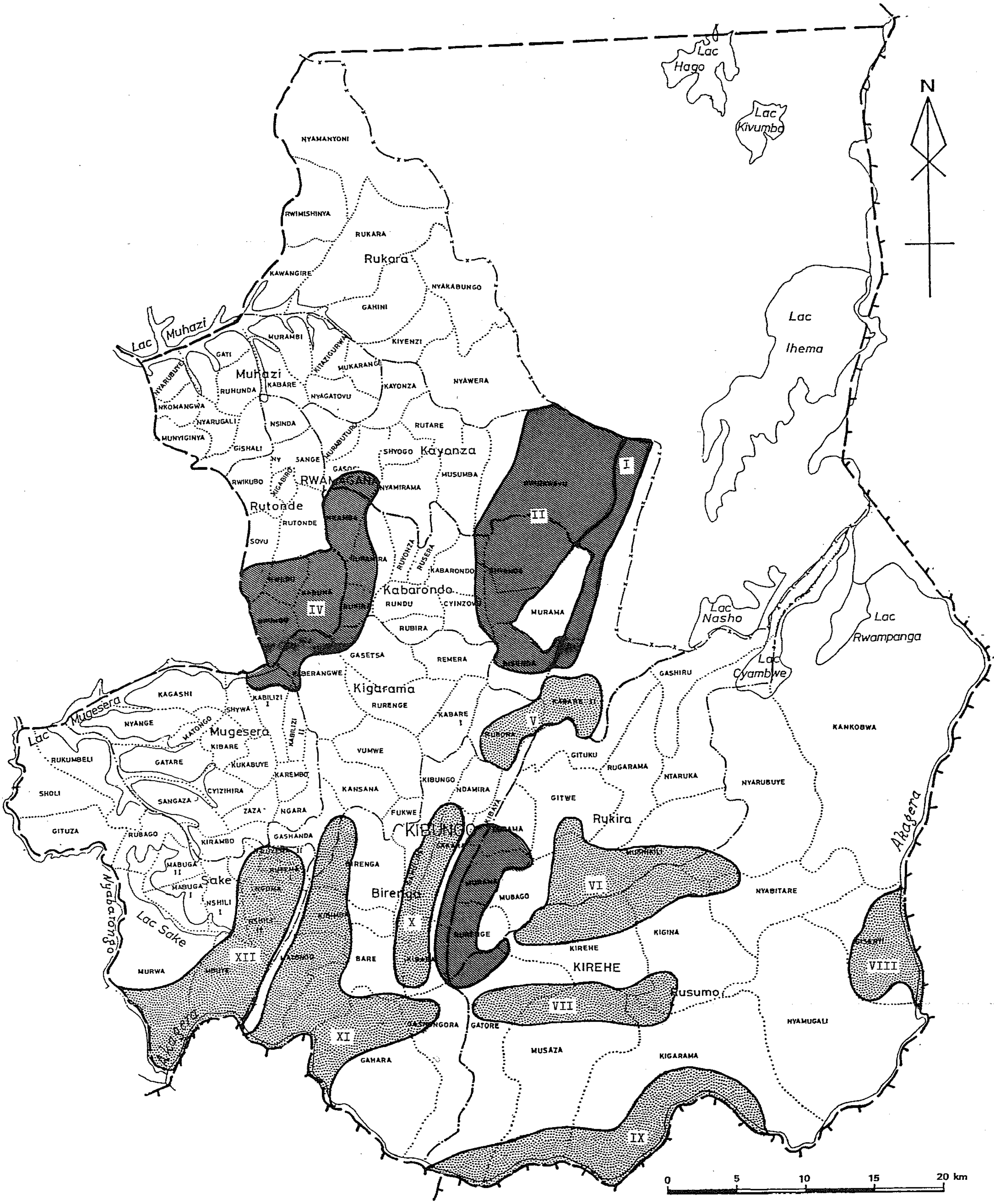



Fig. IV-8 Location Map of water Districts

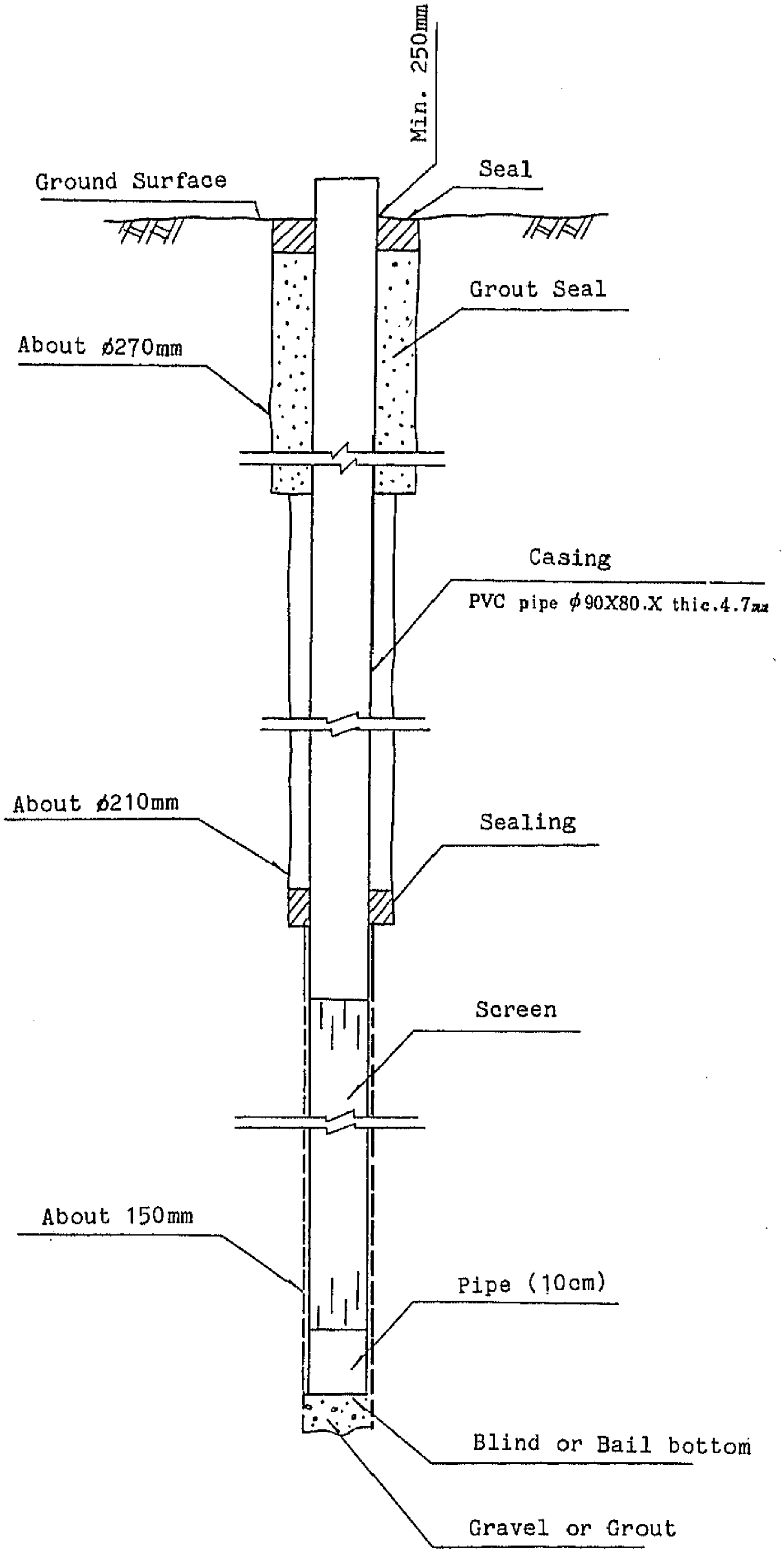
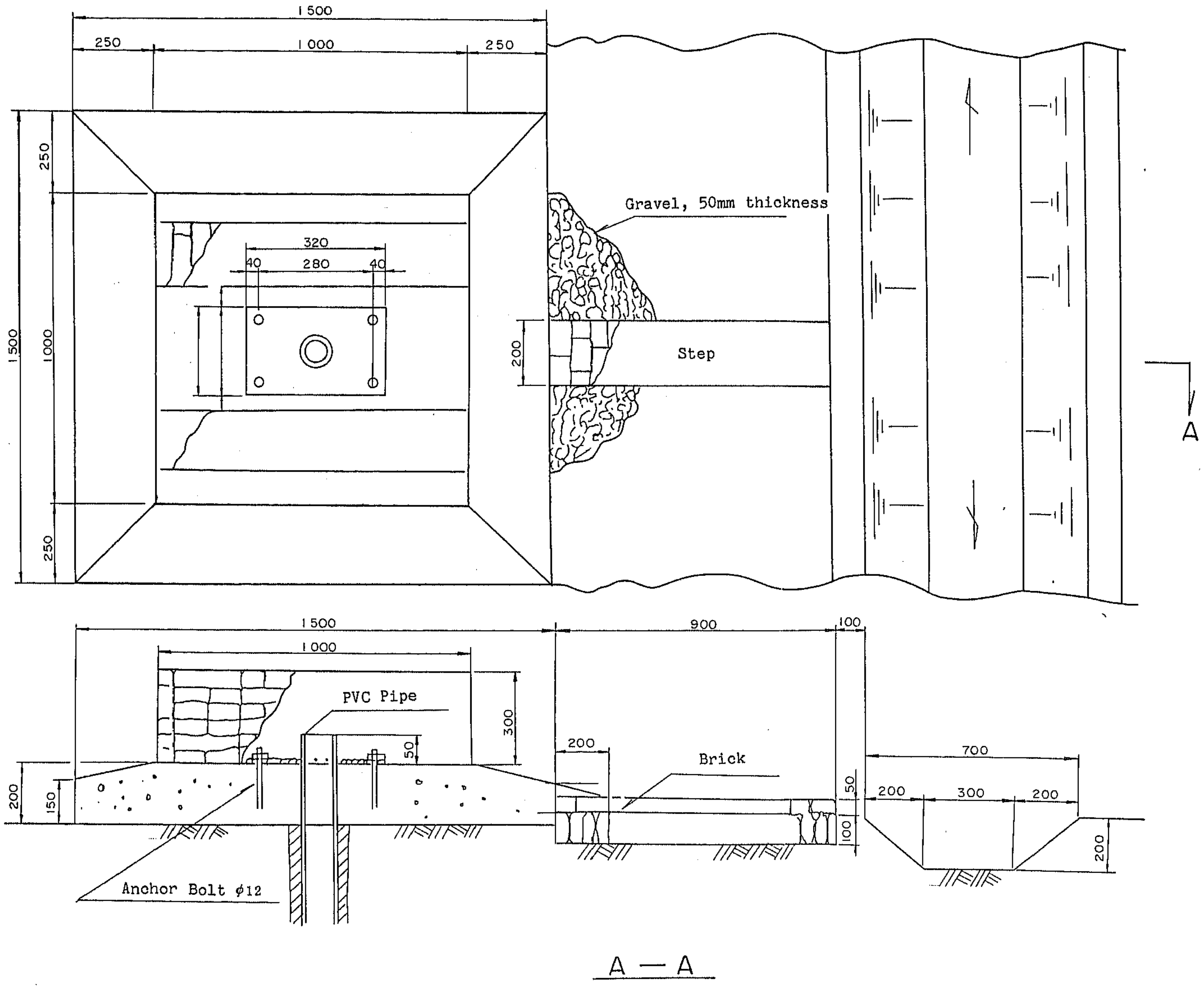



FIG. IV-9

TYPICAL DESIGN OF THE WELL

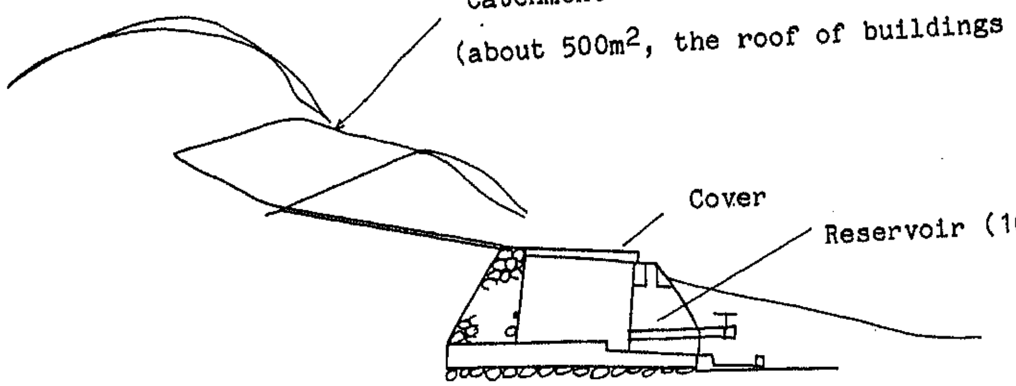



Note:

1. Fence radius is planned at 30m to prevent intrusion of cattle but can be modified in accordance with actual conditions at the site.
2. Regarding foundations refer to the "Pump Instruction Manual".

Fig. VI-10 Typical Design of Pump Platform

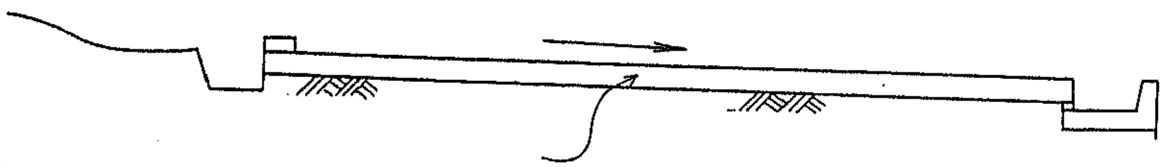
Rainfall Storage Unit



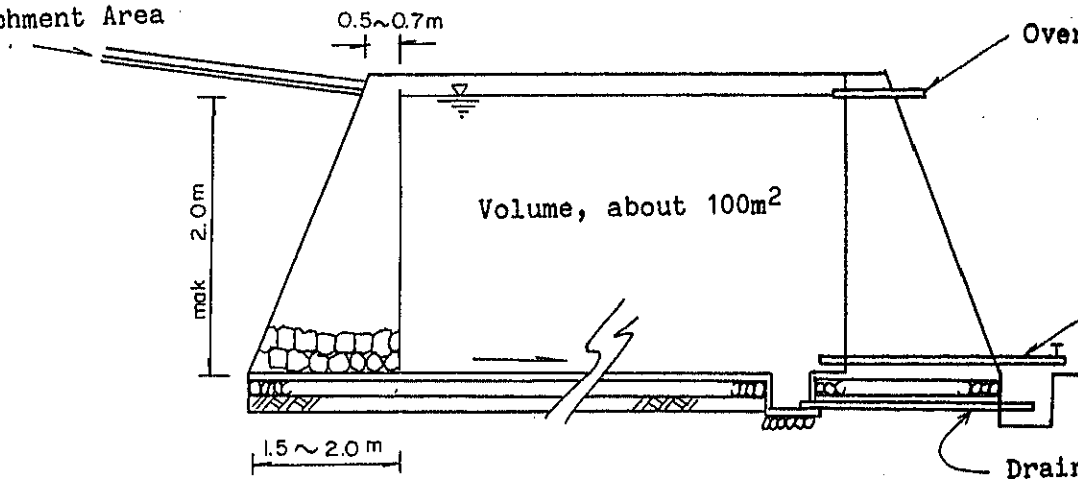

Note:

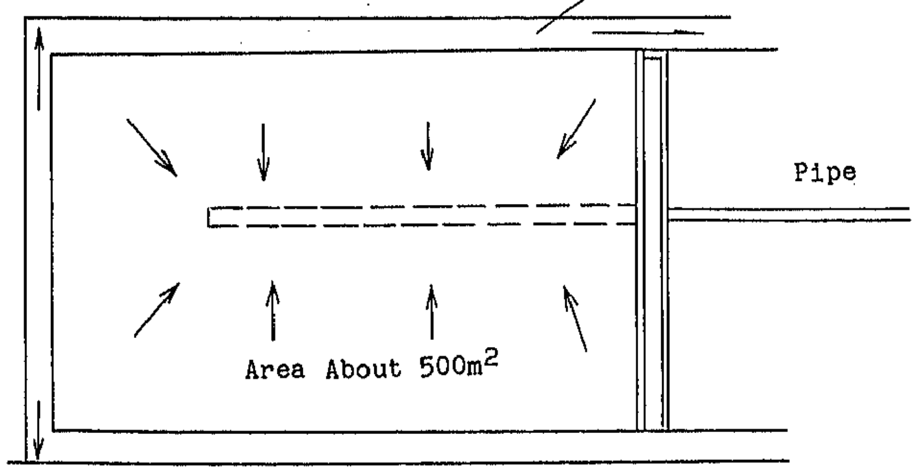
1. Catchment Area is decided by topographic conditions.
2. Catchment area should be located where no contamination by drainage occurs.

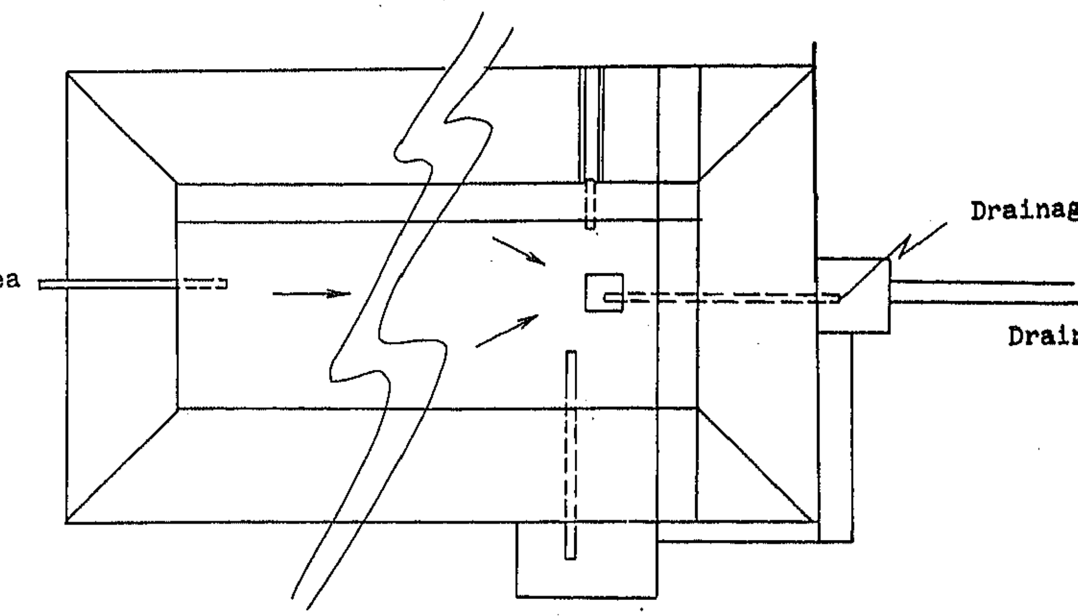
Catchment




Reservoir




Wash Place

Fig. VI-11 Typical Design of Rainfall Storage Unit

# CHAPTER V. PROJECT IMPLEMENTATION

# CHAPTER V

# PROJECT IMPLEMENTATION

## 5.1 Executing Agency

The Ministry of Public Works and Energy (MINITRAPE) is the executing agency for the project and the General Direction of Water, a department within the said Ministry, is in charge of actual project management and coordination.

## 5.2 Implementation Program

Implementation of the project is urgently required to solve water supply problems encountered in the project area, where a great majority of people rely solely on heavily contaminated surface water and springs for their daily water supply. At present, however, lack of financial and technical resources within Rwanda hinders prompt implementation.

As indicated in 2.6.4, all past water projects have been largely financed (85%) by aid from foreign governments. Boring machines required for well construction are unavailable from both government agencies and private companies. Moreover, local contractors have no actual experience in boring work, while only a few of the engineers employed by the Ministry of Industry, Mines and Artisans have such experience. Consequently, implementation of the project will be greatly affected by the availability of both financial and technical foreign aid.

Although a short implementation period is most desirable, a realistic schedule must be considered due to actual conditions and limitations in Rwanda. A five-year implementation period is proposed by the study team as most appropriate. The proposed period will consist of two phases; phase-1 covering two years and phase-2 covering three years.

In phase-1, implementation will mainly be undertaken with foreign grant aid and technical cooperation. During this period, the Government of Rwanda will obtain necessary machinery and equipment provided by foreign aid and at the same time, key Rwanda personnel will participate in project execution and receive as much technical training as possible.

In phase 2, implementation will be conducted by MINITRAPE with partial financial and technical aid provided by foreign countries. At least 3 years is necessary for phase 1 to ensure that MINITRAPE acquires the necessary equipment and knowledge to successfully continue the project in the second phase. The implementation schedule, TABLE V-1, was prepared on the basis of the above considerations.

Sixty-eight (68) wells in which, one is equipped with an electric driven pump and water distribution system, are scheduled to be built in phase 1 and 381 in phase 2. Rainfall storage units will be constructed concurrently with well construction; 3 in phase 1 and 9 in phase 2. Major equipment and machines required for boring work will be supplied by foreign grant aid consisting of one unit in phase 1. Also spare parts of equipment and machines, manual pumps and consumable materials for boring works will be supplied through foreign aid either in phase 1 or phase 2.

Priority in construction will be given to wells and rainfall storage units in districts with the greatest detected inadequacy in quality, quantity, and accessibility of water and where water-borne diseases are most prevalent. TABLE V-1 FIG. V-1 summarizes the project implementation program.

## 5.3 Implementation Plan

Implementation during phase 1 will be the responsiblility of the foreign consultant and contractor hired by the Rwanda Government.

The Contractor will handle procurement, transportation and field construction. The consultant, on the other hand, will carry out electric sounding in the field and prepare all necessary detailed designs. The Consultant will also supervise all activities of the contractor on behalf of the Government of Rwanda. Rwandan counterparts will participate in the construction work as much as possible to ensure adequate on the job training. From phase 2, the Project will be solely under the jurisdiction of MINITRAPE with partial financial and technical foreign aid.

## 5.4 Construction Work

Construction work consists of preparatory works, well drilling, logging and pumping tests, pump installation and construction of platforms, drainage works and fences.

### 5.4.1 Preparatory Work

(1) Access Road Improvement

Generally access of the drilling machines to the work site by existing rural dirt roads is very difficult particulary during and after rainfall. Almost all existing access roads are unpaved, zigzagged and steeply sloped. In addition road width is often insufficient for passage of drilling equipment and supporting vehicles.

The access road should be widened and improved for passage of trailers and vehicles before transportation is required; otherwise the progress of the work will be seriously affected by delayed deliveries.

(2) Extension and Leveling of the Site

A flat space of about 1,000$m^2$ is required for installation of the drilling equipment and extension and leveling work is to be performed by the beneficiaries.

### 5.4.2 Well Drilling

Main equipment required for well drilling are trailers or tractor-mounted-type direct rotary rigs and supporting equipment and vehicles.

Drilling will be performed by a direct-circulation rotary drilling rig which has such advantages as relatively rapid drilling speed in most formations, greater capacity in drilling depth, a screen and simple casing and screen installation. The rotary rig drills a hole by turning a fishtailed, toothed cone or similar bit at the bottom of a string drill pipe. The typical string consists of a bit, which scrapes, grinds, fractures, or otherwise breaks the formation drilled and a drill collar of heavy walled pipe, which adds weight to the bit and helps to maintain a straight hole.

Drill cuttings will be brought to the surface by flushing with a circulating fluid through an annular space between the hole wall and the drilling pipe. The circulated fluid also works to lubricate and cool the bit. Muddy water or compressed air are possible circulating fluids and one of the same should be carefully selected in accordance with field conditions. When drilling is performed with muddy water, removal of muddy water which remains in the hole and the mud wall formed inside the hole during circulation is important. This may be carried out either with a water jet made with the strainer or by injecting compressed air into the hole.

### 5.4.3 **Pump Test and Logging**

(1) Well Test Procedure

Immediately before starting the test, water level in the well should be measured to determine the static water level upon which all drawdowns will be based. These data versus the time of measurement should be recorded. Pump discharge should be kept as constant as possible after the initial excess discharge has been stabilized.

During the well test to determine aquifier characteristics, water level in the well should be measured to give at least 10 observations of drawdown within each log cycle of time. The time schedule should not be adhered to at the expense of accuracy of the drawdown measurement.

A proposed measurement schedule is as follows:

| | |
|---|---|
| 0 to 10 minutes: | 0.5,1, 1.5, 2.5, 3.0, 4,5,6,7,8,9 and 10 minutes |
| 10 to 20 minutes: | 10,12,14,16,18,20 |
| 20 to 100 minutes: | 10,25,30,40,50,60,70,80,90 and 100 minutes |

100 minutes to completion: 0.5 to 1 hour intervals

A flowmeter with totalizing register will be used to measure pump discharge when the discharge pipe is filled with water. The test period will be as long as required to obtain sufficient data in the form of curves obtained from plotting time versus drawdown.

(2) Recovery test

When the pump is stopped after running the pump-out test, measurement of water level in the well is immediately initiated and the manner in which water level recovers is recorded.

(3) Drill hole logging

Drill hole loggings are obtained by lowering an instrument connected to a surface-mounted recording device down the hole to obtain the surface record. Two types of logging will be applied (resistivity and self-potential, and temperature).

1) Electrical logging (resistivity and self-potential)

Electrical logging will be conducted according to regular procedure. The two electrodes applied yield two curves, a spontaneous potential (SP) and a resistivity curve, which are plotted on a two-pen recorder. The SP curve is a record of the variation in natural direct-current potentials which exist between sub-surface materials and a static electrode. This variation is plotted against depth. The resistivity curve is a record of the variation of the resistivity of the sub-surface materials.

The logging instrument consists of a sonde with two electrodes supported by double conductor cables leading to the two-pen recorder and grounded at the surface to complete the circuits; as well as of cable reels, winches, and other auxiliary equipment. The natural direct-current potentials which exist between subsurface materials vary according to the nature of the layers traversed. For example, the potential of an aquifer containing saline water is usually negative with respect to associated clay and shale, while that of a freshwater aquifer may be either positive or negative but of less amplitude than the saline water. This would be evident on the graphic record of the SP curve.

The resistivity of a material is a measure of the specific resistance. It is related to the nature of the material and the quantity, quality and distribution of contained fluid. These factors vary from one material to another, so resistivity measurements made between electrodes in a borehole can be used to determine formation boundaries and some characteristics of the individual layers.

The curve obtained by the normal method can usually be readily interpreted to show aquifer boundaries near to the correct levels, and the thickness of formations if greater than about 30cm. The true resistivity cannot be obtained; only the relative magnitude of the resistivity of each formation will be obtained. These relative magnitudes can sometimes be interpreted qualitatively regarding the quality of water in the various aquifers.

2) Temperature logging

Temperature logging uses a sonde in which a resistance-type theromocouple (thermister) is placed and calibrated to correlate resistance variations with temperature variations. Temperature logging is sometimes made at the same time as electrical logging. The loggings are valuable tools in investigating inter-aquifer migration of water, adequacy of grouting, geothermal activity, landslide and other similar studies.

### 5.4.4 Strainer Installation and Sealing

(1) Strainer Installation

The function and life of the well is significantly influenced by the strainer's quality. The strainer should preferably be installed in the second aquifer instead of the first and a blind tube should be attached at the lowest part. Where the first aquifer is directly adjacent to the foundation rock and the strainer cannot be installed in the second aquifer, it should be set as far below the first aquifer as possible. The structure of the strainer should be determined by actual data concerning size, shape and distribution of grit particles forming the aquifer.

(2) Sealing

To prevent downward percolation of precipitation or surface runoff along the outside of the well casing a seal is made at ground level. The seal can be of combined clay-cement grout material. To make a good seal, a bit should be dug at ground level with sufficient diameter and a depth of about 1m. The pit is then backfilled with cement grout in the bottom and clay on top and compacted adequately. At ground level, backfill should be mounded up to form a small cone-like elevation around the extended casing to provide good surface drainage away from the well.

### 5.4.5 Well Construction Schedule

(1) Preparatory arrangement for equipment and purchase of materials requires 5 days.

(2) Estimated period required for the well construction is as follows:

17 days/hole (average depth D=50.0 m/hole)

| Work | No. of Days |
|---|---|
| - Mobilization | 2.0 |
| - Preparation | 2.0 |
| - Drilling (10m/d) | 5.0 |
| - Logging | 1.0 |
| - Cleaning of drilled hole | 0.5 |
| - Installation of pump chamber-casing | 0.5 |
| - Well test | 1.0 |
| - Foundation concrete | 1.0 |
| - Removal | 1.5 |
| - Pump setting | 0.5 |
| - Demobilization | 2.0 |
| TOTAL | 17.0 |

### 5.4.6 Pump Outlet and Washing Area

A concrete platform will be made for the pump outlet and washing area according to the following procedure.

1) First, the ground is scraped for a 2m area around the pump.

2) A slab form ($1.5^M$ x $1.5^M$ x $0.15^M$ high) is then assembled.

3) A concrete slab is poured in a slight dome shape if possible, to facilitate water drainage. (A 15cm thick slab requires $0.4M^3$ of concrete or three 40kg bags of cement.)

4) The supplied anchor rods are then screwed into the sealing frame, down to the threading end.

5) This frame is sealed in the concrete platform, carefully centering the hole in relation to the pump.

6) Concrete is cured for 48 hours before installing the pump.

## 5.5 Scope of Work

(1) Phase 1 works will be conducted primarily by the foreign Consultant and contractor. The items described below are expected to be carried out by the Government of Rwanda but these will be confirmed later by mutual discussion.

1) Mobilization of "UMUGANDA" to build new access roads and to repair and maintain existing access roads during the construction period.

2) Heavy machinery, equipment and operators required to build large access roads will be supplied by MINITRAPE free of charge.

3) Wages and allowances for Rwandan counterparts will be borne by the Rwandan Government.

4) Expropriation of land and compensation for crops, if any, will be borne by the Rwandan side.

(2) Works for phase 2 will be solely the responsibility of the Rwandan Government; however, the following machinery and equipment will preferably be supplied by foreign aid.

1) Boring machine and supporting equipment — 1 unit

2) Consumable materials for boring work — sufficient quantity for 114 wells

3) Manual pump — sufficient quantity for 114 wells

4) Parts required to repair boring machines supplied during phase 1 and phase 2.

## 5.6 Recommendations for Future Maintenance of Facilities

It is strongly recommended that daily maintenance work be carried out by the users themselves. To facilitate this, an appropriate maintenance system should be organized in every Cellule. At present, existing protected springs are maintained by the "fountainers" from the Commune office. There is also a plan to establish a new section within the prefectural office which will be in charge of management and coordination of the individual activities of the "fountainers". These measures, however, may be insufficient to handle maintenance work required for newly installed wells and facilities in the project. Additional independent caretakers should also be assigned at the Cellule level and integrated into the above existing organization.

Necessary spare parts and consumable materials for repairs should be managed by MINITRAPE at the initial stage but should be shifted gradually to administrators in the prefectural office. Actual repair work should be performed by the proposed caretakers and other concerned beneficiaries in the Cellules under the instruction of engineers from MINITRAPE. It is recommended that MINITRAPE hold regular lecture classes and give practical instruction and training to caretakers to increase their technical level. Exchange of information through meetings may also be helpful to all parties concerned. An intensive monitoring program of actual well utilization is also required.

The proposed organization is outlined in FIG. V-2.

## 5.7 Project Cost and Financing

### (1) Cost Estimate

As aforementioned, implementation of the project is divided into two phases. Although only tentative at this preliminary stage, the total investment cost required for the project was estimated at US$5,902,000 of which US$3,271,000 would be in foreign exchange and US$2,631,000 in local currency. The foreign exchange cost of materials and equipment to be imported was estimated using

1985 mid-October CIF prices. An anticipated price escalation during the implementation period, 1986 - 1991 in Rwanda, amounting to about 10% (annual) of the sum of the base cost, has also been included in the estimates.

(2) Financial plan

Considering the large project investment cost anticipated and the present financial situation of the Government of Rwanda, formation of a program for financing the project through external assistance from several multilateral or bilateral donor agencies is indispensable. Grant aid of foreign governments will be requested to cover the entire foreign exchange cost and a portion of the local currency cost of the project.

Anticipated investment cost for the project is as shown in TABLE V-2.

TABLE V-1

**IMPLEMENTATION PROGRAM**

| | First Stage (Foreign Aid) | | Second Stage (by Rwanda) | | | |
|---|---|---|---|---|---|---|
| Year | 1986 | 1987 | 1988 | 1989 | 1990 | TOTAL |
| Zone | I(1), II(13), III(12) | III(6), IV(40) | V(8), VI(18), VII(12) | VII(6), VIII(5), IX(11), X(16) | XI(24), XII(14) | |
| No. of Wells | 26 | 46 | 38 | 38 | 38 | 186 |
| No. of Boring Machine | 2 | 2 | 2 | 2 | 2 | 2 |
| <u>Water Supply Facilities</u> | | | | | | |
| Manual Pump | 25 | 46 | 38 | 38 | 38 | 185 |
| Electric Pump | 1 | 0 | (depending on the electrification programme in rural area) | | | 1 |
| Rainfall Storage Unit (for public health facilities) | 1 | 0 | 4 | 4 | 3 | 12 |
| <u>Foreign Aid</u> | | | | | | |
| Consultant | Detailed Design<br>Geological/ Topographic Survey<br>Supervision | | Foreign Experts | | | |
| Contractor | Supply & Construction | | Training in Host Country | | | |
| <u>Equipment & Materials</u> | | | | | | |
| Boring Equipment | 1 | - | - | - | - | 1 |
| Boring Materials | (for 72 wells) | - | 38 | 38 | 38 | 182 |
| Mannual Pump | (for 72 wells) | - | 38 | 38 | 38 | 181 |
| Electric Pump | (for Nyankola C.C) | - | - | - | - | 1 |
| Rainfall Storage Unit | (for 1 storages) | - | 3 | 3 | 3 | 12 |

TABLE V-2

**SUMMARY OF PROJECT COST**

Unit: US$

| | Phase 1 | | Phase 2 | | | Total |
|---|---|---|---|---|---|---|
| | 1987 | 1988 | 1989 | 1990 | 1991 | |
| No. of Wells | 25 | 46 | 38 | 38 | 38 | 185 |
| No. of Electric Pumps | 1 | 0 | 0 | 0 | 0 | 1 |
| No. of Rainfall Storage Units | 1 | 0 | 4 | 4 | 3 | 12 |
| 1. Civil & Boring Works | 977,000 | 1,019,000 | 341,000 | 375,000 | 413,000 | 3,125,000 |
| 2. Equipment & Machinery | 571,000 | 0 | 242,000 | 254,000 | 267,000 | 1,334,000 |
| 3. Engineering Service | 123,000 | 81,000 | 71,000 | 78,000 | 86,000 | 439,000 |
| 4. Contingency | 275,000 | 225,000 | 77,000 | 77,000 | 85,000 | 739,000 |
| 5. Administration & Land Compensation | 20,000 | 53,000 | 58,000 | 64,000 | 70,000 | 265,000 |
| Total | 1,966,000 | 1,378,000 | 789,000 | 848,000 | 921,000 | 5,902,000 |
| 1. Foreign Aid | 1,946,000 | 1,325,000 | - | - | - | 3,271,000 |
| 2. Rwanda Final Portion | 20,000 | 53,000 | 789,000 | 848,000 | 921,000 | 2,631,000 |

Note: estimate in Oct, 1985

1 US$ = ¥240, 1 FRW = ¥2.4

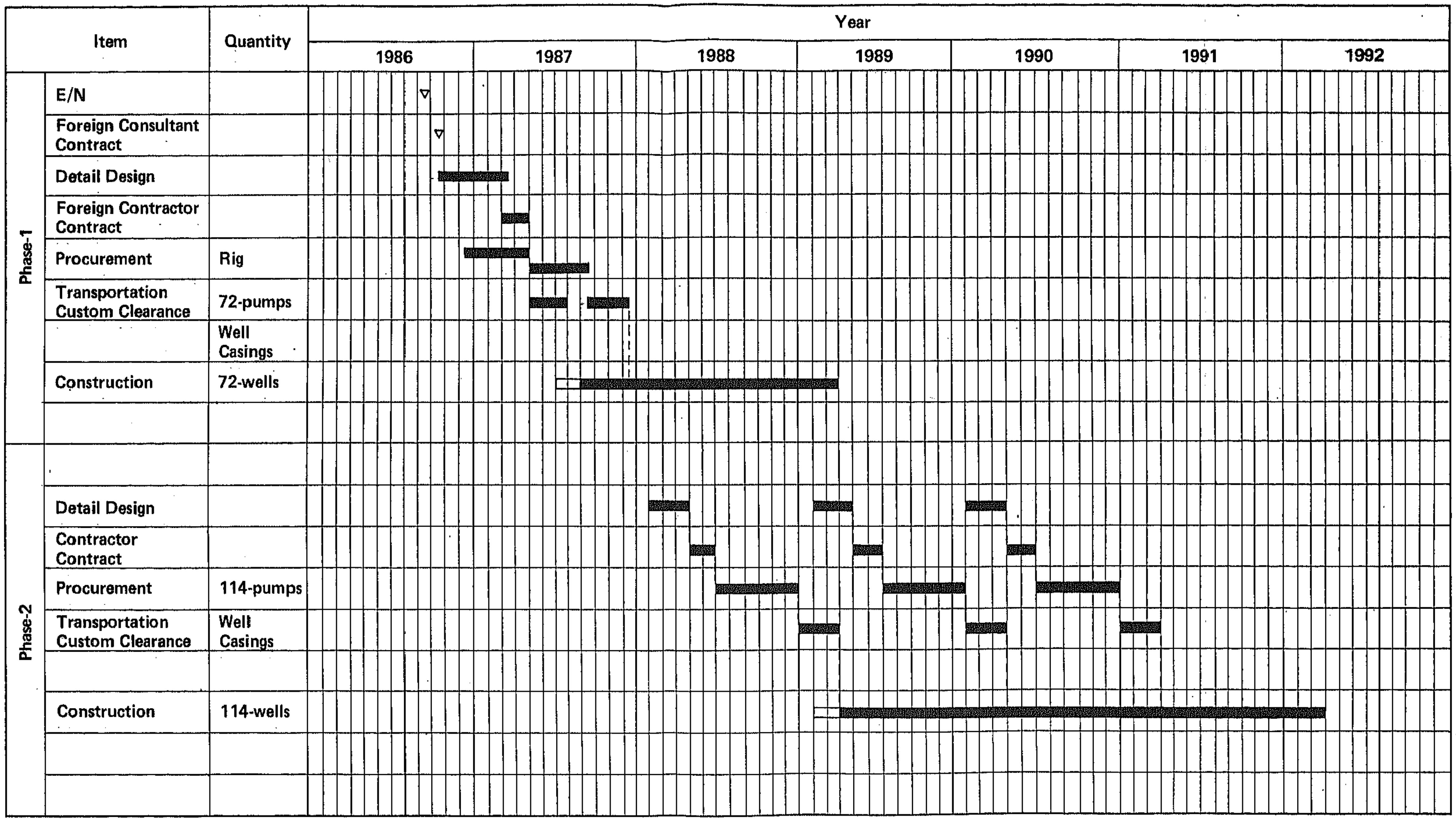
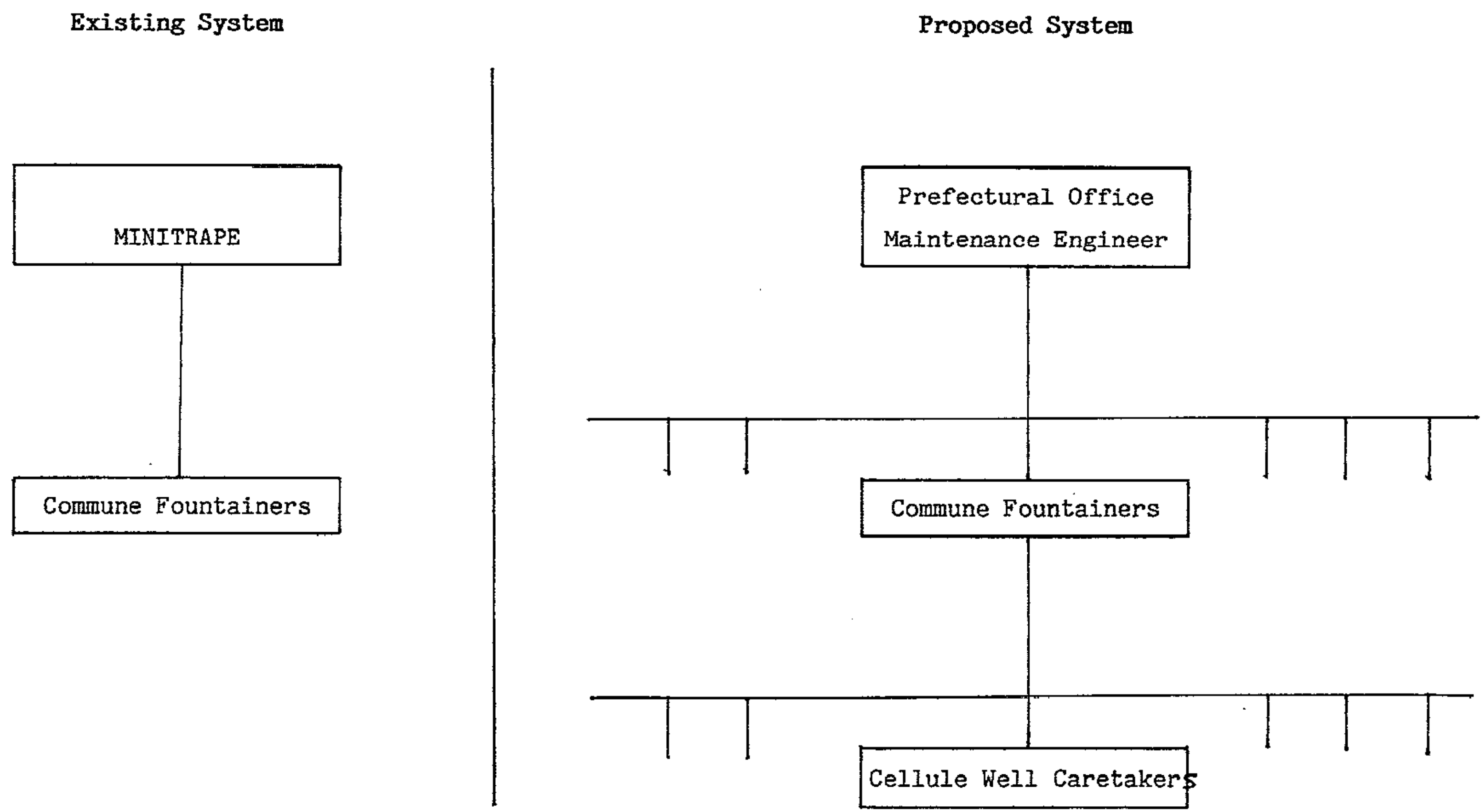



Fig. V-1 Schedule of Project Implementation

FIG. V-2

PROPOSED MAINTENANCE SYSTEM



# CHAPTER VI. PROJECT IMPACT AND RECOMMENDATIONS

## CHAPTER VI

## PROJECT IMPACT AND RECOMMENDATIONS

### 6.1 Project Impact

(1) Rwanda is comparatively rich in ground water resources compared with other African countries. Furthermore the geographical features and the settlement pattern of the rural population make utilization of ground water suitable for daily domestic water supply. However, ground water resources have not yet been developed and fundamental exploration has not yet been undertaken. Implementation of the proposed project would thus represent an important turning point towards ground water development in Rwanda. During project implementation, key Rwandan personnel will obtain valuable technical experience for future development conducted by the Government of Rwanda.

(2) At present, existing protected springs are supplying relatively clean water to the rural inhabitants but service coverage is limited to approximately 45% of total demand. The remaining half of the population, which has no access to protected springs, is forced to rely on heavily contaminated surface water.

Upon project completion a safe drinking water supply will be provided to the latter and the level of per capita consumption will increase to 15 l.c.d. For inhabitants living in areas where ground water is unavailable, the project will consider supplying the minimum drinking water requirement of 2 l.c.d., through rainfall storage units (12 units for 12-hospitals and dispensaries).

(3) The project will also provide safe ground water to rural inhabitants at easy access points. The beneficial impact upon domestic hygiene and public health through increasing domestic water consumption is obvious particularly when it is noted that 8.7% of all sickness in Rwanda is attributable to inadequate water supply. Diseases related to poor water supply and sanitation which are prevalent in the project area at present will be markedly

reduced and the amount of money spent per household on health care will decrease.

(4) Generally, existing springs are not conveniently located and it is very common for users to spend several hours a day in hauling water. The project will facilitate supply of safe ground water at easily accessible points reducing the amount of time spent per day in obtaining water by 2 to 4 hours. The available time resulting from this decrease in water hauling hours may be utilized for more productive purposes.

## 6.2 Project Constraints

(1) The main constraint anticipated in project implementation is the present lack of technical ability in Rwanda, particularly in the essential fields of ground water development such as electrical sounding and well drilling. To solve this problem the project provides an opportunity for Rwandan engineers and technicians to receive special training from foreign experts during project implementation. Without successful technology transfer the project would not achieve its ultimate objectives and maintenance of the wells, facilities, and boring machines after completion would be inadequate.

## 6.3 Recommendations

(1) As described above, ground water development has not been attempted in Rwanda before and thus there is a shortage of experienced personnel. Consequently, in order to continue with long-term ground water development in the future, sufficient technology transfer is essential during the initial development stage, with cooperation of the foreign counterparts. Technology transfer will consist of the following items:

a) On-site training provided during project implementation;

b) Training of Rwandan engineers in the country of the foreign counterpart; and,

c) Stationing of a foreign technical instructor in Rwanda for a certain number of years to assist Rwandan personnel.

(2) The plan prepared and submitted by the study team consists of installation of many small point water sources without any distribution systems, excluding one in Kayonza, the most practical and realistic solution to the water supply problem in the project area considering the present prevailing settlement pattern and technical and financial limitations encountered in Rwanda.

Obviously, however, adoption of many small point sources as water supply sources in the project area is not necessarily justified from a long-range perspective. Point sources have their own limitations due to relatively narrow service coverage. In the future, when the Project area is more socially and economically developed and concentration of population occurs in many areas in the Communes, small point sources equipped with small manual pumps will no longer be able to supply the increased water demand. From a long-term perspective, a more effective and advanced water supply and distribution system must be formulated.

One such plan is installation of a main water pipe line along the existing main road which runs through the prefecture from north to south.

In addition, a plan to distribute water from the main header line to each small water district using gravity flow must be investigated. As a water source, surface water from Akagera River or Lake Sake may be suitable considering their relatively large capacity. In this case, water treatment will be required but simple filteration and disinfection utilizing slow sand filtration may be sufficient. On the other hand, a small size, independent water works with a deep tubewell and a power operated pump may be useful for those areas where the underground aquifer is too deep for manual pump operation, particularly if there is a considerable population concentration.

In either case, however, a considerable large investment cost will be required implmentation the above and as well as a considerable operation cost upon completions. A cautions, comprehensive study is therefore required before adoption of either plan.

(3) In spite of many financial and technical restrictions which prevent the Rwandan Government from improving water supply in the rural area, there are still several practical measures which would alleviate the situation to some extent at relatively low cost and effort as discussed below.

1) Usually rural inhabitants carry water in traditional bottle gourds or dirty kerosene cans. Contamination occurs in transport or in storage thus off-setting possible benefits from a clean water supply source.

An apropriate campaign to enlighten the rural population on domestic hygiene should be carried out in rural communities to maintain clean water sources and, if possible, new, clean containers should be supplied to the rural people free of charge.

2) A considerable number of people obtain water from the lake nearby. The access to the shore is also usually used by cattle. Shallow water is taken from the shore which is naturally heavily contaminated. If a simple wooden pier to be used by people only is provided extending several meters over the lake, cleaner water can be obtained.

3) The rural population is often unaware or misinformed about the benefits of improved water supply, while at the same time they appreciate convenient access. Therefore proper education is necessary in recognizing the health benefits of safe water usage. When such benefits are widely appreciated among the rural population, new water supply points installed under the project will be fully utilized and their practical significance as a water source will be greatly increased.

# ATTATCHMENTS

LIST OF STUDY MEMBERS

DOCUMENT COLLECTED IN RWANDA

## LIST OF STUDY TEAM MEMBERS

| Assignment | Name | Company |
| --- | --- | --- |
| Team Leader<br>Water Supply Plan | Mr. Hiroatsu Narita | Chuo Kaihatsu Corporation (CKC) |
| Socioeconomy | Mr. Seishiro Ogita | " |
| Hydrogeology | Mr. Shigemi Kimura | " |
| Implementation Schedule/cost estimation | Mr. Toshinori Toda | " |
| Organization/system | Mr. Wataru Shiga | " |
| Geophysical exploration (A) | Mr. Takashi Aoyama | " |
| " (B) | Mr. Sadao Sakunaga | " |
| Well boring (A) | Mr. Kazutoshi Nakamura | " |
| " (B) | Mr. Masao Ohtsuki | " |
| Interpreter | Mr. Fumio Matsuzawa | " |
| | Mr. Kenichi Takahashi | " |