# D COMBINED WELLS



A combined well is a well supplied by a borehole reaching a confined aquifer. This allows exploitation of a deep aquifer with a static level near the surface, without digging a very deep well. The well therefore acts only as a storage tank, which is refilled when not in use (see Chapter 8A). This solution can be useful when the borehole yield is low, because the well acts as a water tank from which it is possible to draw a higher flow than that of the borehole. Finally, combined wells do not require the installation of any pump when local social end economic conditions do not allow it, but they nevertheless provide good-quality water.

It is relatively simple to carry out this type of work, by digging the well either around the borehole casing ('central combined well') or beside it ('lateral combined well').

Many wells have been dug on boreholes drilled with ACF-PAT 201 and 301 rigs in Asia, in sedimentary formations presenting confined aquifers with static levels near the surface. The combined wells are then equipped with VN6 handpumps (static level above 6 m) or left uncovered (extraction with a bucket) or with a shaduf (see Chapter 7A Section 1.2.2). The technical and financial aspects of this type of programme, drawn from the programmes which ACF has been carrying out in Cambodia and Myanmar for several years, are shown below.

Since 1996, ACF has also built combined wells in the North of Mali. These are equipped with traditional water-drawing systems that allow pastoral populations to exploit deep water resources without being dependent on motorised pumps. The boreholes reach 110 m on average and the wells, built beside the boreholes, are 50 to 70 m deep.

# 1 Central combined well

## 1.1 Implementation

### 1.1.1 DRILLING THE BOREHOLE

The borehole is equipped with a 2" (Myanmar) or 4" (Cambodia) casing. Gravel pack is installed around the screens, topped by a clay plug and cement grout to prevent any pollution from the surface.

The average depth of these boreholes is 15 to 30 m. They are drilled with an ACF-PAT 201 rig in non-consolidated formations, or with a 301 rig in harder formations (sandstone, compact clays).

### 1.1.2 DIGGING THE WELL

The well is dug around the borehole, with a 1.2 m diameter, down to a minimum depth of 2.5 m below the static water level measured in the borehole (the lowest during the low-water period). For a given well diameter, the depth is chosen on the basis of technical criteria (obtained by pumping tests – see Chapter 6) and human criteria (daily needs, water-drawing rate).

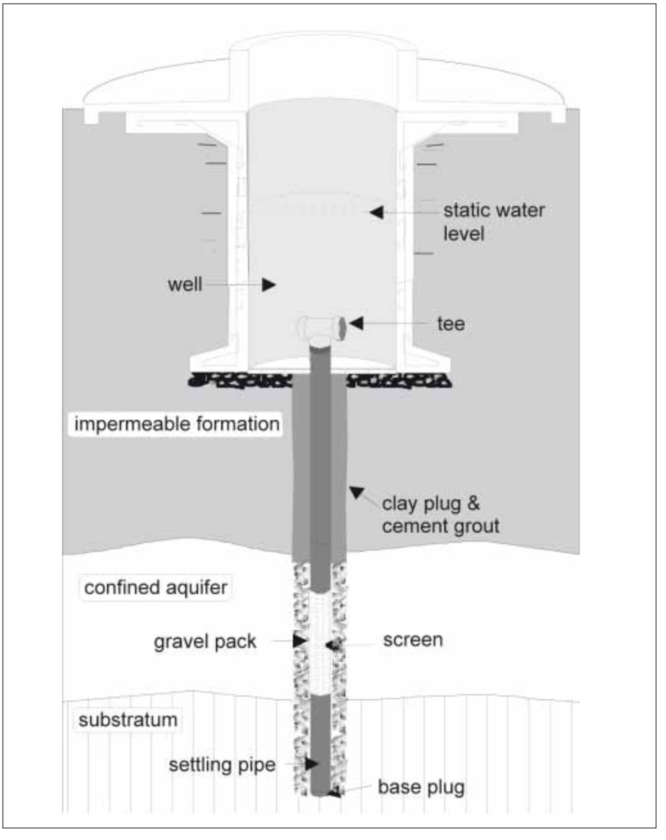


**Figure 8.27: Central combined well (ACF, Cambodia, 1998).**

In Myanmar, well rings with an internal diameter of 1 m (height 0.5 m) are pre-cast on site one week before use. A bottom slab for the well is cast in reinforced concrete (thickness 10 cm) on a hard-core foundation, to support the well-ring column which is then built up to the surface. To ensure impermeability in cases where a large quantity of water comes in to the well along the borehole casing, quick-setting cement is used to grout around the borehole casing (see Figure 8.27).

In Cambodia, the well is built using the bottom-up *in-situ* lining technique (see Chapter 7A). The borehole casing is then cut 0.5 m above the bottom slab. To avoid leaving the casing opening facing upwards and to limit any intrusion into the borehole, a tee is fitted at the top of it. Surface works (headwall, apron and drain) are then built.

### 1.1.3 PLANNING

An example of building time is given in Table 8.XXXVII.

**Table 8.XXXVII: Time required for construction of a central combined well.**

| | Week 1 | Week 2 | Week 3 |
|---|---|---|---|
| Drilling and development | .................... | | |
| Pre-casting of well rings | ........... | ....................... | |
| Digging of the well | .. | ............................ | |
| Bottom slab and lining | | | ........................... |
| Surface works | | | ................ |

## 1.2 Resources required

### 1.2.1 HUMAN RESOURCES

The human resources required are the same as those required for digging a well and drilling a borehole, Table 8.XXXVIII. (see also Chapters 7B and 8C).

**Table 8.XXXVIII: Human resources (ACF, Myanmar, 1997).**

| | Indicative monthly salary (US$) |
|---|---|
| *Borehole team* | |
| 1 geologist | 200-250 |
| 1 driller | 150-250 |
| 1 driller assistant | 100-150 |
| 1 mechanic | 100-150 |
| 3 labourers | 40-80 |
| 1 driver | 60-80 |
| *Well team* | |
| 1 site manager | 150-200 |
| 1 assistant | 100-150 |
| 5 labourers | 40-80 |
| 1 driver | 60-80 |

### 1.2.2 COST OF A BOREHOLE AND A WELL

An example of the cost of materials necessary for the construction of a combined well is shown in Table 8.XXXIX.

**Table 8.XXXIX: Cost of materials for a combined well (ACF, Cambodia, 1997).**

| Description | Units | Quantity | Unit cost (US$) | Total cost (US$) |
|---|---|---|---|---|
| *25 m borehole* | | | | |
| PVC 2” casing (63 mm ext.) | pcs 3 m | 7 | 8 | 56 |
| 2” screen | pcs 3 m | 1 | 9 | 9 |
| 2” plug | pcs | 1 | 1 | 1 |
| Tee | pcs | 1 | 2 | 2 |
| 2” sockets | pcs | 10 | 1 | 10 |
| Gravel filter | $m^3$ | 0.3 | 20 | 6 |
| Cement | 50-kg bags | 3 | 7 | 21 |
| Quick-setting cement | kg | 3 | 1.5 | 4.5 |
| Diesel | l | 90 | 0.5 | 45 |
| Petrol | l | 10 | 0.4 | 4 |
| Total cost per borehole | | | | 158.5 |
| *Well with a 1 m internal diameter, 6 m deep* | | | | |
| Cement | 50-kg bags | 62 | 7 | 434 |
| Sand | $m^3$ | 4 | 5.5 | 22 |
| Gravel | $m^3$ | 6 | 5.5 | 33 |
| Stone | $m^3$ | 3 | 7 | 21 |
| Bricks (apron, drain) | pcs | 200 | 0.04 | 8 |
| 8-mm reinforcement bar | m | 200 | 0.4 | 80 |
| 6-mm reinforcement bar | m | 400 | 0.3 | 120 |
| Iron wire | kg | 7 | 2 | 14 |
| Total cost per well | | | | 732 |
| GENERAL TOTAL | | | | 990.5 |

# 2 Lateral combined well

Another design involves digging the well beside the borehole (see Figure 8.28). This can be a little bit more complicated to build, but has the following advantages:

– it provides two distinct water sources; one potable water source for human consumption (water pumped from the borehole) and another one for livestock (water drawn by traditional methods from the well);

– in the case of deep wells and a risk of sand intrusion (due to traditional water-drawing, wind-blown sand etc.), it is possible to use a derrick to clean out the well with a bailer, which is impossible in the case of a well around a borehole without damaging the connection between the two;

– the borehole remains accessible for maintenance and development.

In the Sahel, the well is usually connected to the borehole with lateral connections, but this connection can only be made if the ground is stable enough for horizontal digging (up to 2 m).

## 2.1 Implementation

In order to facilitate the connection, the well must be dug approximately 1 m from the borehole. Knowing the vertical deviation of the borehole will help to define exactly where to dig. This information can be obtained from the drilling files.

The pumping test will determine the yield and dynamic levels, that will allow the establishment of the depth of the connection (see Chapter 6). The study of the geological log obtained during drilling will confirm the feasibility of constructing the connection at that depth (stable ground, not sandy). In the case of instability, the connection should be done deeper (if economically acceptable) or the well should be dug around the borehole, see Section 1.

When the depth of the connection is decided, the well can be dug using the normal method, up to 1.50 m below the level of the connection, in order to enable settlement of any solids in the water to below the level of the connection, to protect it from obstruction by sediment.

The connection to the borehole is the crucial part of the construction. This connection must be made with great care, in order to ensure the longevity of the combined well. The levelling is carried out in the well, vertically using a plumb-line, and horizontally, taking distance estimation and geological factors into account.

A tunnel 1 m long and 0.6 m high must then be dug horizontally, in order to clear a space around the casing to be able to make the connection. Once the casing has been reached, there are several possible solutions, the objective being to make the connection between the borehole and the well completely water-tight, to protect it from outside elements that could contaminate it, or cause blockage.

In Mali the connection is made with pre-fabricated reinforced concrete box sections 0.60 x 0.40 x 0.20 m (L x H x D), 5 cm thick. This solution has the advantage of using ready-made elements, given that it can be difficult to pour concrete in a tunnel where water runs in. The pre-cast box sections are laid going backwards from the borehole, with the first one closed behind the borehole to guarantee water-tightness. The box sections are attached to each other with 'pins' and then a fine layer of concrete is applied on the lower part and on the inside for solidity and water-tightness. The tunnel is also coated with a fine layer of mortar going backwards. The last box section has protruding reinforcement bars that allow it to be tied to the reinforcement bars of the well lining. The main concern is always the water-tightness of the structure. It is also possible to pour the concrete with wooden shuttering. The use of an accelerator such as Sicalatex can increase the quality of the concrete.

Another solution is to connect the borehole casing to another pipe that carries the water directly to the well without a tunnel.

When the connection is finished, it is preferable to wait several days before allowing water to flow, in order to let the concrete set. There are two options for opening the connection; either perforating the casing directly (with a special tool), or installing a saddle clamp (or ferrule strap) with a valve.

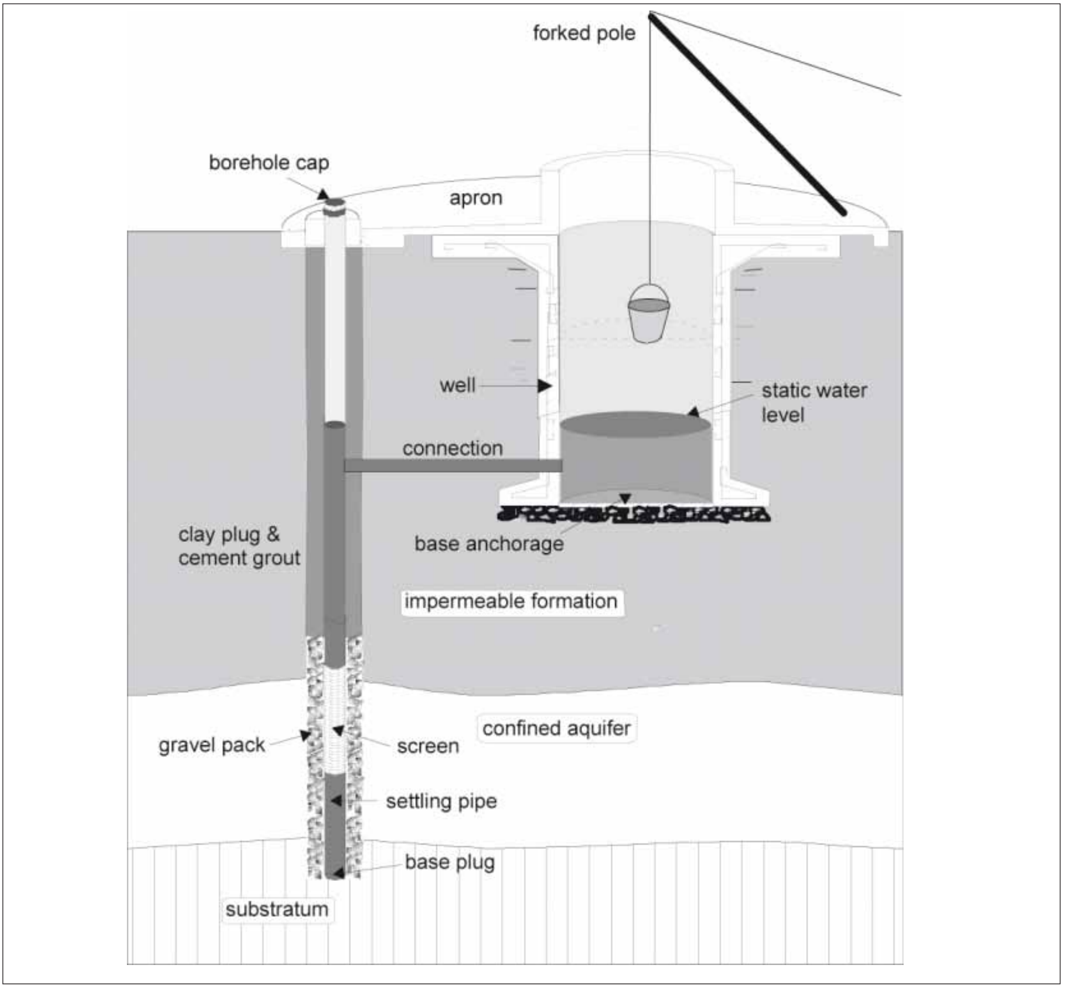


**Figure 8.28: Lateral combined well (ACF, Mali, 2003).**

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ISBN 2 7056 6499 8