SPRING TAPPING BY DRAINAGE

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This Technical Note explains the major steps in tapping a seeping spring by drainage. This is based on the *Sadoye 7* tapping (Gesuba Water Supply project, Ethiopia).

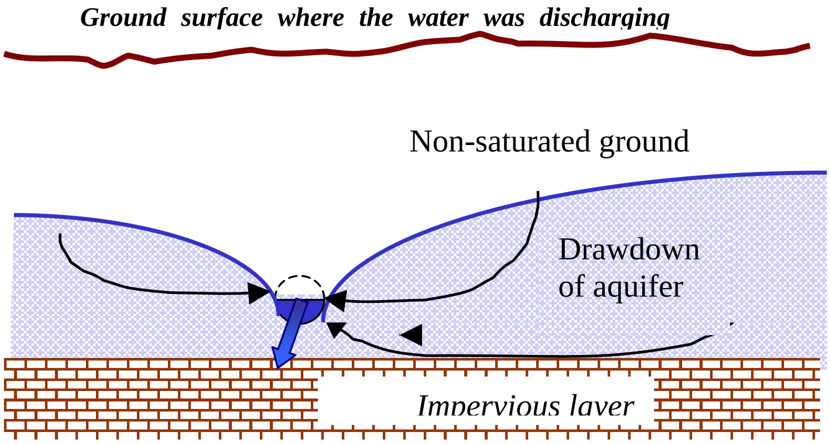
1 – When is it appropriate to use this tapping technique?

Some springs do not have an obvious single outlet; the discharge area is large and spread out. The water comes out of the ground on a slope over a wide, swampy-looking area.
These types of seeping discharges are found in overflow gravity (or depression) springs in soft rock aquifers and in artesian springs where the water exits through a soft rock cap.

In these types of springs, the installation of catchment drains (*or interception drains*) could be the best solution to catch and store the water.
Drains can also be used to increase a basic collection chamber influence area and productivity (see Note Water and Sanitation 1.3.1, Tapping of a Spring (aquifer drawdown)).

2 – Principle of tapping by drainage

Definition: The drains used to catch seeping discharges are underground, non-watertight pipes that collect the aquifer's water by gravity.
The water is collected in the drains through a process called aquifer drawdown; the hydraulic conductivity of the water in the drain is lower than the water in the aquifer.



Aquifer drawdown through a drain

The water collected flows in the sloping drain.

The drainage system is installed at the bottom of one or several trenches dug at the discharge level and laid out to intercept all ot the spring's rivulets

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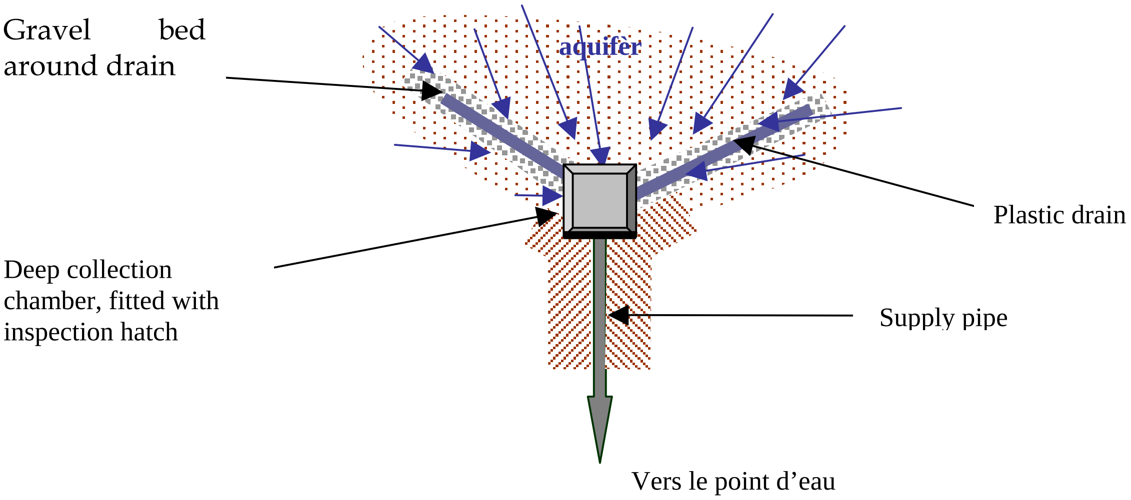
The drains can:

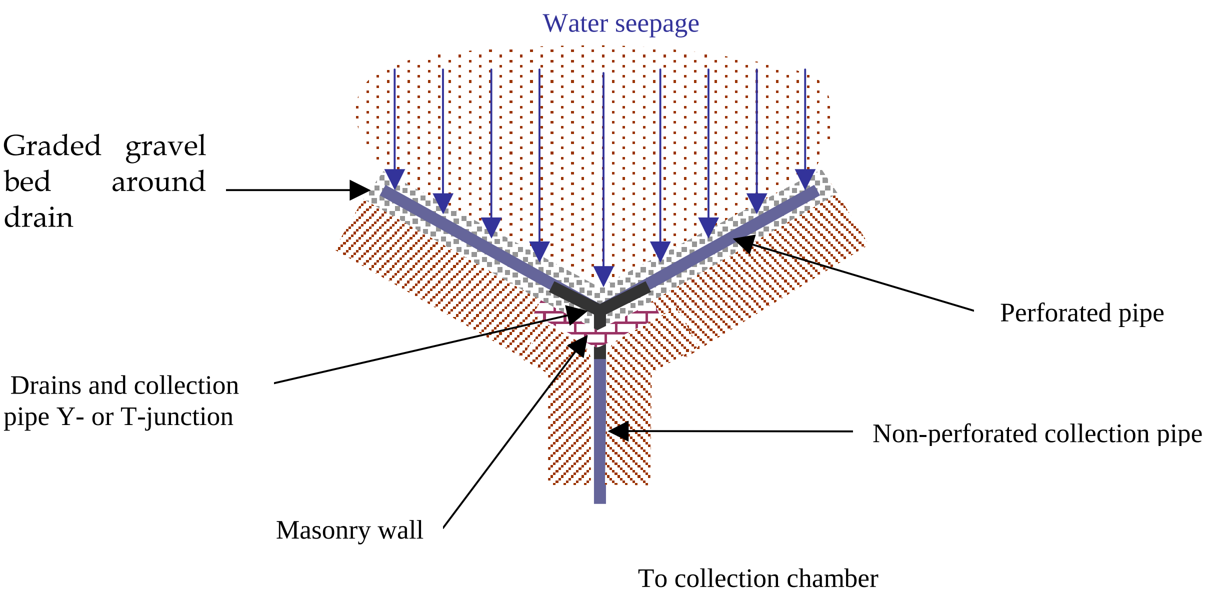
- run directly into a basic collection chamber, thus increasing the influence area (see Figure 1)

<u>Figure 1</u>: Example of a collection chamber influence area being increased by underground drains (plan view, 1 to 3 metres below ground level)



☞ or in the case of a large discharge, catch the water through a Y- or T-system, which has arms (called fins) installed upstream of the main drain, and a collection pipe installed on the steepest slope which empties into the collection chamber (see Figure 2).

<u>Fig.2 :</u> Details of a Y drainage system used for the Sadoye spring (underground plan view)

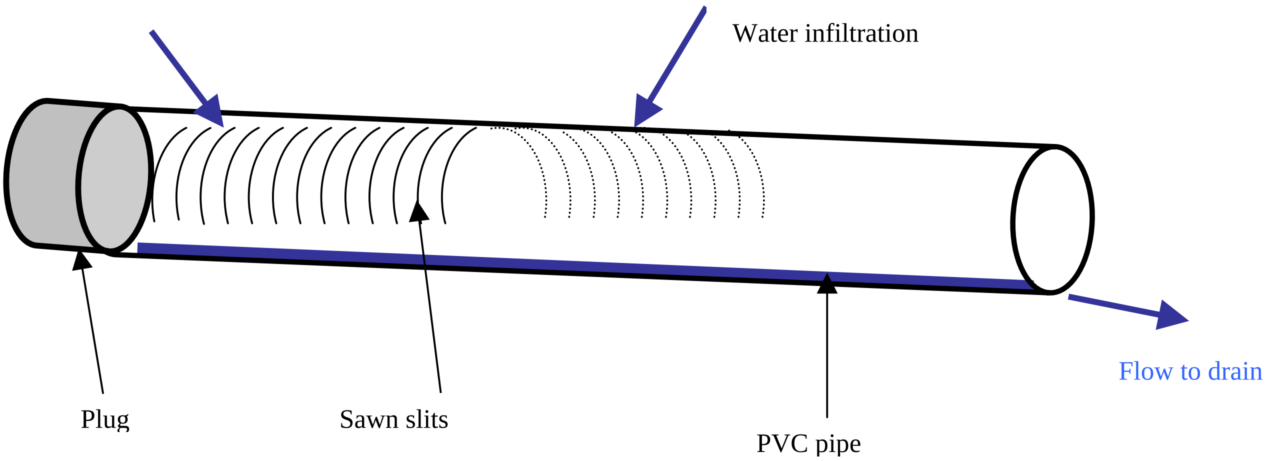


Material to use for the drain.

Various methods and materials can be used to tap a spring: rock drains, catchment galleries, pottery drains, prefabricated plastic drains or drains manufactured out of PVC pipes.

In this Note, **the drains are manufactured out of PVC pipes**, which are now readily available. They are also easy to manufacture locally or on the project site by the builders: all is needed is a fire to melt one of the ends to cap it and a saw to cut a few slits in the pipe.

These pipes have a good output and are not easily clogged, unlike rock drains.
PVC drains are also easy to install and handle, and they fit well in trenches.



<u>Figure 3 :</u> Locally manufactured drain from a PVC pipe (90 mm diameter).

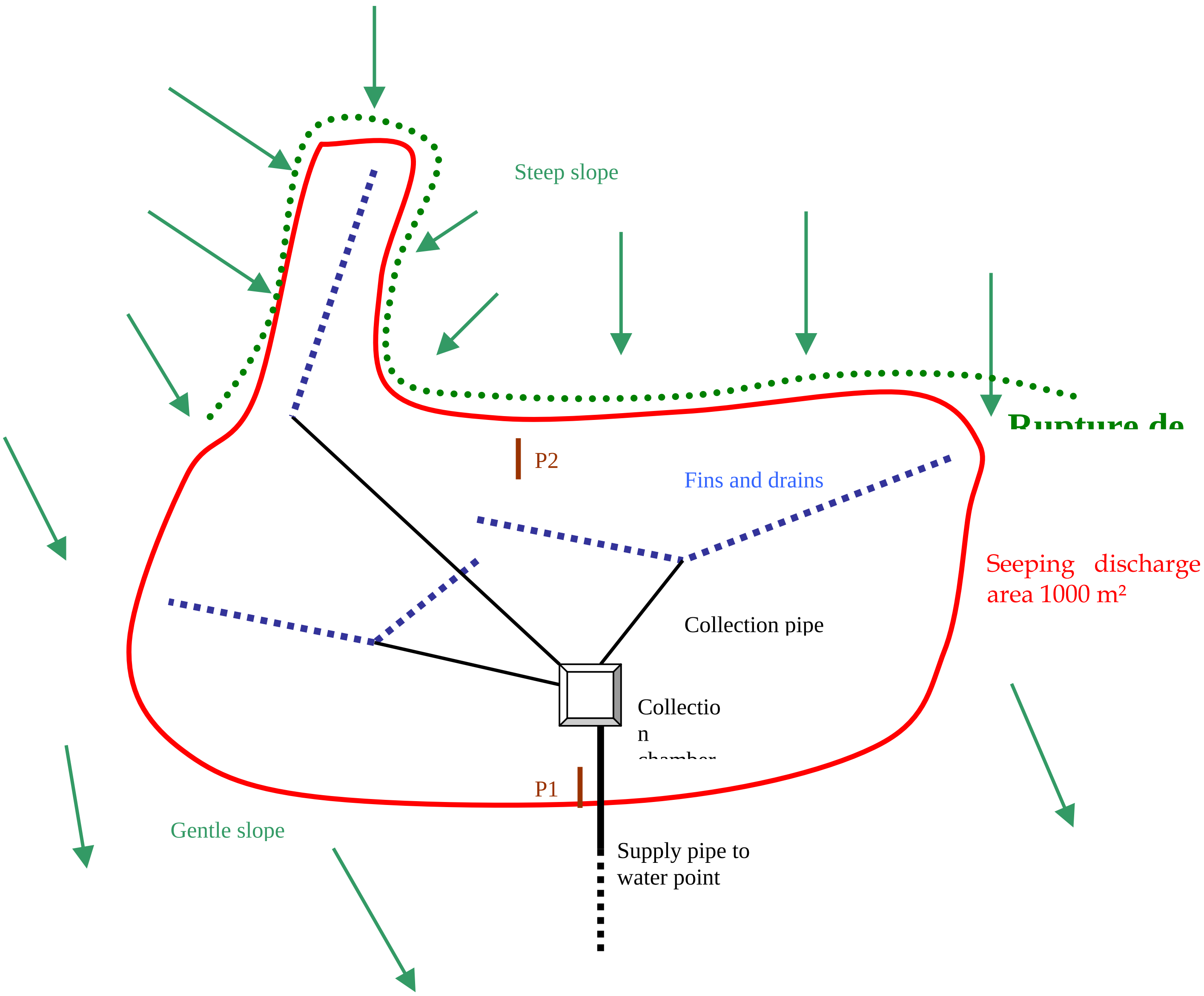
- **Manufacture of PVC drain**

To manufacture a PVC drain (see Figure 3), slits are cut along the length of PVC pipes (70 mm minimum, 90 mm preferred) with a metal saw. A slit is cut every one or two centimetres; this can be done on both side of the pipe to facilitate water intake. However, care must be exercised to ensure not to cut too deeply to avoid breaking the pipe.
The upstream end of the pipe must be plugged, either by a PCV end cap (if available) or by melting the end with fire.

3- Tapping a seeping spring by drainage (Sadoye 7 example)

On the Sadoye site, the discharge area was spread out significantly (several areas of ten metres or more). Since there were three major discharge areas, several Y tapping drains (same type as in Figure 2) had to be built. The water collected in each of the arms of the system was pooled into a collection chamber built downstream of the drainage pipes.

If the seeping discharges had proved to be consistent and equally spread out over the area to tap, a deep tapping connected to lateral drains installed around the chamber across the entire area would have been built. This type of tapping (detailed in Figure 1) would have been located in the centre of the discharge area, slightly to the left of the collection chamber, as shown in Figure 4.



<u>Figure 4 :</u> Tapping by drainage design, Sadoye 7, Ethiopia – Plan view.

<u>The various steps for tapping:</u>

Once preliminary surveys have been completed (including meetings with the users and elders to find out how the discharge behaved throughout the seasons and the years), it is time to start excavating, then tapping the spring.

- Organizing the excavation teams is important, and the following points must be considered:

- Determination of the drainage outlet lowest point (and of the collection chamber).
- Evacuation of liquids (water, mud) when digging.
- Gradual soil type surveys L'organisation des équipes de creusement a une importance.

<u>It is recommended to carry out the tapping in dry season.</u> The spring's flow during the rain season could lead to tap a temporary discharge rather than a less productive, but perennial one.

The first step is to thoroughly clear the spring and the area of vegetation in order to clearly see the main discharges.

- **Choosing the location of the excavation trenches.**

The goal is to determine the seepage area and identify the part of this area that will be tapped (digging the trenches could lead to reconsidering the initial plans, the discovery of deeper concentration of flow, for example).
On the steepest slope axis, the lowest discharge area to be tapped (P1) is marked with the first stake. This could possibly correspond to the surfacing point of the aquifer impervious substratum.
Still on the axis, the highest discharge point in periods of high water (P2) is marked: from either side of that point and on the same countour line, the lateral limits of the discharge area are marked (possible area to be tapped).

•Pre-excavation

If possible (if the conditions are good), it is preferable to dig the **pre-excavation trenches** <u>several weeks before starting the tapping work</u> so the highest terrain can dry properly. These opened drainage trenches have a trapezoidal shape, and their depth limits blockage (the water must flow freely at the bottom of these trenches, without being impeded by obstacles).This step relies on logical, common sense and experience, and drains could be installed on the bottom of these excavation trenches, if they are productive.

The pre-excavation trenches allow personnel to observe the spring to determine if it has been affected or has found new outlets: normally, (all or part of) the rivulets will concentrate around the first opened drains once the terrain above the discharge is dry. These observations will confirm (or not) the initial plan for the trench location.

- **Digging of drainage and fin trenches, and collection pipes (or collection chamber).**

The trenches will be 40 cm deep, at a minimum, and their depth will depends on the terrain as they are dug.

Trench digging advice is given in Technical Note 1.3.1, *Tapping of a Spring*, page 4.

In all cases, the type of material being extracted must be studied: topsoil, clay, fallen rocks, erosion or decomposing material, healthy rock, etc. These give a good indication on the make-up of the substratum and whether an impervious or other geological layer is near. Also, the spring output should be checked regularly during stable flow to see if the work has lead to a decrease or increase in the water output (drains should not be installed in all the trenches, but only in the ones that are productive).

The work is often carried out on unstable ground and must be done as fast as possible, using several, well-organized teams.

To avoid collapses as much as possible, the material extracted should always be taken away from the edge of the trenches; the heavy, humid soil puts pressure on the trench walls, which can easily cave in. Although this causes additional work, the excavated soil must be taken a fair distance away from the trenches.
In the case of ground prone to cave ins, the excavation will only be possible if the walls are propped up and great care is taken while digging.

Sadoye 7 experience: :
On the Sadoye 7 site, we had to deal with landslides that crumbled the trenches within hours of their excavation. The soil where we were working was saturated with water. This large quantity of water in the soil was pushing the ground downstream, sliding in and filling the trenches. We tried as best as possible to prop up the walls, to drain the water upstream of the excavation areas, but this was not always sufficient to prevent a cave in.
We therefore decided to work faster for the fin installations; this required major hands-on involvement by the community. We were digging the trenches one at the time, installing the drain and filling the trench the same day. This was extensive work, but it allowed us to deal with the cave in.

- **Calibrating and waterproofing trenches**

The flow quality in the trenches will determine the length of the drains to install.
At the end of the excavation, the trenches should be nearly horizontal and, if possible, on the impervious highest level (which is not always horizontal). From the end of the fins, the

trenches are dug again to get a 1 to 2 degrees slope (the slope of the drains) without damaging the bottom waterproof layer.
In the case of a steep slope and depending on the aquifer type, it could be necessary to waterproof the downstream portion of the fins and the intake part of the collection pipe using compacted clay.
In the case of a gentle slope, it is not necessary to waterproof the downstream portion of the fins; however, the intake part of the collection pipe must be waterproof to avoid losing water through run-off along the pipe.

- **Installing the drain**

Each perforated PVC drain is placed at the bottom of the trench (if the soil is firm) or on a gravel bed (if the bottom is too muddy).
The closer the drain will be to the substratum, the more efficient the drain will be to drawdown.

Once installed, **the entire length of the drainage pipe is quickly covered with a gravel layer** approximately 20 cm deep by 20 cm wide (if possible, the gravel should have been previously graded and cleaned on site).
This gravel layer will increase drainage capability. It will also provide some filtering of impurities, thus lowering risk of pipe perforations clogging.
The entire drain will be covered with a **filtering, protective fabric, tucking** in the sides, such as geotextile or a woven synthetic fabric.

- About geotextile :
    - It is recommended to add a layer of sand between the gravel and the geotextile to avoid tearing it so complete filtration is achieved; the slits (cracks) between the gravel and the geotextile are smaller which improves filtering capabilities.
    - The type of filter is important; some fabrics are loaded with chemicals (for example, fertilizer bags). Some fabrics work well: rugs, weaved coir (the first geotextile were made of woven coir). However, these must be free of soluble or separable chemicals products (glues, etc.).

Then, the entire work will be quickly “anchored” with a few shovels of soil before being completely buried.

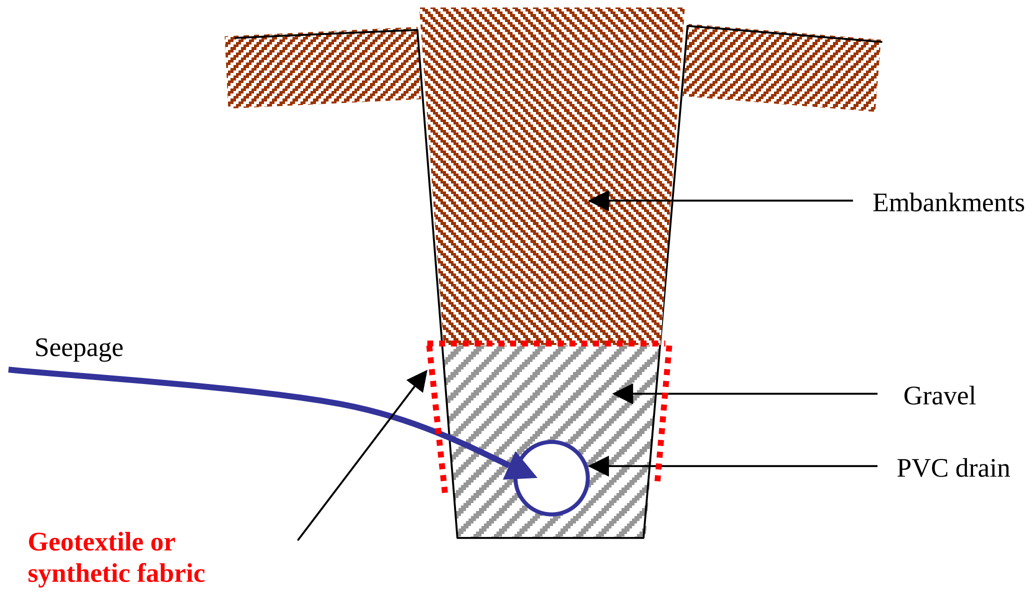


Fig. 5 : Cross section of drain at a fin level

Laying of a gravel bed on unstable ground:s :

When the trench walls are unstable, laying the gravel bed is dangerous. It is necessary to built a crib, with planks, that will be the same width as the trench (approximately 40 cm) and fitted with handles so it can be removed easily (see Figure 6). Once the trench has been dug to the impervious layer, the crib is installed. The drain is then installed and covered with gravel. The external sides of the crib are filled with soil (no topsoil) and once the entire work is stable, the crib can be removed by pulling on the handles. The gravel bed is then in place.

Fig. 6 : **Crib for laying gravel**

- **Filling in the trenches *(cf. fig. 5)***

Once the drains have been installed and are secured, the trenches are filled with soil from the excavation.
Clayey material can be put aside and used at the end of the filling process; a compacted clayey layer will limit surface water infiltration.
For shallow drains (1 m), a buried plastic sheet layer placed above the drainage area could improve the drain by protecting against polluting the water by superficial infiltrations.

It is best to quickly seed the filled areas with grass.

- **Collection pipe**

The collection pipe diameter will be determined by the spring output. Possible changes in the flow during rain season must also be considered when choosing the pipe size.
A Y- or T-junction is used to connect the collection pipe and the fins, as depicted in *Figure 2.*

- **Collection chamber**

The collection chamber serves one purpose only: to store the water from the drains. It must be as basic as possible and equipped with an inspection hatch, an overflow and the starting end of the supply pipe to the water point. Also, depending on the water collected, it can also have a clarification system.

- **Tapping protection and maintenance**

Once the tapping is completed, the tapped area will dry progressively (drawdown of the aquifer at drains level). If the entire discharge has been tapped, the terrain will dry permanently.
The area, which was previously very humid, will then be transformed significantly and different vegetation will grow.

Once finished, the sites are made up of tilled soil (not or very lightly compacted) and must be protected against erosion.

☞ A water committee that will include users and the landowner where the tap is located needs to be organized to bring awareness of the importance of the long-term protection and maintenance of the tapped area.
☞ A fenced protection perimeter will have to be set up around the tapped area to prevent surface pollution (animals, defecation, waste water, garbage, etc.).
☞ If required, run off diversion ditches and anti-erosion systems will need to be installed.
☞ It will be impossible to farm the land above the drains; vegetation must be allowed to grow naturally. It must be regularly mowed to prevent shrubs and trees from taking roots.
☞ Users will have to be made aware that shrubs and trees must not be allowed to grow near the drains; their roots could reach and clog the drains (in spite of the geotextile).

For drains connected directly to a collection chamber (see Figure 1), it is important to clean the chamber and the drains that are reachable (cleaning inside the pipes with tools from the inside of the chamber) whenever deposits and roots start to appear.

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