CHAPTER 2
Basic Details of an MHP Scheme

In this chapter, we try to describe the main features of an MHP scheme and their functions, together with considerations and procedures for the site survey and design of the layout. Figure 2.1 shows the main features or components of an MHP scheme. These include a river, from which part of the flow is to be diverted for power generation, a small weir, intake, power canal (headrace), forebay, penstock pipe, powerhouse, and tailrace. Depending upon such factors as the size of the plant and length of the canal, many other components such as a sluice gate, cross-irons, trash racks, and valves may also be provided at various locations.

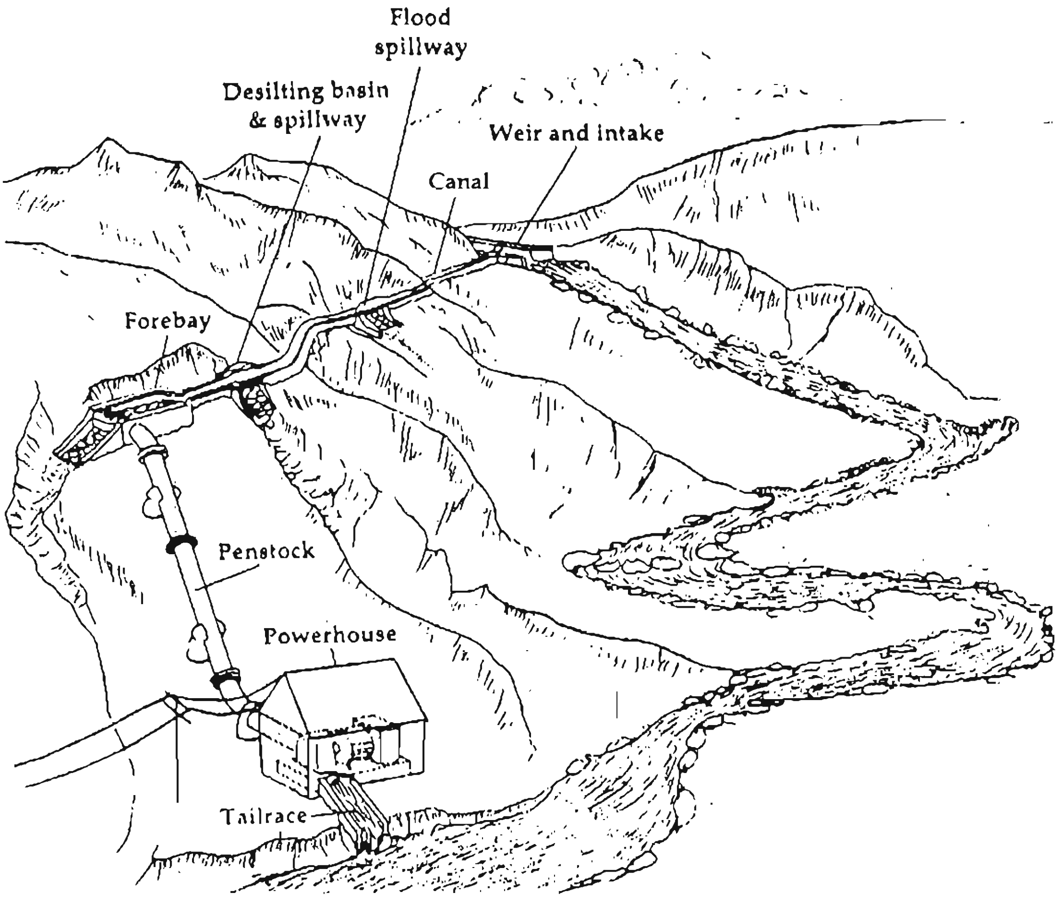

Figure 2.1: The Main Components of a Micro-Hydro Scheme

2.1 Main Components and Structures

The first man-made component in a run-of-the-river type MHP plant is a weir or dam built across the stream to raise the level of the water so that some of it can be diverted to enter the power canal through the intake mouth (Figure 2.2). The weir does not stop the flow in the stream completely; it only raises the water level to a predetermined position above which the stream flows over the weir. During the high-flow season, a weir is usually unnecessary or even undesirable. Therefore, in many smaller installations, temporary weirs are built from boulders and stones that are washed away during the high flow period and rebuilt during the dry season. In other cases, the weirs may be permanent structures, sometimes having wooden gates to maintain the desired water level.

As shown in Figure 2.2, the intake is simply a window (sometimes called an intake mouth) in a well-constructed retaining wall that allows a controlled flow into the canal. The window may have some vertical bars or even a crude trash rack to prevent the entry of stones or other such material. The intake can also be a very simple structure made of mud and stones without any bars or regulating system; depending upon the size, sophistication, and cost of the plant. It is usually desirable, however, to incorporate some components in the intake to control the flow of water and debris into the power canal.

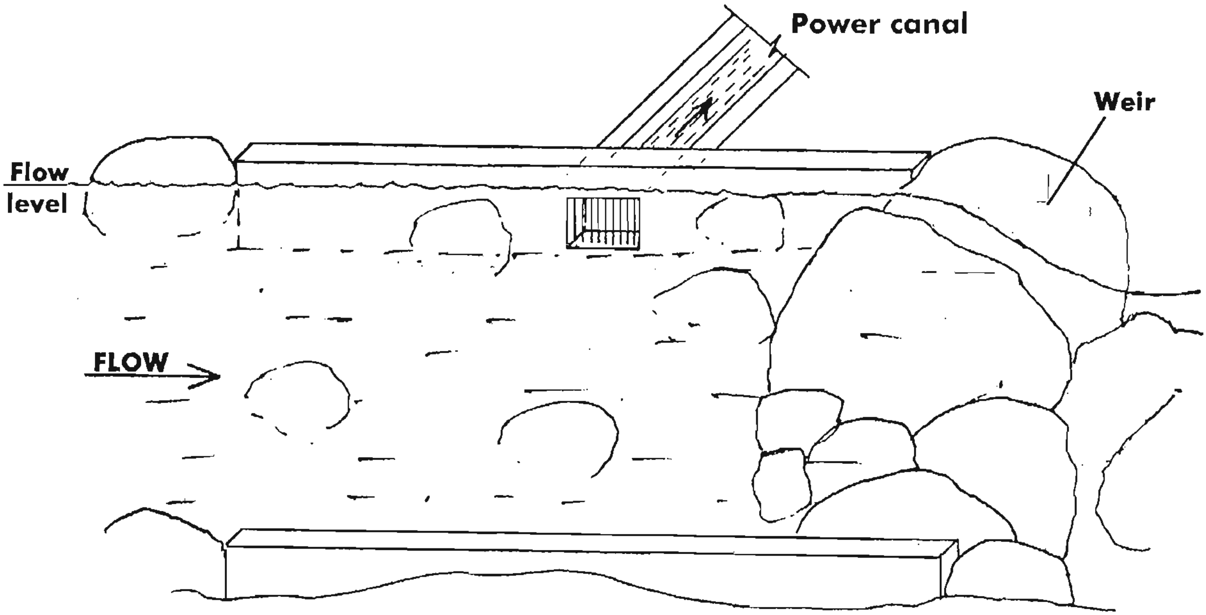

Figure 2.2: The Water Intake and a Temporary or Natural Weir

As shown in Figure 2.1, the power canal or headrace carries the required flow from the intake to the forebay safely. Its width, slope, and cross-section should be designed for optimum performance. The headrace can be constructed from a pipe over a part or the whole of the length. If it is an open channel, it can be constructed from loam, stones, and mortar and may sometimes be lined with a suitable sealant. In order to ensure that excessive flow does not enter and get transported to the forebay, spillways and sometimes gate(s) are also provided in the canal, preferably nearer the intake. Similarly, gravel and silt is 'settled' from flowing water in one or more desilting basins in which the flow is slowed by increasing the cross-sectional area, particularly the width, allowing the particles to settle. Structures are also constructed to 'flush' out the accumulated silt at appropriate intervals.

The destination of water flowing in the canal is the forebay, where water enters the penstock pipe. The forebay is usually a small rectangular tank in which the mouth of the penstock is located. The mouth is covered with a trash rack to prevent entry of solid materials, especially suspended materials such as leaves and branches. The forebay usually contains a spillway, desilting chamber, and flushing gate as well.

The penstock is a robust pipe which transports water from the forebay to the nozzles in the turbine. Here, the potential energy of the water is converted into kinetic energy which in turn rotates the turbine. The penstock is usually the most expensive component in the water transporting system and is made from mild steel or high density polyethylene (HDPE). Usually, a valve is provided in the penstock near the lower exit to stop or control the flow. Sometimes a valve or a stopper is also provided at its mouth in the forebay. The penstock has to be properly supported and anchored since the flowing (or stopped) water can cause forces and vibrations of significant magnitude.

The main job of the surveyors, and particularly the designers, of the layout is to site (identify the locations of) the weir and intake, the power canal, the forebay, the penstock, the powerhouse, and the tailrace. The locations of the three main components, the intake, the forebay, and the powerhouse, are the most crucial and depend upon the minimum acceptable power that needs to be generated.

2.2 Parameters for Layout Design

Power generated is calculated using the following equation:

$$\text{Power (kW)} = 9.81 \times \text{efficiency of system} \times \text{flow } (m^3/s) \times \text{head (m)}$$

The conversion efficiency varies with the type of turbine and flow conditions; but, in the preliminary stage of calculations, it is assumed to be between 0.5 and 0.6. Thus the net head* (the vertical height of water from the level in the forebay to the level of the exit nozzles in the powerhouse, where it emits and hits the turbine blades) and the flow are the main parameters. The maximum amount of flow that can be diverted from the river for power generation, and which is available without problem all year round, is referred to as the design flow or rated flow. It is usually less than the minimum flow available in the river/stream during the dry season. This is mainly because some water may have to be left flowing in the original stream for other purposes such as drinking and washing, support of riverine life, or irrigation. Thus, it is necessary to estimate or measure flow during the dry season. Depending upon the needs, the amount of flow to be left in the stream is determined and deducted from the total flow to arrive at the design flow. The value of the design flow is used in the design of various structures and components including the turbines.

For example; if the measured flow in a stream is 150 l/s during the month of March (considered to be the driest month and thus minimum flow), and about 30 l/s needs to be retained in the stream, then the design flow available for the MHP installation would be 120 l/s. Some other factors also need to be taken into account. The minimum flow may vary during the dry seasons of different years; therefore, the choice of design flow should be made carefully. It is usually preferable to measure flows more than once during the dry season to get more reliable values, or even during the dry seasons of two or more consecutive years. However, this may not be a serious problem in many situations where only a small portion of the minimum available flow is to be diverted for the MHP scheme.

It should be realised that the actual flow determined after the installation is complete may be higher or lower than the flow calculated on the basis of the information available at the time of the site survey. The owner-manager may even be able to increase the flow deliberately after the completion of the plant with a little additional expenditure by, for example, raising the weir. In any case, the initial estimates are often not very accurate even when they are based on actual measurements.

The gross head** is chosen so that the maximum power can be produced within the possibilities presented by the site. The layout, that is the exact and relative positions of the individual components, is then designed accordingly. The correct choice of gross head is very important, since it can be difficult and expensive to change the layout, and thus the gross head, after construction is complete. The optimum sites for the three components, powerhouse, forebay, and intake, are selected by an iterative process. Usually, the

* Net head is defined as the difference between total head at the entrance to the turbine proper (entrance to the spiral casing and the total head at the tailrace).

** Gross head is defined as the difference between head water and tail water elevations.

first step is to identify a suitable location for the powerhouse, then to choose a position for the forebay giving the requisite gross head, and then to survey the path of the proposed headrace to reach the intake. If no suitable position can be found for the forebay or intake, then a new site must be selected for the powerhouse (and/or forebay) and the process repeated. The interconnecting components, the penstock and the canal, must also be located on stable ground. If the proposed path of the canal or penstock is found to be unstable, or to make construction difficult as a result of problems, e.g., too steep a slope, obstructing rock, or easily eroded soil, then again another suitable location must be found for the powerhouse, forebay, canal, and intake, and the whole process repeated. The proposed locations may be changed many times before the optimum layout is achieved. A whole range of geological aspects will affect the final selection of the layout.

Once the basic layout has been determined, the route of the small channel (tailrace) that transports the water exiting from the turbine back to the river also needs to be finalised. This is not usually difficult. In a few cases, it may be possible to use this exit water for irrigation of the surrounding land.

After finalising the location of the components of the MHP scheme, maps or sketches are prepared showing distances, heights, angles, bends, and other necessary information. The locations are also demarcated on the ground.

After the completion of the preliminary survey and layout, it is usually necessary to carry out a more detailed survey and investigation to measure the distances, heights, angles, and so on more accurately and to determine the exact dimensions and sizes of the intake, canal, forebay, penstock (especially the penstock), and powerhouse. The flow may also be measured more accurately, if possible during the dry season. The forebay, powerhouse, and tailrace may also be designed and sketches prepared. Other investigations would include geological and soil conditions, landslide and flooding possibilities, and environmental considerations.

It is sometimes possible to complete all the surveys, measurements, and design work within one site visit, especially for a smaller plant, say less then 20kW. However, it is advisable to conduct the second detailed survey one to three months after the preliminary survey and to observe any changes in such things as the terrain, the stream, and forest cover. These aspects are discussed in more detail in the following chapters.