Water Lifting and Transport

OVERVIEW

Once a source of water has been found and developed, four basic questions must be answered:

1. What is the rate of flow of the water in your situation?
2. Between what points must the water be transported?
3. What kind and size of piping is needed to transport the required flow?
4. What kind of pump, if any, is necessary to produce the required flow?

The information in this section will help you to answer the third and fourth questions, once you have determined the answers to the first two.

Moving Water

The first three entries in this section discuss the flow of water in small streams,
partially filled pipes, and when the height of the reservoir and size of pipe are
known. They include equations and alignment charts (also called nomographs) that give simple methods of estimating the flow of water under the force of gravity, that is, without pumping. The fourth tells how to measure flow by observing the spout from a horizontal pipe.

Four entries follow on piping, including a discussion of pipes made of bamboo.

You will note that in the alignment charts here and elsewhere, the term "nominal diameter, inches, U.S. Schedule 40" is used along with the alternate term, "inside diameter in centimeters," in referring to pipe size.

Pipes and fittings are usually manufactured to a standard schedule of sizes. U.S. Schedule 40, the most common in the United States, is also widely used in other countries. When one specifies "2-inch Schedule 40," one automatically specifies the pressure rating of the pipe and its inside and outside diameters (neither of which, incidentally, is actually 2"). If the schedule is not known, measure the inside diameter and use this for flow calculations.

Lifting Water

Next, several entries follow the steps required to design a water-pumping system with piping. The first entry in this group, "Pump Specifications: Choosing or Evaluating a Pump," presents all the factors that must be considered in selecting a pump. Fill out the form included there and make a piping sketch, whether you plan to send it to a consultant for help or do the design and selection yourself.

The first pieces of information needed for selecting pump type and size are: (1) the flow rate of water needed and (2) the head or pressure to be overcome by the pump. The head is composed of two parts: the height to which the liquid must be raised, and the resistance to flow created by the pipe walls (friction-loss).

The friction-loss head is the most difficult factor to measure. The entry "Determining Pump Capacity and Horsepower Requirements" describes how to select the economic pipe size(s) for the flow desired. With the pipe(s) selected one must then calculate the friction-loss head. The entry "Estimating Flow Resistance of Pipe Fittings" makes it possible to estimate extra friction caused by constrictions of pipe fittings. With this information and the length of pipe, it is possible to estimate the pump power requirement using the entry, "Determining Pump Capacity and Horsepower Requirements."

These entries have another very important use. You may already have a pump and wonder "Will it do this job?" or "What size motor should I buy to do this job with the pump I have?" The entry "Pump Specifications: Choosing or Evaluating a Pump" can be used to collect all the information on the pump and on the job you want it to do. With this information, you can ask a consultant or VITA if the pump can be used or not.

There are many varieties of pumps for lifting water from where it is to where it is to be delivered. But for any particular job, there are probably one or two kinds of pumps that will serve better than others. We will discuss here only two broad classes of pumps: lift pumps and force pumps.

A lift or suction pump is located at the top of a well and raises water by suction. Even the most efficient suction pump can create a negative pressure of only 1 atmosphere: theoretically, it could raise a column of water 10.3m (34')

at
sea level. But because of friction losses and the effects of temperature, a suction
pump at sea level can actually lift water only 6.7m to 7.6m (22' to 25'). The entry
"Determining Lift Pump Capability" explains how to find out the height a lift pump will raise water at different altitudes with different water temperatures.

When a lift pump is not adequate, a force pump must be used. With a force pump, the pumping mechanism is placed at or near the water level and pushes the water up. Because it does not depend on atmospheric pressure, it is not limited to a 7.6m (25') head.

Construction details are given for two irrigation pumps that can be made at the village level. An easy-to-maintain pump handle mechanism is described. Use of the
hydraulic ram, a self-powered pump, is described.

Finally, there are entries on Reciprocating Wire Power Transmission for Water Pumps, and on Wind Energy for Water Pumping. Further details on pumps can be found in the publications listed below and in the Reference section at the back of
the book.

Margaret Crouch, ed. Six Simple Pumps. Arlington, Virginia: Volunteers in Technical Assistance, 1982.

Molenaar, Aldert. Water Lifting Devices for Irrigation. Rome: Food and Agriculture

Organization, 1956.

Small Water Supplies. London: The Ross Institute, The London School of Hygiene and Tropical Medicine, 1967.

WATER TRANSPORT

Estimating Small Stream Water Flow

A rough but very rapid method of estimating water flow in small streams is given here. In looking for water sources for drinking, irrigation, or power generation, one should survey all the streams available. If sources are needed for use over a long period, it is necessary to collect information throughout the year to determine flow changes-especially high and low flows. The number of streams that must be used and the flow variations are important factors in determining the necessary facilities for utilizing the water.

Tools and Materials

Timing device, preferably watch with second hand
Measuring tape
Float (see below) <see figure 1>

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Stick for measuring depth

The following equation will help you to measure flow quickly:

Q = KxAxV,

where:

Q (Quantity) = flow in liters per minute

A (Area) = cross-section of stream, perpendicular to flow, in square meters

V (Velocity) = stream velocity, meters per minute

K (Constant) = a corrected conversion factor. This is used because surface flow is normally faster than average flow. For normal stages use K = 850; for flood states use]K = 900 to 950.

To Find Area of a Cross-Section

The stream will probably have different depths along its length so select a place where the depth of the stream is average.

o Take a measuring stick and place it upright in the water about one-half meter (1 1/2') from the bank.

o Note the depth of water.

o Move the stick 1 meter (3') from the bank in a line directly across the stream. Note the depth.

o Move the stick 1.5 meters (4 1/2') from the bank, note the depth, and continue moving it at half-meter (1 1/2') intervals until you cross the stream.

Note the depth each time you place the stick upright in the stream. Draw a grid, like the one in Figure 2, and mark the varying depths on it so that a cross-section

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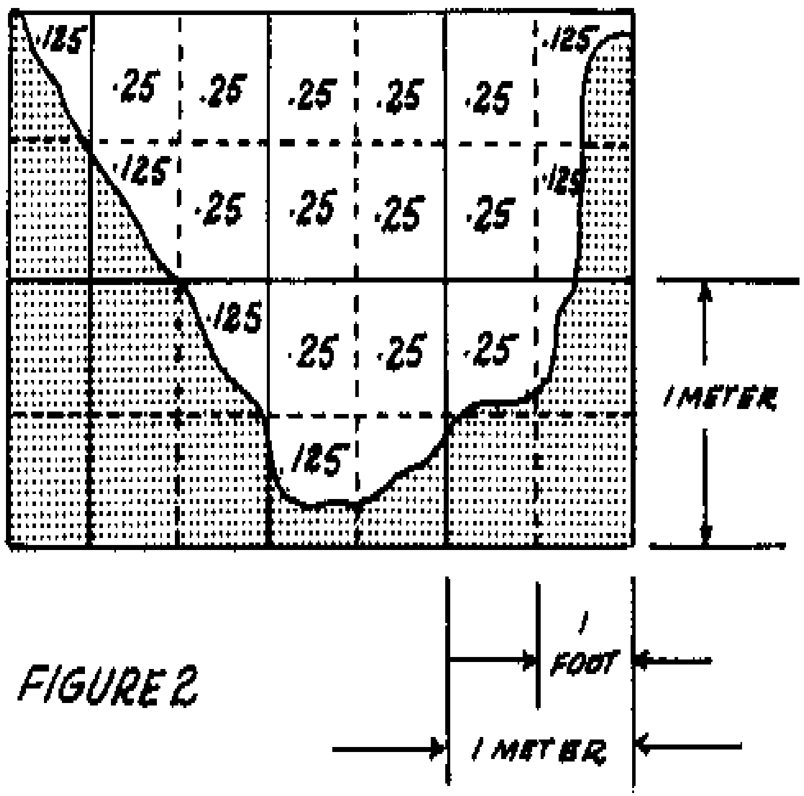

FIGURE 2

of the stream is shown. A scale of 1cm to 10cm is often used for such grids. By counting the grid squares and fractions of squares, the area of the water can be estimated. For example, the grid shown here has a little less than 4 square meters of water.

To Find Velocity

Put a float in the stream and measure the distance of travel in one minute (or fraction of a minute, if necessary.) The width of the stream where the velocity is being measured should be as constant as possible and free of rapids.

A light surface float, such as a chip, will often change course because of wind or surface currents. A weighted float, which sits upright in the water, will not change course so easily. A lightweight tube or tin can, partly filled with water or gravel so that it floats upright with only a small part showing above water, makes a good float for measuring.

Measuring Wide Streams

For a wide, irregular stream, it is better to divide the stream into 2- or 3-meter sections and measure the area and velocity of each. Q is then calculated for each section and the Qs added together to give a total flow.

Example (see Figure 2):

Cross section is 4 square meters

Velocity of float = 6 meters traveled in 1/2 minute

Stream flow is normal

Q = 850 x 4 x 6 meters

.5 minute

Q = 40,800 liters per minute or 680 liters per second

Using English Units

If English units of measurement are used, the equation for measuring stream flow is: Q = K x A x V, where:

Q = flow in U.S. gallons per minute

A = cross-section of stream, perpendicular to flow, in square feet

V = stream velocity in feet per minute

K = a corrected conversion factor: 6.4 for normal stages; 6.7 to 7.1 for flood stages

The grid used would be like the one in Figure 3; a common scale is 1" to 12".

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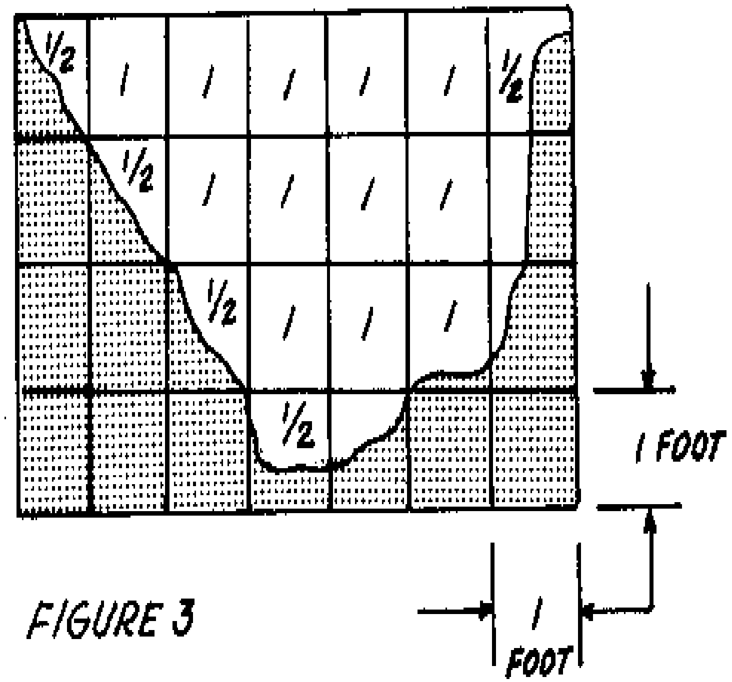

FIGURE 3

Example:

Cross-section is 15 square feet

Float velocity = 20' in 1/2 minute

Stream flow is normal

Q = 6.4 x 15 x 20 feet

.5 minute

Q = 3,800 gallons per minute

Source:

Clay, C.H. Design of Fishways and Other Fish Facilities. Ottawa: P.E. Department of Fisheries of Canada, 1961.

Measuring Water Flow in Partially-Filled Pipes

The flow of water in partially-filled horizontal pipes (Figure 1) or circular

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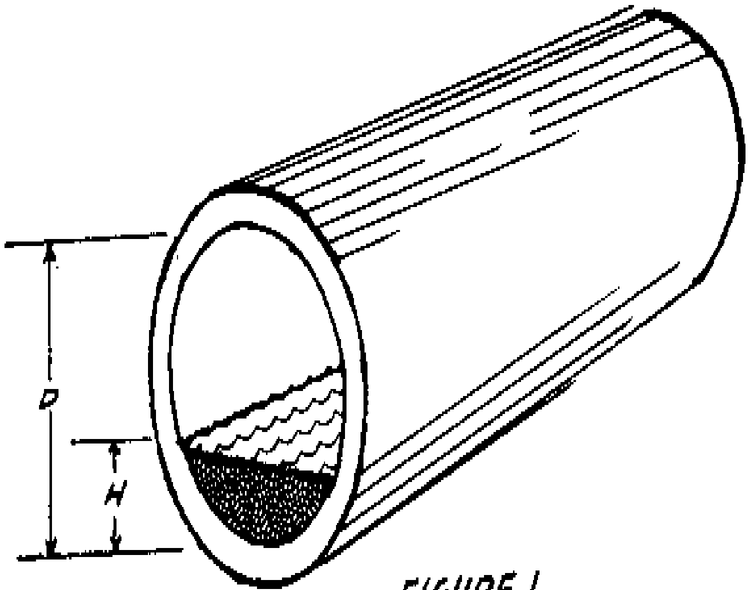

FIGURE 1

channels can be determined-if you know the inside diameter of the pipe and the depth of the water flowing-by using the alignment chart (nomograph) in Figure 2.

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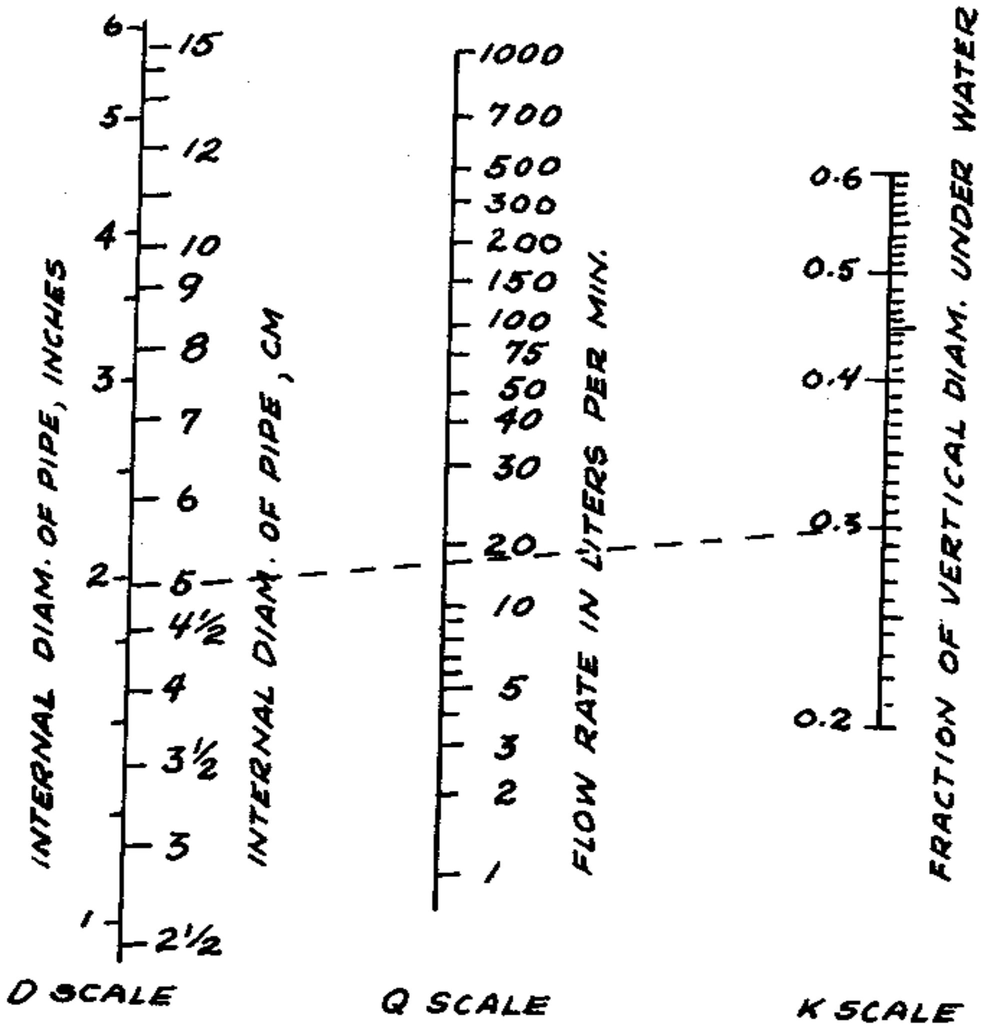
FIGURE 2



This method can be checked for low flow rates and small pipes by measuring the time required to fill a bucket or drum with a weighed quantity of water. A liter of water weighs 1kg (1 U.S. gallon of water weighs 8.33 pounds).

Tools and Materials

Ruler to measure water depth (if ruler units are inches, multiply by 2.54 to convert to centimeters)
Straight edge, to use with alignment chart

The alignment chart applies to pipes with 2.5cm to 15cm inside diameters, 20 to 60% full of water, and having a reasonably smooth surface (iron, steel, or concrete sewer pipe). The pipe or channel must be reasonably horizontal if the result is to be accurate. The eye, aided by a plumb line to give a vertical reference, is a sufficiently good judge. If the pipe is not horizontal another method will have to be used. To use the alignment chart, simply connect the proper point on the "K" scale with the proper point on the "d" scale with the straight edge. The flow rate can then be read from the "q" scale.

q = rate of flow of water, liters per minute 8.33 pounds = 1 gallon.

d = internal diameter of pipe in centimeters.

K = decimal fraction of vertical diameter under water. Calculate K by measuring the depth of water (h) in the pipe and dividing it by the pipe diameter (d), or K = h (see Figure 1).

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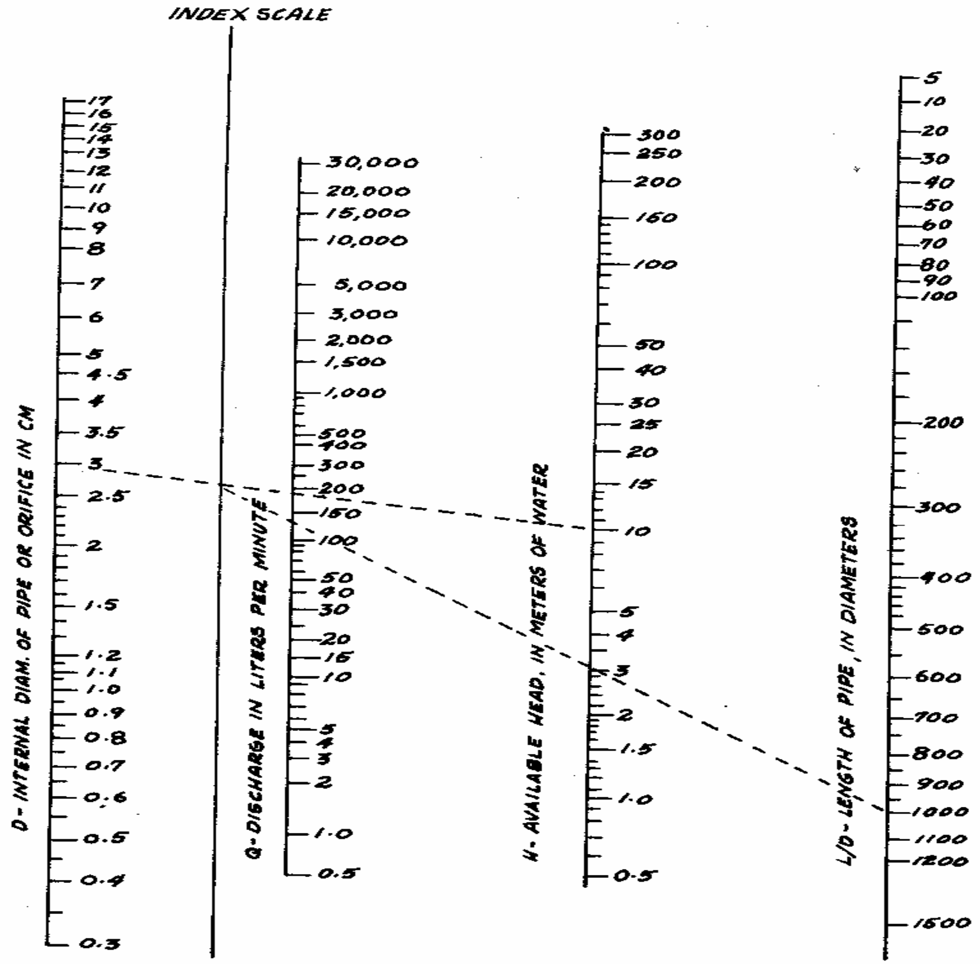
FIGURE I



Alignment chart for determining probable water flow with known reservoir height and size and length of pipe.

Source:

Crane Company Technical Paper #407, pages 54-55.

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d

Example:

What is the rate of flow of water in a pipe with an internal diameter of 5cm, running 0.3 full? A straight line connecting 5 on the d-scale with 0.3 on the K-scale intersects the q-scale at flow of 18 liters per minute.

Source:

Greve Bulletin 32, Volume 12, No. 5, Purdue University, 1928.

Determining Probable Water Flow with Known Reservoir Height and Size and Length of Pipe

The alignment chart in Figure 1 gives a reasonably accurate determination of water flow when pipe size, pipe length, and height of the supply reservoir are known. The example given here is for the analysis of an existing system. To design a new system, assume a pipe diameter and solve for flow rate, repeating the procedure with new assumed diameters until one of them provides a suitable flow rate.

Tools and Materials

Straightedge, for use with alignment chart
Surveying instruments, if available

The alignment chart was prepared for clean, new steel pipe. Pipes with rougher surfaces or steel or cast iron pipe that has been in service for a long time may give flows as low as 50 percent of those predicted by this chart.