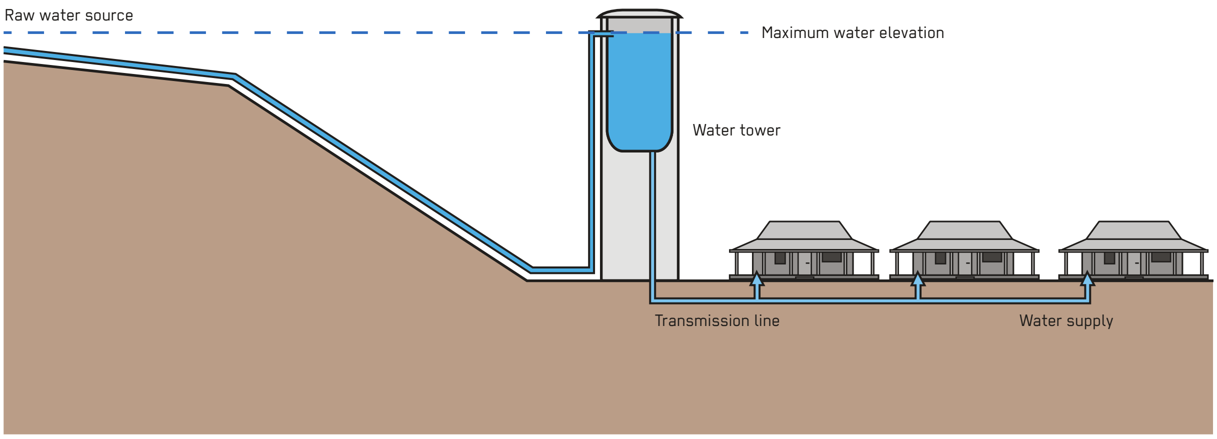
# Gravity

| Response Phase | Application Level | Management Level | Objectives / Key Features |
|---|---|---|---|
| ** Acute Response<br>** Stabilisation<br>** Recovery | Household<br>** Neighbourhood<br>** City | Household<br>** Shared<br>** Public | Abstraction and transport of water without external energy sources |
| **Local Availability** | **Technical Complexity** | **Maturity Level** | |
| *** High | *** High | *** High | |




Gravity can be used as an energy source for transporting water by taking advantage of differences in elevation to move water (usually via pipelines). This can occur either from elevated water sources to storage tanks and treatment facilities or directly from elevated storage facilities to supply points. It can be used in many different stages in a water system and in all phases of an emergency.

Water sources from where water can be suitably transported through Gravity include springs, streams, lakes, reservoirs or simply an elevated tank. As an energy source, the major advantage of using Gravity is that it is free, so pumps are rarely needed within a Gravity-based system. Where pumps are used, the principles of water flow in pipes, which are described below, also apply to those systems (only the energy source changes).

**Design Considerations:** The total energy of water at any specific point in a Gravity system is the sum of its energy due to elevation, pressure and velocity. When water is not flowing (e.g. in a full tank with closed taps), the pressure head, indicating the energy per unit weight of water measured in metres, is determined by the difference in height between the tap and the surface level of water in the tank. When a tap is opened, water flows, and the pressure head at the tap reduces due to the energy lost through heat dissipation to the environment that occurs when water molecules collide with each other and the pipe wall. This reduction of pressure energy is known as 'friction loss' or 'head loss' and is a known quantity for any particular pipe that is fully filled with water and open at the other end (usually given in metres friction loss per 100 metres). Friction loss varies according to the type of pipe and its diameter. For example, rougher or smaller pipes have more turbulence, which creates more energy loss, so the pressure at the end of the pipe will be less. Also, the longer the pipe, the greater the friction loss.

With the known friction loss, the hydraulic gradient line can be calculated. Since some energy is lost when water is moving, the pressure head will be less than when the taps are closed, so this line always slopes downhill from the source. Importantly though, this line should always be above ground (ideally 10 metres or more to keep air in solution, or if not, then air release valves should be used), as going underground causes negative pressure and a siphoning effect that can bring in air or soil contamination via poor pipe joints and could block the flow. The hydraulic gradient line should also terminate above the last tap in the system so that there is an excess ('residual') pressure at the furthest point. This ensures that water will flow at a sufficient speed through the tap (which will add some energy loss that varies according to the type of tap) while accounting for any discrepancies in actual pipe runs. The usual rule of thumb is to plan for at least five metres of residual pressure above the taps in larger Gravity systems; however, in acute emergencies for short distances, less residual pressure is required (e.g. usually one metre vertical distance between bladder base and tapstands is sufficient to meet recommended Sphere flow rate indicators). It is also possible to have too much pressure at a tap. Where residual pressure would be over 56 metres, measures have to be installed in the pipeline to reduce this pressure.

**Materials:** Materials needed depend on the particular Gravity system, which usually require pipes, valves, tanks and taps **(see D.7 and D.8)**.

**Applicability:** During the acute response phase, short pipe lengths to tapstands are often used, so a detailed design is less important initially. For larger systems, a thorough topographical survey and design are essential, so they require a longer time for implementation. Here a quick topographical estimate using elevation data from GPS or satellite will not be accurate. This means that for these larger systems, they tend to be more applicable to the stabilisation and recovery phases. Gravity flow systems are particularly suitable in areas with topographical variation (e.g. hills, mountains).

**Operation and Maintenance:** O & M needs will vary according to the type of Gravity system, though will generally involve pipe repair and tap replacement **(see D.7 and D.8)**.

**Health and Safety:** Health and safety concerns will be linked to the type of Gravity system installed, and will typically involve tank construction or pipe trench work **(see D.7 and D.8)**.

**Costs:** Gravity is a free energy source. Depending on the size of the system, the capital costs of Gravity-fed schemes are usually higher than the costs for those that obtain water from underground sources. This is due mainly to the cost of long pipelines from the upland sources down to the villages and partly due to the cost of providing storage tanks. In contrast, running costs over time are usually low.

**Social and Environmental Considerations:** Gravity is well accepted as it is a free energy source, which can reduce ongoing expenses. It is environmentally favourable, since it reduces the need for pumping using energy derived from fossil fuels, which have a greater impact on a system's carbon footprint as well as overall air quality.

**Strengths and Weaknesses:**

(+) Have lower O & M and running costs
(+) Provides more reliable supply due to not depending on fuel supplies or pump repairs

(−) Needs a natural difference in elevation to operate, so not applicable everywhere
(−) May need alternative energy sources for support

→ **References and further reading material for this technology can be found on page 213**