Technology brief

Gravity-flow water systems

Natural water sources are not always in a convenient place for collecting water. Gravity water systems use gravity to transport water from the source to the user through a pipe network. Bringing water closer to people reduces time, effort and risk – especially for women and girls – and protecting water as it is transported prevents it from being contaminated.


WaterAid/ Ernest Randriarimalala

Local technician pointing to the water source on distant peak. (Madagascar 2016)

The water source

Water quality

If there is a spring or river uphill from a settlement, it may be suitable for a gravity-flow water system. The area uphill of the **intake** should be protected (see **Protected springs technology brief** https://washmatters.wateraid.org/sites/g/files/jkxoof256/files/2022-04/Protected%20springs.pdf), with no housing and limited agriculture around. This prevents the water becoming contaminated. Piping the water away from the intake limits the need for people to go there, reducing contamination at the source and protecting the water.

Water quantity

As a stream flows downhill, it typically becomes bigger and more contaminated. The site of the intake should be a balance between maximising the available flow and minimising the risk of pollution. The quantity of water may vary seasonally. Not all the water should be taken as it is also needed by other users and the natural environment downstream.

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Steps in supplying water by gravity

A gravity-flow water system starts above the intake, with a protected **catchment** area. Activities must be controlled in this area to keep the water source clean.

The intake

The intake can be a protected spring or clean stream. The stream may have a small dam that raises the water level locally. A screen can prevent leaves being washed into the system. If the water is silty, especially in the wetter season, then a **settlement tank** may be needed. This keeps the water still for a while, allowing solids to fall to the bottom of the tank. The Intake also needs to withstand floods.

Moving water

The water goes down a pipe, flowing under the force of gravity. If the intake is very high up compared with the end of the pipe, the pressure can increase to a level that could cause damage. In this case, a **break-pressure tank** is needed. The water flows into this tank, which then acts as an inlet at a lower level for the next length of pipework. The pipework needs to be protected from damage; bends in the pipe should be supported by thrust blocks.

To design the pipework, you must carry out a site survey, select a route, and assess the location of valves and break-pressure tanks if needed (this is often completed by engineers). A constant downhill slope is preferred. An engineer should calculate the size of the pipes needed, based on the elevation difference and flow rates expected.

To construct the system, specialist labour is required to install the pipework fittings, while unskilled labourers can assist with digging and laying the pipe trenches, if supervised.

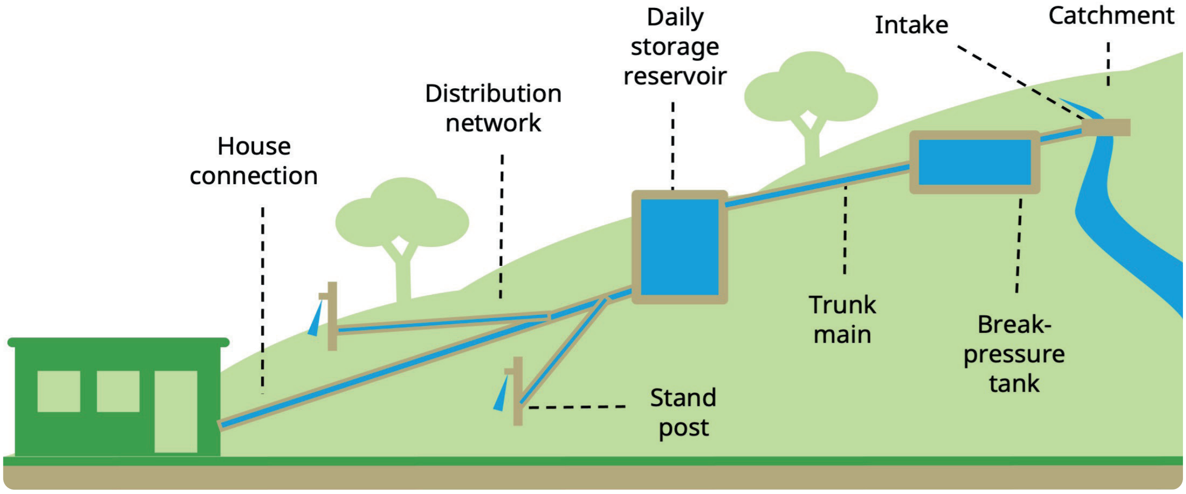
Storing the water

Generally, as the water source flows constantly day and night, service reservoirs are installed at the end of the main pipe to balance the volume produced with the varying demand. From the reservoir, the water is piped to stand posts (tapstands) and household connections.

Treating water

The water should not need treating if the water quality of the source is good and **adequate source protection** is in place, especially for springs. Any protection is only as good as the weakest part of the system, as contamination at one point could lead to contamination throughout the entire network. The collection of water from stand posts in containers is another likely point of contamination.

If water quality is not good (perhaps only in the wetter months) or the water will be used by people particularly vulnerable to infection, then some additional household-level water treatment may be needed. For large systems and those serving health centres, you may want to consider residual chlorination at the inlet to the service reservoir.



Issues to consider

Physical issues

The physical resources needed are standard building materials. Water-grade pipes should be used as they need to withstand pressure and last a long time. Concrete is needed to construct the intake, secure the pipeline and make stand posts.

The reservoir can be made from concrete, plastic or masonry. Valves and pipe fittings are needed to manage water flows. Taps and valves are required to make the stand posts and house connections. The amount of material depends on the size of the system and the topography.

Environmental issues

The water source needs to be naturally clean and run all year round. Flow records over several years will help plan the system. Calculations will show how many people can be supplied by the pipework.

The area above the intake needs to be protected, with limited activity. Forested areas are good as they help reduce erosion and flooding that can damage the intake and pipework, especially with a changing climate. Deforestation, agriculture and settlement can all contribute to pollution. However, changing existing land use to protect this catchment can have economic implications, so it is important this is discussed during the planning stages.

Economic issues

Gravity-flow water systems are capital intensive. Money is needed to build the pipework and reservoirs. Once complete, the systems are low-cost to run, lasting many years without major expenditure. However, asset replacements costs (for example, for pipes and valves) need to be budgeted for in the long term.

Depending on the population location, the topography and the flow rate of the water source, these systems can supply thousands of people. This spreads the costs across a large population, so high capital costs may be a low per capita cost.

Social issues

Depending on the geography, stand posts can be placed near people's houses, reducing the time and effort needed for water collection. The community should decide where the stand posts are best located, taking into consideration factors such as the location of houses and specific requirements of people who are less able to travel to access water.

Because large schemes may serve thousands of people, while the technology is straightforward, the social organisation can be complex. Payments need to be collected so money can be saved for repairs, even if there is limited daily expenditure.

The system has to be managed as a whole. Activities near the intake affect the water quality, so local residents may require incentives to maintain the catchment area. Where demand for water is larger than the available supply (for example, during the dry seasons), community management measures can be helpful, such as limiting the hours that the stand posts are available for use, to allow the storage reservoir to refill.


WaterAid/ Ernest Randriarimalala

Technicians working at the water source of a gravity fed scheme. Amberomena village, Belavabary commune, Moramanga district, Alaotra Mangoro region, Madagascar, September 2018.

Management issues

Gravity-flow water systems need financial and technical support when they are implemented, but can then operate for many years. Regular maintenance will be needed to clean the reservoirs and inspect and repair the pipeline when required.

The repairs can be expensive, so ensuring there are sufficient financial reserves enables rapid restoration of the water supply. A system of regular inspections, including a water safety plan, can identify problems in advance. The catchment above the intake will need to be **protected**, perhaps with community regulations, education or compensation.

A suitable **management model** (see https://washmatters.wateraid.org/publications/management-models-for-piped-water-supply) should be selected before project implementation to ensure the operation and maintenance of the system can be carried out sustainably and properly funded. Mechanisms for accessing support (especially for larger repairs) from government and local service authorities should be identified and established as part of this model.

Another sustainability issue is equity of supply. The water source can only supply a limited number of people, so an increasing population and/or greater water use may exceed what is available. An engineer should carry out a technical assessment before systems are extended to explore the options for increasing the supply and the impact these may have on existing systems. Possible measures include adding additional storage, leak control, charging for excessive water use, and developing additional water sources.

- Top: Maria, the Chief of the Water Management Committee, fixes a water tap in Timor-Leste. 2017
- Above: Community members checking the reservoir tank at Kushadevi, Kavre, Nepal, January 2018.

Case Study – Gravity-flow water system in Nepal

In the mountains of Nepal, springs are often found that can supply villages with good quality water. However, where these springs are located far from households, gravity-flow water systems are needed to reduce the time spent collecting water.

WaterAid and local partner NGO Community Development Forum (CDF) are implementing a Water Security and Climate Resilient WASH project in the Dolakha district. Dolakha is highly prone to climate-variation-related disasters, experiencing both landslides and droughts. The district has seen erratic and unseasonal rainfall in recent years and has been ranked under the 'high' category of climate vulnerability and risk assessment in the National Adaptation Plan of Action (NAPA).

Communities here are often dispersed and hard to reach, and their access to water can be threatened by many factors, including natural climate variability and exclusion because of age, disability, gender, caste, race, social status or political affiliation.

Good quality gravity-flow water systems will increase communities' resilience to climate variability and water scarcity, as well as reducing the time and effort spent on water collection. The communities are involved in the construction of the systems, learning how to repair and maintain them for when they take over their management through village-level water user committees.

Prior to construction, the area is mapped to identify water sources and the best route to lay the pipework, while existing systems in need of rehabilitation are assessed. For this project, WaterAid used drone technology to map six of the systems – a successful technique that will hopefully be used more in future.

Water will be collected at springs high above the communities, which will be protected and fenced to ensure good water quality by preventing contamination by people and livestock. The water will be collected in a collection tank and carried through a pipeline to a reservoir tank, from where it will be distributed to individual household taps in the villages. High density polyethylene (HDPE) pipe will be used for the underground pipes, with stronger galvanised iron (GI) pipe used above ground. Where necessary due to changing elevations, break pressure tanks will be constructed to release excessive pressure in the pipe system. Household water connections will provide the community with an improved level of water service, with a metering system initiated by the municipal authorities.


WaterAid/Laxmi Subediv

Water user committee members loading pipe onto a truck, Dolakha

Useful resources

For more information on the design and construction of gravity water systems, see:

Jordan TD (1980). A handbook of gravity-flow water systems for small communities. London, UK. Intermediate Technology Development Group. Available at: https://practicalactionpublishing.com/book/987/a-handbook-of-gravity-flow-water-systems.

Arnalich S (2010). Gravity flow water supply conception, design and sizing for cooperation projects [online]. Available at: www.arnalich.com/en/books.html.

For more information on the management of gravity water systems, see:

Njonjo A and Lane J (2002). Rural piped water supplies in Ethiopia, Malawi and Kenya: Community management and sustainability. Water and Sanitation Program. Available at: http://documents.worldbank.org/curated/en/380381468591542967/pdf/266330WSP0Blue0Gold0field0note0no1013.pdf.

Silkin T (1998). Hitosa water supply : A people's project. London, UK. WaterAid. Available at: www.ircwash.org/sites/default/files/Silkin-1998-Hitosa.pdf.

WaterAid is an international not-for-profit, determined to make clean water, decent toilets and good hygiene normal for everyone, everywhere within a generation.

Part of a series of WaterAid technology briefs available at www.wateraid.org/uk/technology

WaterAid (2021). Technology brief: Appropriate technologies for sustainable and inclusive water and sanitation services. London. Available at: washmatters.wateraid.org/publications/technology-resources

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