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Gravity water supply from protected catchments

M.A. O'Sullivan, W.S. Moffat and M.D. Bako

INTRODUCTION

Gravity water supply is a simple low cost technology applicable to both urban and rural communities, where the basic design requirements are satisfied. This mode of supply lends itself to the use of community labour, which is of great importance if the systems are to be operated and maintained throughout their projected design life. Large scale utilisation of local materials is also facilitated, thereby reducing the capital costs and involving the community to a greater extent.

Gravity water supply has a history of successful application in sub-Saharan Africa, where high levels of service have been provided at low cost. In this paper an example of successful gravity water supply in Sierra Leone is presented; some other African countries are also cited.

If protected catchments can be found, usually in forest reserves or mountainous areas, then the water can be supplied directly, obviating the need for treatment, which can be both complex and expensive. Storage tanks serve not only to cater for peak demands, but also provide sedimentation, allowing larger particles to settle out, and harness night flow which can increase the number of consumers served from a single source.

Recent developments in the production of materials not available locally, notably the introduction of plastic piping, has also served to reduce costs, both capital and recurrent. Their robust nature allows them to be laid in virtually any ground conditions, and not to any particular gradient. It is also possible to manufacture them 'in-country'.

As water can be piped to the exact point at which it is required, high levels of service can be provided, which will encourage its use and satisfy the aspirations of consumers. Simple gravity water supply schemes can then be recommended as a viable alternative to the often expensive exploitation of groundwater, with its dependence upon mechanical plant and costly pumping requirements.

CATCHMENT IDENTIFICATION AND PROTECTION

The catchments usually tend to be mature upland forest, located above the levels of habitation and cultivation, either of which could prove sources of pollution to the streams or springs.

Protection of the catchments is often ensured by existing government legislation, which seeks to preserve the forests as natural resource. Elsewhere local by-laws, even agreements between communities to desist from felling trees, can fulfil the same function if properly observed.

BASIC DESIGN CONSIDERATIONS

In the design of gravity water supply schemes certain parameters have to be taken into consideration before any construction work is done.

The population to be served needs to be estimated taking into consideration the design life of the scheme and also as population varies from one region to the other within the same country. After the estimation and forecasting of the population to be served, the per capita consumption should also be estimated taking into consideration the existing water practices.

Having established the size of design population and per capita consumption, a simple multiplication provides the total daily demand. Hence measurements from potential sources can be made either by V-notch gauging or the cruder method of bucket and stop watch.

For the pipeline design a level survey between a suitable dam site within the catchment, and the population to be served, determines the 'head' available. It is advisable to make a longitudinal plot of this survey, which should follow the proposed route, as this will disclose locations at which air-valves, or 'wash outs' should be included. Calculations involving comparison of the head available against hydraulic characteristics of pipelines allows appropriate pipeline diameters to be selected.

Storage tanks should be designed in such a way that they allow night flow to be captured. This is often desirable where the yield from the sources is not quite high enough to meet peaks in demand.

SUCCESSFUL APPLICATIONS IN SUB-SAHARAN AFRICA

SIERRA LEONE

A gravity water supply project in Sierra Leone started in 1986 with a village in the Eastern Province. The experience of the initial project was that of the old saying, "there is no success without a bitter beginning." The villagers attempted to construct a gravity water supply system independently. The scheme floundered due to insufficient funds and lack of technical supervision as the dam was poorly constructed and had a bad siting.

The community's desire for an improved supply was obvious from its abortive effort, and this proved an ideal location in which to pilot gravity supply. Discussion with leaders indicated the willingness for cooperation on a self-help basis, and the extent of contributions from the community and the government respectively were clearly defined. The government was to supply imported construction materials and technical assistance while the community was to contribute locally available materials, labour, accommodation and sustenance for the village based government staff.

The community comprised Mende people only, and proved so organised and willing to participate that the scheme became a training exercise for the technicians rather than a touchstone for the evaluation of potential community participation. The scheme was completed on schedule, following four months intense activity. The scheme was a simple design featuring a 90mm main, a 50 cubic metre storage tank and 22 standposts. Since then more than a dozen similar schemes have been implemented throughout the province.

Community Mobilisation

Separate committees have been formed to perform the tasks of labour organisation, provision of accommodation, and the daily sustenance of government technicians and artisans. Pre-conditions such as the accumulation of local materials have been achieved with such alacrity as to leave little doubt as to the people's desire for the new systems. The propensity of the Mende people for full contribution to the schemes has been a marked feature. Almost without exception they have grasped the initiative, has ensuring rapid progress.

Different groups worked on different days, and supervised by members of their own tribes they were presented with equitable targets, based upon the numbers of each group within the community. These targets were assessed by the committees in discussion with technicians, who described the degree of difficulty associated with each task.

Staff Training

The training of staff in the unfamiliar techniques associated with community participation has to date been accomplished in the field, with veterans of the early schemes being accorded 'supervisor' status. The supervisors are the sole link with the committees, and they convey the needs of the artisans engaged in construction or plumbing work to the committee leaders. The aptitude of the artisans to assimilate the unfamiliar techniques such as reinforced concrete construction and adjustments to new piping materials can be further enhanced by training of the new artisans by older ones during the rainy season when construction stops.

Materials Selection

The initial policy was to select robust components to be incorporated into simple designs. Storage tanks and small impounding dams were constructed in reinforced concrete, and standard designs for tanks 10, 20, 30 and 50 cubic metres have been prepared; these are constructed to a high standard and require little maintenance apart from periodic flushing.

The piping used below ground is black Medium Density Polyethylene (MDPE), standardised into four sizes, 32, 50, 63 and 90mm. The black colouring is significant in that it does not degenerate in ultra violet light, and pipes can therefore be stored in the open. Where trench digging is not possible, usually in the initial few hundred metres from the dam (where rocky ground is often encountered) galvanised steel piping is used. Galvanised pipes are also used above ground at standposts which feature bamboo reinforced aprons and large soakaway pits.

Tariffs

Tariffs are levied on a household rather than an individual basis, as the number of permanent residents varies seasonally. The suggested initial charges were based upon liberal estimates of maintenance costs. These estimates will obviously need to be reviewed, as use of the systems over an extended period indicates the particular elements which are most likely to need repair or replacement.

Community Initiative

A particular initiative arising from the communities is the strict control of water use in the dry season. Any wastage has been frowned upon, and in one case drawing water was only permitted at certain hours of the day. This was based upon the mistaken idea that the storage tank should remain permanently full. In this instance it was demonstrated that when the tank was full, water was actually overtopping the dam, and that sufficient water was available to replenish the tank. It is interesting to note the value placed upon the new system, and the degree of self imposed asceticism people are willing to endure to preserve it. This augers well for the proper use of the systems throughout their design lives.

Difficulties Encountered

Members of other tribal groups not represented in the Mende hierarchy displayed reticence at first, feeling that they would not remain long enough to enjoy the full benefits of the new supplies as they tend to be a mobile tribes involved in alluvial diamond mining. In these amorphous communities progress was less dramatic but still satisfactory as visits to completed schemes combined with assurances of representation on all the relevant committees convinced them that their contribution would be worthwhile.

Other difficulties were encountered during the Ramadan month when working hours had to be rescheduled to suit the Moslems.

Disputes were settled locally with the Chief who is usually the principal arbiter.

Scheme Evaluation and Recommendations

The schemes are undoubtedly popular and seemingly successful in their present form. However, to ensure that this trend is continued, evaluation and refinement of techniques based upon further experience are necessary. This should not be overlooked, and the evaluation should take cover of operation, use and efficiency of the systems, and fulfilment of objectives as detailed in O'Sullivan (1988). Recruitment and training of more staff prior to further expansion is recommended by the authors.

Although not on the grand scale of the schemes in Malawi, some of which serve more than 50,000 people, a programme of gravity supply schemes aimed at populations of between 500 and 6,000 is being established in Sierra Leone. The nature of the undulating topography dictates the size of the schemes, as pipelines are unable to connect neighbouring villages. Additionally difficulty with logistics particularly the necessary importation of cement, demanded a modest approach.

Again full community involvement has been a feature of the schemes, which augers well for their future maintenance, although that will also depend on strict adherence to the tariffs being levied. Early signs are encouraging.

MALAWI

The rural piped water schemes in Malawi are well documented, but it is still astonishing to realise that in excess of one million people receive their domestic water through these schemes. Equally amazing is that the schemes were constructed with self-help labour, and continue to operate successfully, even after almost 20 years in some cases.

This is not of course an overnight success, and various periods of consideration were required, during which the vital process of staff training took place prior to further expansion. The 'in-country' manufacture of PVC pipes beginning in the late 1970s playing a vital role in this expansion process.

UGANDA

Gravity water supply was proposed and designed for the hilly and mountainous districts of Uganda (Arebahona, 1987) where borehole and shallow well construction are impossible. The preliminary survey proposal took into consideration the necessary information required for gravity water supply design and construction. Unfortunately, due to a coup d'etat in 1985 the project was abandoned. However, a new proposal has been put forth by one of the pioneers and designers of the 'old project' for a new gravity water supply scheme for the hilly and mountainous regions of Uganda since the old plan has been lost. He further proposed an institutional framework between the water, health, education, agriculture and local administrations to harmonise the activities of the various water supply participatory agencies.

With the present government's theme of 'grass-root' involvement in community projects, the authors believe that gravity water supply can be a viable project in the hilly communities if the experience from other successful schemes are taken into consideration.

ADVANTAGES OF GRAVITY SUPPLY SCHEMES

There are several advantages to be gained from this form of drinking water supply, most notably the great reduction in both capital and recurrent costs, obtained by obviating the need for powered pumping or treatment processes.

Other advantages relate to the simplicity of this mode of supply, and the high levels of service which it is capable of providing as there are few constraints upon the location of standposts.

Additionally, there is the opportunity for large scale utilisation of local materials in the construction process. This applies particularly to stone for aggregate, and to sand, both of which are used to mix concrete, and which are almost invariably available within an accessible distance.

Furthermore, this method of water supply lends itself to the use of community labour. This is of great relevance if the supply systems to be constructed are to be operated and maintained by the users, as it helps to engender the necessary sense of ownership.

CONCLUSION

Gravity water supply from perennial streams or springs sources can be harnessed to supply intrinsically safe drinking water without treatment processes or mechanical plant. The method has been shown to be successful in some African countries. The method of gravity water supply described above can be adopted in areas where this is feasible and it is the contention of the authors that this will help supply millions of people in the developing world who would otherwise not have had access to 'clean' drinking water.

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