are subject to a high degree of pollution. Some points have been re-built, but most are in need of improvement or re-design. The deeper wells are less likely to become directly polluted; nevertheless some instances have occurred where pollution has been caused from the shallow permeable strata (usually the settling point for sewage effluent) seeping water into the well. This has been overcome, where found, by casing (surrounding the well lining with concrete) the borehole through these strata near the surface.

4.(b) Treatment

At present the only method of treatment throughout the Kingdom is the use of chlorine for sterilisation purposes. Other methods are unnecessary because the present sources meet the required standards of water quality.

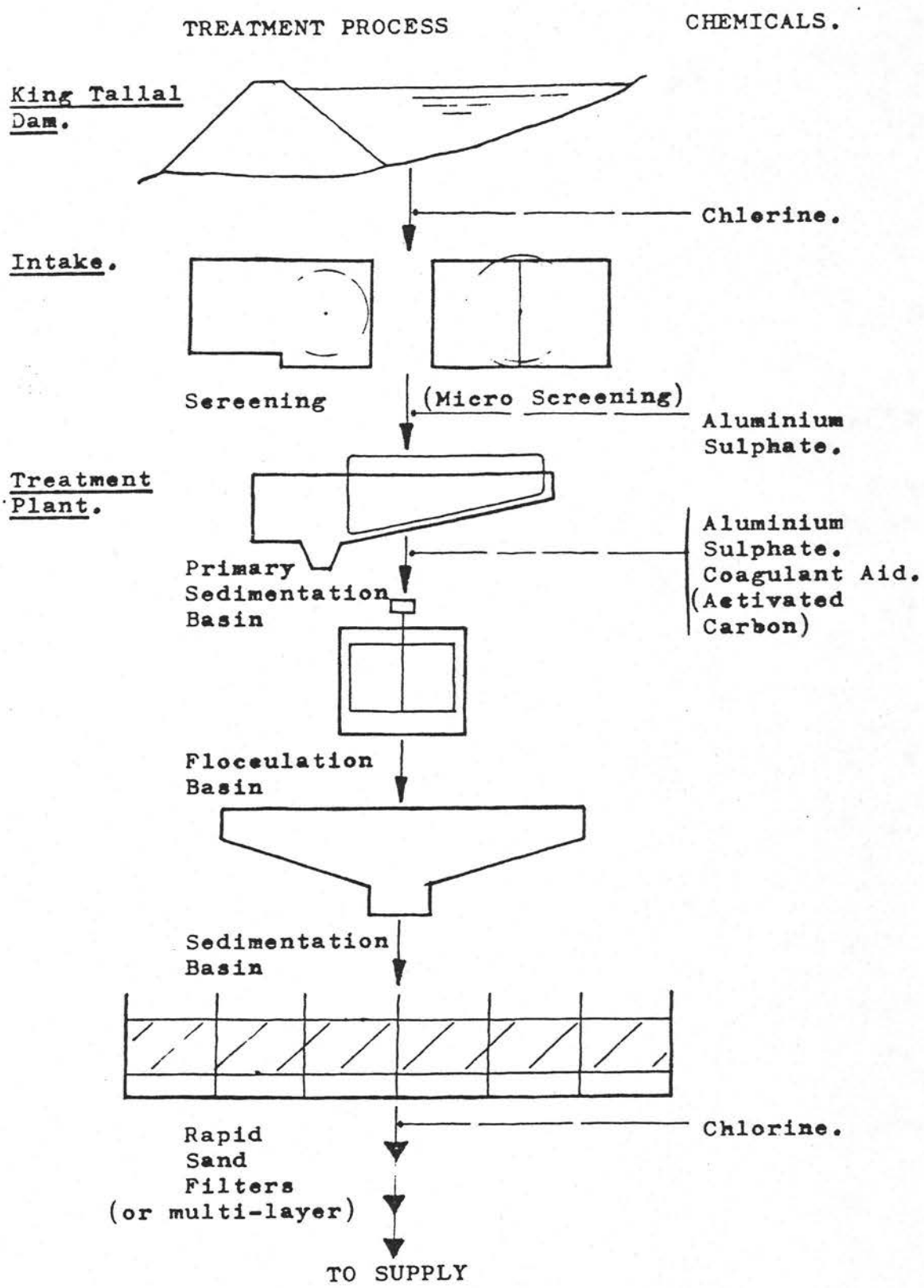
The first scheme, where water quality will be a problem is the scheme to abstract water from King Tallal Dam to supply Amman. Analysis of the water indicates it to be high in colour, high in suspended solids with an excess of various chemicals all of which are above the acceptable limits for drinking water. It is also expected to produce a multiplicity of algal blooms throughout each year.

From the Water Symposium

To overcome this problem a treatment process has been designed to reduce all residuals to acceptable limits, and produce a final water to meet World Health Organisation standards. The proposed process stages are shown in Figure 1.

Items in brackets thus (micro-Screening) indicate where provisions has been made for an additional treatment unit, or chemical process, should this prove necessary after a period of operation. Many safeguards are included in the system such as automatic controls, auto alarm systems, together with a modern laboratory for analysis and testing, to help maintain these standards.

The plant will be very up-to-date and will require a high degree of expertise and know how to keep the various processes functioning satisfactory, and maintain final water quality.



Treatment Process of Water from King Tallal Dam.

-Figure 1-

projects and industrial sites already require water but a supply is not likely to be available for several years.

Development in general, is at present allowed to spread over large areas with no proper town planning which makes the development of essential services, including water, very difficult. There is no coordination between Municipalities and the Water Supply Corporation which can draw funds from the Ministry of Rural Affairs for the development of a water network without liaising to find if there is sufficient water to fill the mains.

In order to overcome this problem in the future, a comprehensive survey of all schemes is required, on the concept that all consumers will eventually be supplied with water from a pipeline. It will also require showing where the needs are greatest, a presentation of a cost evaluation developed into a table of priorities, and the inclusion of a financial plan similar to that previously discussed.

At the same time, greater emphasis should be made on the availability of water in giving approval to go-ahead with developments, and controls should be set to limit development where necessary.

These can be prepared in the form of Codes and Practice and Procedures for laying and jointing pipes, use of materials, and protection of equipment etc.

The appropriate organisations would be responsible for enforcing such regulations which include those having responsibility for the distribution of water and include Amman Water and Sewerage Authority, Water Supply Corporation, Jordan Valley Authority, and the Ministry of Rural Affairs (which is responsible for villages and municipalities).

4.(g) Unaccounted for Water

"Unaccounted for water" is a special term used to signify the total quantity of water lost between all the sources and the total recorded at bulk supply meters or consumers meters, which ever is used. These losses can be estimated, but not be measured precisely, and as a result many misconceptions about how much water is lost from burst pipes, leaking fittings, and inaccuracy of meters etc. are made.

The Water Supply Corporation is responsible for supplying water to most municipalities in bulk up to a boundary point. The Corporation charges the municipalities for water consumed through a meter situated at the boundary and therefore does not know if the water is being properly used, or even if the level of waste

is unduly high. Some estimates however indicate that the level of leakages etc. in some municipalities is as high as 40%. The Water Supply Corporation can only therefore control the wastage of water from the source, to the Municipal boundary point by patrolling the distribution pipes to check fittings and repair leakages as they occur.

The estimate of water losses throughout the country could however be made by reference to the comprehensive study carried out by the Amman Water and Sewerage Authority during the period 1975 - 1976 to estimate the various categories of unaccounted-for water. The total of water produced from all sources compared with the total of consumers meters per period showed a difference of 48%. However, by calculating all the known losses, this figure was considered too high. An extensive series of tests was then carried out on the type, size and accuracy of meters used in Amman, both new makes and ones in use. It was found that the largest numbers of meters in use were ones with fan or impeller type mechanisms and on average were approximately -27% accurate for the flow conditions in Amman. The most reliable meters were the positive displacement meters whose accuracy can be relied upon at $\pm$5%. These however suffer from stoppages if sand or dirt particles are conveyed in the water but this can be overcome by the installation of sand traps or filters in the main lines. Figure 2 shows the estimated losses in the water network.

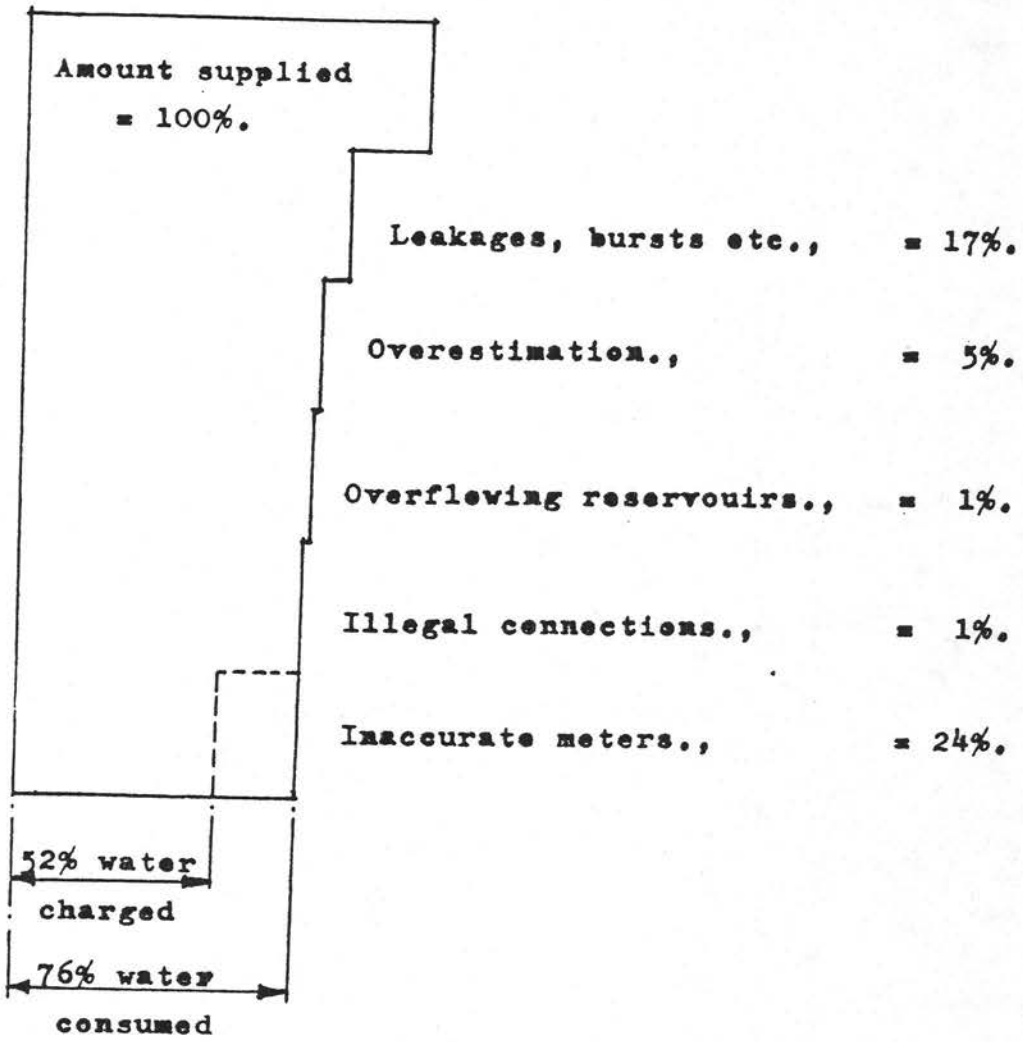


Diagram of estimated water losses for the City of Amman during the period 1975-76.

-Figure 2.-

The low accuracy of consumers meters can only be overcome by using the more reliable meters. This has already been approved and the work of changing meters is already being carried out. In the meantime this category of water loss represents a substantial loss of revenue that could have been available, if this information had been known earlier.

The diagram shows that the greatest loss of water occurs from burst pipes and leaking fittings, but unfortunately this amount cannot be further categorised to identify the losses occurring in houses, and other buildings. Neither can losses be accounted for, from meters that are intentionally damaged to falsify water consumption.

Testing of the water meters was carried out at the Authorities meter test shop, where a properly, but inadequately equipped workshop is available for test purposes. Trained meter mechanics can be relied on to run the shop and produce accurate results. Other such testing shops are at Zerka, Irbid, and the Water Supply Corporation, but unfortunately trained and experienced mechanics are not available to carry out this skilled work. This results in bad installation and repair, higher damage rates, and a greater inaccuracy of the meters.

In the water network, conventional waste detection methods cannot be used successfully because of the rotational system of supplying water, which means the Authorities have to rely on locating bursts by sounding methods or visual inspection.

The public show little interest in minimising waste; a small leak on a pipe joint, a dripping tap, an overflowing tank, or even the need to protect a meter from damage, may seem trivial, but all together represent a large area where water can be saved.

Water is a precious commodity that everyone has to be aware of, and to reduce the amount of wastage requires continuous attention before benefits can be shown.

4.(h) Operation and Maintenance

The recruitment of skilled workmen to run stations and properly maintain equipment requires an above normal experience due to the wide range of equipment in use. This problem is exacerbated by the continual drain of technicians and skilled workmen to neighbouring countries where salaries far in excess of those paid in Jordan are available. Also, salaries and conditions, particularly at the Water Supply

Corporation, are less than those in the private sector and therefore recruitment usually results in sub-standard labour being appointed rather than having none at all.

The wide range of equipment in use adds to the problem of stores control, equipment ordering, and the availability of spare parts. The resulting delays in the delivery of equipment cause, on average, most stations to be out of order for 2 - 3 weeks every year.

Most equipment is manually operated, and therefore with virtually no adequate communication system between stations, much time and effort is wasted in travelling to check or carry out routine visits.

Telemetry control, radio links, and other automatic systems will eventually over-ride the need for manned stations, and therefore fewer workmen will be required. These however will require skills in maintaining equipment, and training must be available either locally as a branch of existing Colleges or at International level through equipment suppliers.

Some equipment is maintained and repaired by the Authorities themselves and some by local Contractors, but with proper plant and tools more work could be carried out directly to give a greater

incentive and job satisfaction to the workmen.

There is a need for additional vehicles at all levels to improve the movement of plant and equipment, workmen and materials. Vehicles are not available much of the time, and considerable delays are experienced in equipment being delivered to site. Also engineers and other personnel waste time waiting for transport.

This section repeats the statement from other sections for manpower planning, plant and equipment requirements, stores systems, ordering procedures, vehicle and plant schedules etc. as well as a standardisation of salary and wage levels, and conditions of employment to attract a better class of workmen and make improvements that are so necessary.

Most of the equipment used in providing a water network is buried underground, and therefore maintenance and repair, as well as identification of problems cannot be resolved visually. The basic need in this respect is the availability of accurate drawings to show accurate location of pipes and fittings; in many cases no pipes or fittings exist at locations shown in the drawings. Most of the delays in repairing bursts or faulty fittings can be attributed to delays in locating check valves or the location of a pipeline, and the lack of records of how to control the flow of water. Lack of

records means also that below-ground fittings cannot be maintained regularly and results in their deteriorating or becoming unusable. The setting up of a comprehensive recording system needs to be organised on a continual basis to ensure that information is recorded as developments are carried out.

The setting up of local operation and service centres for routine work, rather than relying on one main workshop, would help to overcome communication problems, and provide better facilities locally.

V. ADMINISTRATIVE PROBLEMS

5.(a) Consumer Responsibility

The consumer assumes that the Government will take care of everything when it comes to providing water for his needs, and making available the pipe network.

The average consumer has little respect for saving water, possibly because of the misconception that water will always be available and when it is, he must use his full allocation, but also perhaps because he thinks the amount he uses is not enough.

Water can be provided in any quantity and for any foreseable use, but at a price; the greater the quantity the greater the price, and therefore the consumer must realise that for the reasonable price charged for water the Water Authorities expect a reasonable usage.

The consumer can be of considerable help in saving water by basic attention to house maintenance such as prompt repair of leaking pipes, and faulty fittings, and also making better use of water. Bath, shower and washing water can be re-used for watering plants and gardens, flushing toilets, and some cleaning jobs etc. In many cases, garden watering is overdone

and much water is lost in evaporation or lost by draining away.

The Authorities rely on the public to report burst pipes wherever they may occur or any other abnormal occurrences such as low pressure, or lack of water (when it should be available), taste, or even colour etc. for it is this type of reporting which helps to locate problems that are not normally obvious.

The public can also help by paying meter and other accounts promptly as this helps with cash flow, and would result in providing a better service.

5.(b) Government Responsibility

The problems arising out of Government decisions can be related to those of the organisation structure of water supply, procedural requirements, loans and grants, charges, development policies, and the level of salaries and conditions of service.

It cannot be responsible for mis-management, bad design, technical faults, faulty materials or workmanship.

With different organisational structures and operating conditions at the various Water Under-

takings, different priorities are given and varying standards result to create an unbalanced situation. Varying salary and wage rates have caused uneven recruitment opportunities, and adherence to tendering procedures has reduced standardisation and increased maintenance problems. Development policies do not restrict building even if water is not available, but by allowing this policy to continue, the ensuing problems of trying to provide water to housing areas where water schemes have not been planned, or where they may be very costly in relation to more urgent schemes, causes unnecessary difficulties in programming and organisation.

Water quality is directly related to pollution control and in Amman where the Amman Water and Sewerage Authority is responsible for both water supply and sewerage development this can be planned to minimise pollution. In other parts of the country there is no such policy and pollution of sources will continue until the responsibility for water includes all aspects of the water cycle.

The increase in charges for water due to the development of larger and more distant resources will put a financial burden on the consumer he may not be able to afford; in turn the Water Authorities will have problems of collection, and if, as is now the case, income is delayed, the supply of water may suffer.

VI. APPROACHES TO THE SOLUTION

The problems that have been described illustrate the difficulties facing the various Water Organisations in trying to maintain water supplies.

Most of them are common to each other, although they may vary in magnitude or intensity.

Various approaches can be made to overcome these problems and below are given some suggestions that could be used as possible solutions, namely:

6.(a) Financial, Tarriffs and Charges

- Equilisation of charges for water by all Water Authorities on a graduated scale of charges, increasing with the amount used. Low minimum rates will ensure maintenance of living standards for low income groups, and higher rates will create a control for reducing excessive usage.

- If, as is likely to happen with major supply schemes being developed, the financial burden to the public becomes excessive, the Government should increase grants, or if necessary, take over the financing of these projects.

- Direct collection of revenue for water sold by meter would ensure an income for direct water use.

6.(b) Technical

- Standardisation of plant, materials, and equipment wherever possible.

- Preparation of standards for quality and reliability of materials.

- Manufacture or assembly of materials and/or equipment locally.

- The installation, maintenance and repair of all water meters by one Authority.

- The adoption of National Regulations for good plumbing practice to minimise the wastage of water.

- Centralised ordering and storage of basic materials such as pipes, fittings, valves, etc.

6.(c) Re-cycling

This could be grouped under the Technical heading, but the subject is considered sufficiently important

to be separated.

With the demand for water increasing, many savings can be made by re-cycling or re-using water. Water that has been used (effluent) is a ready available source of water but it suffers from being polluted by bacteria, virus, and chemicals, etc. The effluent can be treated to whatever standard is required and the possibilities for re-use include some of the following:

- Irrigation - without treatment should only be used for non-eatable crops, and strict control is required to prevent use of water with heavy metals.

- Recreation - water quality depends upon purpose of recreation (bathing, fishing, boating, etc.) and the dilution with natural water.

- Industry - in general the proper way to re-use water for industry is by internal circulation with specific treatment for the pollutant. Thereby treatment can be tailor-made to the particular contaminant.

- Technical Water - water quality depends on the approved use of the water. The

possible uses for technical water could include the following:

Toilet flushing.
Garden watering.
Carwashing.
Cooling for industry.
Process water for non-food industry.
Cleaning purposes.
Irrigation for certain crops.
Recreation.
Fire fighting.

- Potable Water - recirculated water which could be used for drinking purposes requires an elaborate and extensive system of treatment. Re-use of water for drinking purposes is mostly accomplished indirectly by re-circulating the treated effluent to part of the hydrological cycle. The effluent can be discharged to a river and abstracted further downstream or it can be recharged to replenish a ground water supply.

Technically however, drinking water can be produced from waste water, but it is the economics in relation to conventional sources which determine which source is used.

However, from the consumers view point, it is not the economics that govern acceptability, but the psychological aspects. If not acceptable, the produced water can only be used as technical water.

6.(d) Administration

- The establishment of a National Water Council for overall strategy and policy matters, finance, and organisation of all water affairs.

- Grouping the responsibility for potable water supply, sewage collection and treatment, and pollution control under Regional Authorities but responsible to the National Council.

- Establishment of a training scheme for all water personnel to provide a variety of courses ranging from Management, Hydro-sciences, Day to Day works, Supervision, and Mainlaying Techniques, etc. The extent and variety of courses would depend on organisational requirements.

- Improvements of salaries and wages structures to provide a more even balance throughout the country.