23rd WEDC Conference Durban, South Africa, 1997

WATER AND SANITATION FOR ALL: PARTNERSHIPS AND INNOVATIONS

Sand abstraction systems

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IN MANY AREAS in Southern Africa river waters have an extremely high sediment load or turbidity. Numerous problems, and high costs, are associated with the abstraction and treatment of such waters. Problems include loss of storage through siltation, siltation of intake structures, rapid wear of raw water pumps and pipework, low throughput rates through water treatment plants and high costs of water treatment.

These problems can be alleviated by utilising sand abstraction systems. These are systems which are designed such that surface water is abstracted through the sand in river beds, as opposed to abstracting the surface flow directly from rivers. In this way the river sand bed is utilised as a natural filter. The water is thus filtered and has negligible turbidity once abstracted.

In addition to alleviating, or reducing, the problems discussed above, sand abstraction systems offer the following advantages:

- Utilisation of storage in river sand beds.
- Reduced environmental impact, as the natural river course is not altered where water is abstracted.
- Opportunity for using labour intensive methods and unskilled labour during construction.
- Minimal operation and maintenance requirements.
- Generally, the only treatment required after abstraction is disinfection e.g. chlorination.

Sand abstraction systems are suitable for application in medium to larger scale applications. In addition, the advantages mentioned above make them extremely suitable for use for small water supply schemes and for applications in rural areas. This is particularly true where communities are responsible for the operating costs and for the operation and maintenance of their own water supply schemes.

Although sand abstraction systems offer many advantages, the behaviour of these systems can be considered to be somewhat unpredictable. Problems have been experienced with a number of existing systems, where the yield of the system has dropped rapidly with time. Factors that could possibly contribute to such problems include the reduction in the permeability of the river sand, clogging of the abstraction pipes or geofabrics by fine sand particles, or clogging of the abstraction pipes by microbiologically induced fouling.

If abstraction systems are to be used to their full potential, a better understanding of these systems and the problems associated with them is required. Research is therefore currently being conducted into the design and operation of these systems and the causes of problems of low yield associated with these systems.

Case study

During 1994 a sand abstraction system was constructed in the White Mfolozi River near Ulundi, KwaZulu-Natal. A sketch of the system is shown in Figure 1. The system consists of 1288m of slotted screen pipes which were installed horizontally at a depth of 2,5m in the river sand, immediately upstream of an existing weir which had been completely silted up. The pipes have an internal diameter of 150mm, with a slot size of 0,25mm. The abstraction pipes lead into a collector gallery from which the water gravitates to a raw water pumpstation intake works. The system was designed to meet a peak abstraction rate of 313 l/sec, with an associated head loss of 0,86m across the system.

Shortly after completion of the system, it was found that the system could not deliver the design capacity, and that the head loss across the system was extremely high. From the end of 1994 to early 1996, numerous tests were conducted and measures were taken in an attempt to improve the flow through the system. The determination of the cause of the problem was, in this case, complicated by the fact that prior to completing construction of the system, the system was flooded, with a large amount of fine silt and rubbish being washed into the system.

Despite extensive investigations, it was not possible to determine the exact cause of the problem of low yield. Indications were, however, that biofouling was a major factor contributing to the problems of low yield.

Factors that indicated biofouling include:

- Total bacterial counts in the water in the abstraction system of the order of x 10^6, which indicated that microbiologically induced fouling could be present.
- Samples of organic matter washed out of the system were identified as a sheath-forming iron bacteria, genus Leptothrix, which is commonly associated with biofouling.
- A portion of abstraction pipe which was removed for inspection was found to be coated with a brown slime of bacterial sheaths.
- After dosing the abstraction pipes with chlorine, the yield of the system increased to 228 l/sec, but diminished rapidly thereafter to 78 l/sec. Total bacterial counts in water samples taken from the system 24 hours after dosing also increased by a factor of 10,

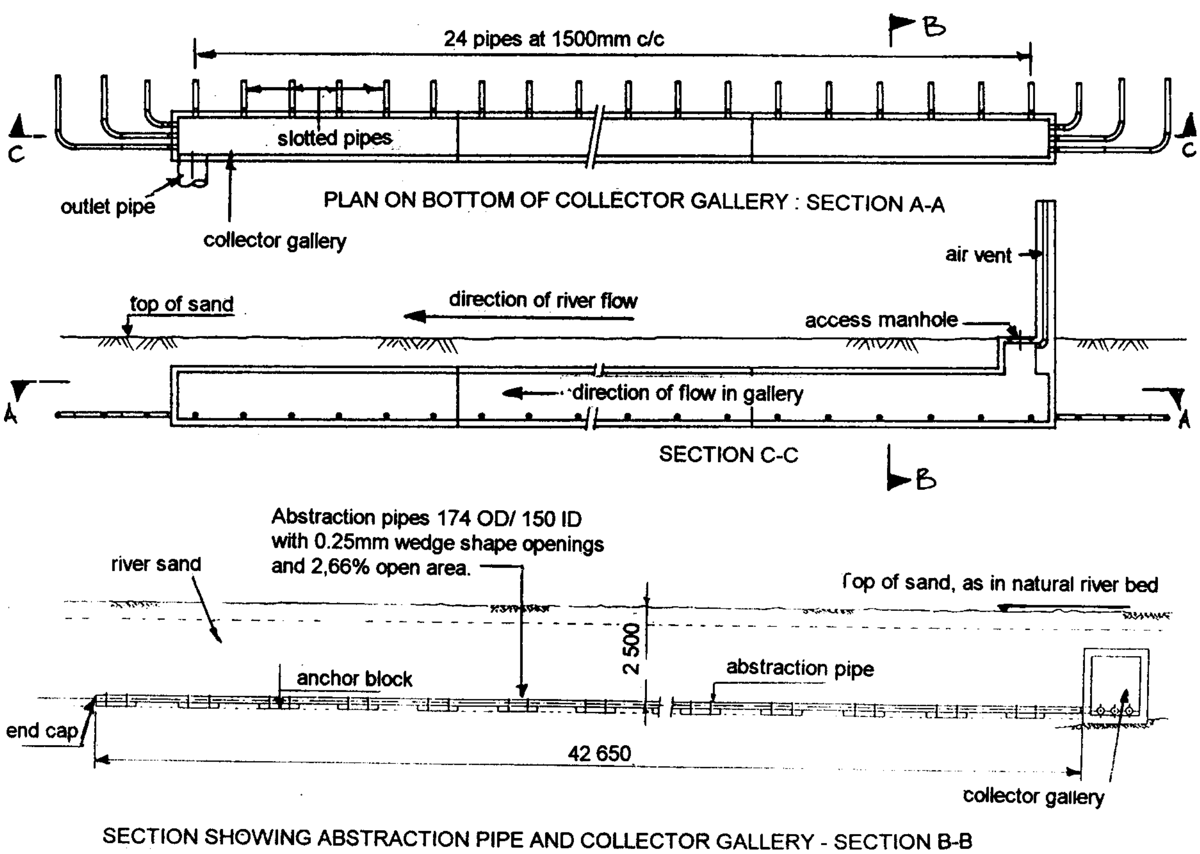

Figure 1. Sketch of Ulundi sand abstraction system

indicating sloughing of bacteria from the inside of the abstraction pipes.

Although these factors indicated biofouling, it could not be categorically stated that this was the root cause of the problem, or, if this was the root cause of the problem what conditions led to the development of bacteria in the system.

A fact that is anomalous, and that indicates the complexity of the problems of low yield of these systems, is that the design of this system was based on the same theoretical principles as the design of a system in the Buffalo River near Nqutu, KwaZulu-Natal. This second system, designed for a yield of 180 l/sec, has successfully been in operation since 1979, under conditions very similar to those found at the Ulundi system.

Based on the experience with the system at Ulundi, further research into sand abstraction systems was initiated. The aim of the research is to determine causes of problems of low yield in sand abstraction systems, and to develop design guidelines for these systems. The research is being funded by the Water Research Commission of South Africa.

The research, which is currently being conducted, consists of two main aspects. These include a survey of existing sand abstraction systems in Southern Africa, together with modelling of the sand abstraction system at Ulundi.

Survey of existing sand abstraction systems

Survey - phase I

The survey of existing sand abstraction systems is being conducted in two phases. The purpose of the first phase of the survey has been to find as many sand abstraction systems in Southern Africa as possible, and to determine whether problems of low yield have been experienced with these systems.

The preliminary survey was distributed to some 742 groups within the water sector in Southern Africa. These included consulting civil engineers, irrigation boards, water boards, universities, technicons and government bodies. To date a total of 114 surveys have been returned. Of these 114 responses, 78 respondents were not aware of any existing sand abstraction systems, while 36 respondents provided information about 61 separate abstraction systems. A summary of the information given about these 61 systems is shown in Table 1.

With a few exceptions, the systems found through the initial survey are located in four main areas:

- Northern Province, close to Messina and Louis Trichardt.
- The KwaZulu-Natal coast and the area around Ulundi.

Table 1. Summary information of existing sand abstraction systems

Is the system currently in use ?		Have problems been experienced with the system ?		
		Yes	No	Unknown
Yes	39	15	11	13
No	4	3	0	1
Unknown	17	1	0	16
Design phase	1	N/A	N/A	N/A
TOTAL	61	19	11	30

- The north-western part of Lesotho and bordering area of the Free State
- Matabeleland, Zimbabwe.

These are all areas that are known for the high turbidity of the river waters.

The results of the initial survey indicate that in areas where the river waters have high turbidity the use of sand abstraction systems is becoming more common. Problems of low yield are, however, commonly experienced, thus justifying the research that is currently being conducted.

Survey - phase II

During the second phase of the survey, detailed surveys are being conducted of those systems which were found through the initial survey. The purpose of the detailed surveys is to establish a data base of design, system and operating parameters of existing systems. These parameters include factors ranging from the type of pipes/screens used, to water quality, total bacterial counts in the system and local geology.

Where data on the existing abstraction systems is incomplete, the sites of the abstraction systems are being visited, on-site testing is being conducted and samples taken for laboratory testing. This phase of the research is currently in progress.

The data base will be used to determine correlations, if any, between system parameters and system yield, particularly where there are problems of low yield. A theoretical analysis of each system will be conducted, and the theoretical yield compared to the actual yield of the system. For the purposes of statistical correlation analysis, rating systems for factors such as water quality and geology will be established.

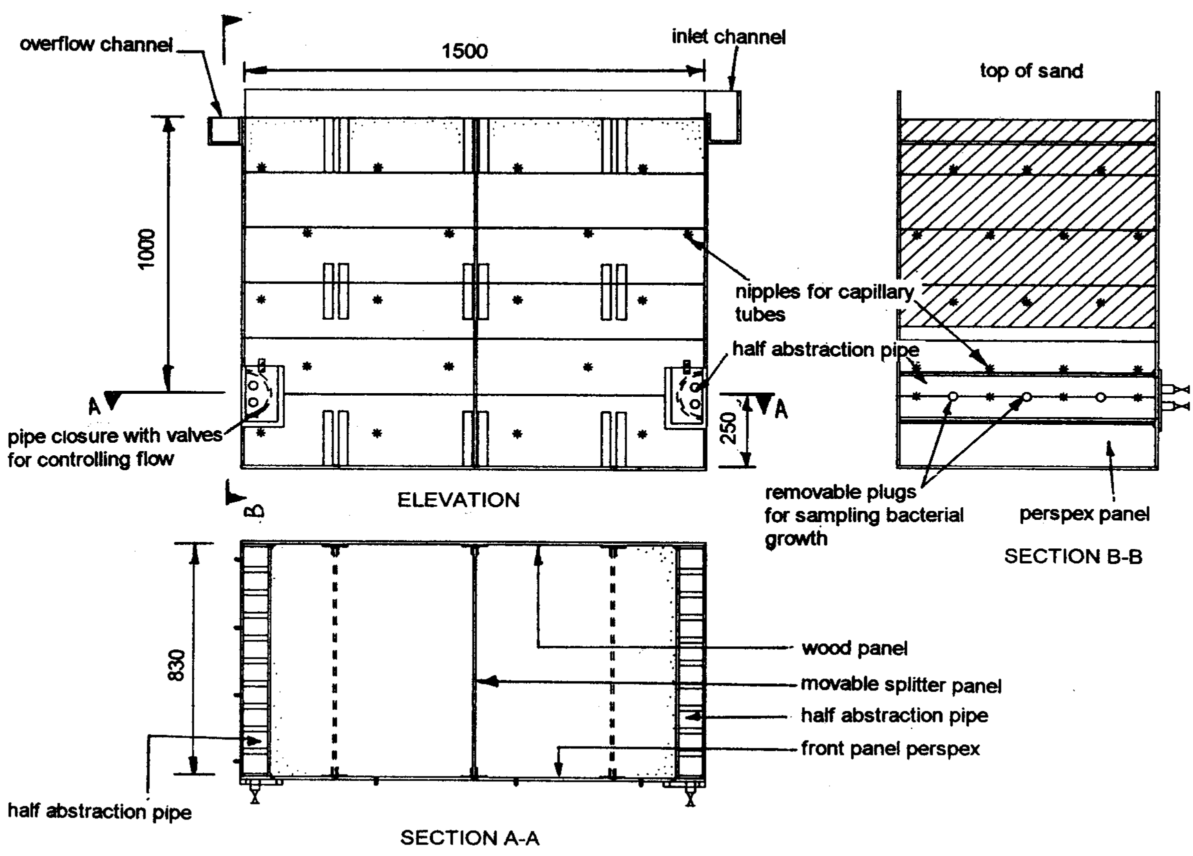

Figure 1. Model - control unit

Modelling

Scale models of the Ulundi abstraction system are being built on site at Ulundi. The aims of modelling the Ulundi abstraction system include:

- Confirmation of the theoretical principles (hydraulics and seepage) on which the design of the system is based.
- Determination whether the major factor contributing to the low yield of the Ulundi system is biofouling.
- If biofouling is the main cause of low yield, determination of the conditions which led to the establishment of biofouling in the system.
- If biofouling is a common problem in abstraction systems, determination of methods of controlling or eliminating it.
- Determination of factors other than biofouling which contribute to problems of low yield.

The models are being constructed such that there is a control unit, simulating the actual Ulundi system, and five other units which will be used to model different factors. A sketch of the control unit is included as Figure 2.

As previously mentioned the Ulundi system is similar to a system at Nqutu, which has successfully been in operation since 1979. The factors that are therefore being modelled are those aspects (events in the history of the system and/or physical parameters) of the Ulundi system which differ from those of the Nqutu system. These factors include events such as the fouling of the Ulundi system through flooding prior to completion of construction, and the use of different pipe materials. If results from the detailed survey indicate that there are other major aspects that should be considered, then the models will be modified accordingly.

Throughout the modelling period samples from the actual abstraction system are being taken to allow for comparison to the model. Sampling units, which consist of small boxes containing slides, have been inserted into the abstraction pipes of the system to allow for easy sampling of the bacterial growth in the system.

Once the main factors contributing to low yield have been established, control methods will be proposed. The efficacy of these methods will be tested using the model.

Conclusion

As discussed previously there are numerous advantages associated with the use of sand abstraction systems. These systems are however, not closed systems, and in some regards their behaviour is governed by Mother Nature, making them somewhat unpredictable in their behaviour. This research is being conducted to gain more knowledge about the manner in which these systems operate and the problems associated with these systems. Hopefully, such knowledge will result in more ensured success with future installations of such systems.

Acknowledgements

Funding organisation: Water Research Commission of South Africa.

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