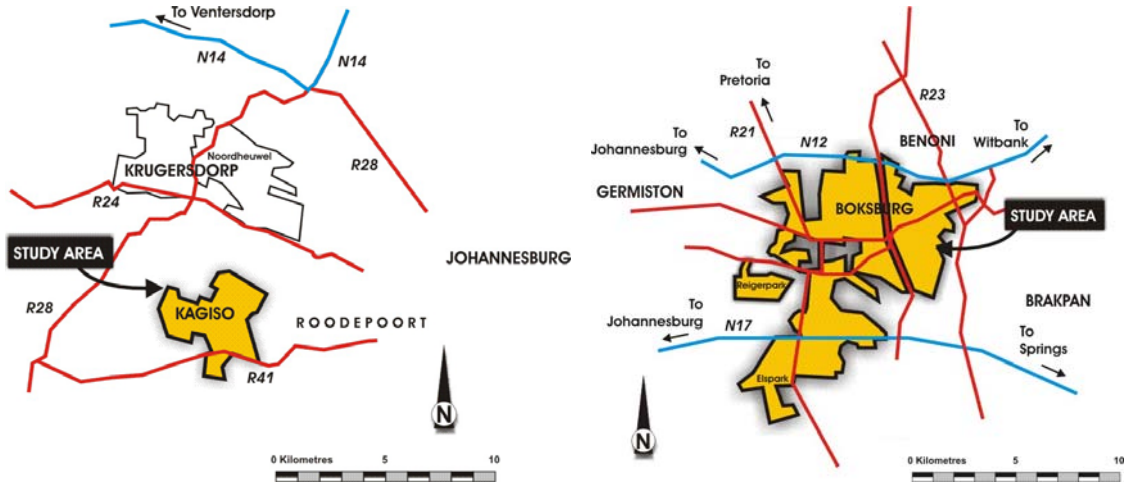
Benchmarking water usage at Gauteng day schools

Derek G Hazelton, TSE Water Services



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Benchmarking water usage at Gauteng day schools

Prepared for the
Water Research Commission
by

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for supplying the information on the number of learners and educators at each of the schools studied. This information, together with information abstracted from *Leakage reduction projects undertaken by Rand Water,* a booklet funded by Rand Water and the United Nations Centre for Human Settlement (Habitat) (McKenzie et al 2002), forms the basis of this report. **The locality maps and photos on the front cover** have also been abstracted from the *Leakage reduction projects* booklet. The locality maps are courtesy Habitat/Rand Water/WRP and the photos are courtesy Ayanda Consulting. From left to right, the top row of photos shows: 'a vandalised toilet pan', 'repairs to underground pipework', and 'a retrofitted dual flush toilet'. The bottom row shows: 'a broken urinal push button system', 'a school pupil using a push button tap', and 'a retro fitted urinal push button system'.

Lastly, the author acknowledges that he was motivated to write the report by a request from an Ekurhuleni community-based organisation, **Wonga Amanzi (Save Water) Community Development Services,** that sought a quick way of estimating the quantity of water being wasted by their local schools.

CONTENTS

TABLES

FIGURES

1. INTRODUCTION

1.1 Study details

This report is a brief study of the water usage at a number of schools in the Greater Boksburg and Greater Krugersdorp areas of Gauteng, that have been retrofitted to reduce losses.

1.2 Aims

a) To examine the water usage per user at the selected schools before and after retrofitting.

b) To examine the water usage per user after retrofitting against selected criteria including number of users, ratio of learners to educators, location, and school level (primary or secondary).

c) To make brief recommendations on the management of water at schools.

1.3 Motivation

Little information is currently available on water usage in Gauteng schools, and even if this were obtained from records of municipal meter readings, the figures would tend to reflect excessive usage and to be unreliable, because of the poor state of the infrastructure and of the water meters.

Schools are a significant user of water and an understanding of that water demand is important:

a) to planners of new schools and of the townships in which they will be situated,

b) for the monitoring, evaluation and management of ongoing water usage at schools,

c) for educators, when they are using a school's environment to actively involve learners in water conservation and demand management projects.

2. METHODOLOGY

2.1 Baseline study information

This report is based on sections 3.1 and 3.2 (pages 3.1 to 3.16) of the August 2002 Rand Water / United Nations Centre for Human Settlement (Habitat) / Water Resource Planning and Conservation (WRP) booklet *Leakage reduction projects undertaken by Rand Water* (McKenzie et al 2002). These sections describe two projects carried out to reduce water losses in schools in two municipalities that receive their bulk water from Rand Water. The projects concentrated on reducing the inefficient use of water, and on repairing leaks, as follows:

- **Urinals:** Tip tray flush mechanisms on urinals are widely recognised as a major source of water wastage in schools. Therefore, automatically flushing urinals were replaced with manually operated push button systems.
- **Toilet pans:** Particularly as the number of toilets available in many schools is limited, broken pans were replaced, as were cracked pans to avoid the risk of injury to the user should the pan break.

- **Toilet Cisterns:** All the existing toilet cisterns, generally with a capacity of 13 litres per flush, were removed and replaced with modern cisterns having 9/4,5 dual flush mechanisms.
- **Taps:** All existing conventional taps and non-SABS push taps were replaced by SABS-approved push button taps that close automatically as soon as the pupil releases the button. Such taps are designed to operate at a maximum pressure of 3 kPa. In cases where pressures above 3 kPa were found, pressure-reducing valves were installed on the supply pipe. All taps not requiring replacement had new washers installed and taps that were leaking at the head were serviced through replacement of the tap head assembly, or replacement or tightening of the graphite seal.
- **Pipework:** Underground piping was repaired where leaks were found. Copper pipe was used for all repairs carried out in the ablution and toilet facilities due to its toughness and resistance to corrosion.
- **Municipal water meters:** At a number of schools the municipal meters were found to be faulty or inoperative. This is one reason why before and after retrofitting results were not available for 37 % of the schools covered by the projects. Such problems were reported to the relevant municipality.

Some social interventions also took place to encourage behaviour change. These consisted of:

- Training school caretakers in basic repairs and better water usage practice.
- Having a programme for learners and educators on the importance of both hygiene and wise water usage

As can be seen from tables 1 & 2, and figures 1 & 2, the water savings achieved by the projects were significant. However, the results are unlikely to be sustainable because:

- Insufficient attention was paid to involving the schools' learners, educators, and caretakers in the planning and implementation of the projects, and in informing them of the results.
- No attempt was made to ensure that hygiene and wise water usage became a standard part of the schools' curriculum.
- No plans were made to ensure that regular meter readings would continue to be taken and evaluated, by learners and educators, after the completion of the projects.

2.2 Extending the information contained in the baseline study

The Rand Water booklet (McKenzie et al 2002) contains some details of the 'before' and 'after' water consumption at the schools.

However, since benchmarking was not part of the terms of reference, the booklet contains very little information about the schools. Their location is not clear, the level of schooling (primary or secondary) is not given in the majority of cases, but, most importantly, the number of learners and educators at the schools is omitted. Thus, the calculation of typical water usage per user is not given. Throughout this report, **number of users is defined as the total number of learners plus the number of educators registered at the school.**

By searching the Gauteng Department of Education's website, and by contacting the Gauteng Department of Education and the implementers of the two projects, the missing information described in the previous paragraph was obtained. There are still some discrepancies, because the Gauteng Department of Education could only supply figures for the number of learners and educators for the year 2002, whilst all other figures are from the years 1999 to 2001 inclusive.

Table 1: Greater Krugersdorp day schools: Water usage before and after retrofitting

No	School name	Area	Level	No of learners	No of educators	Learners per educator	No of water users Ls plus Es	Water usage before (kl/mth)	Water usage after (kl/mth)	Water usage before (l/user.day)	Water usage after (l/user.day)	Saving (%)
1	Ahmed Timol	Azaadville	Secondary	1 155	33	35,00	1 188	205	198	5,67	5,48	3,41
4	Boipelo	Kagiso	Primary	787	22	35,77	809	442	394	17,96	16,01	10,86
5	Bosele (Tuthuzekani)	Kagiso	Primary	1 243	29	42,86	1 272	260	173	6,72	4,47	33,46
6	Diphalane	Munsieville	Primary	1 040	24	43,33	1 064	428	282	13,22	8,71	34,11
7	Dr Yusaf Dadoo	Azaadville	Primary	1 081	30	36,03	1 111	454	277	13,43	8,20	38,99
11	Kaselihle	Kagiso	Primary	983	23	42,74	1 006	188	183	6,14	5,98	2,66
14	Madiba	Kagiso	Secondary	1 407	40	35,18	1 447	1 156	647	26,26	14,70	44,03
16	Mathasedi	Kagiso	Primary	867	22	39,41	889	300	146	11,09	5,40	51,33
17	Mosupatsela	Kagiso	Secondary	1 603	38	42,18	1 641	1 623	977	32,52	19,57	39,80
18	Phatudi	Munsieville	Primary	938	21	44,67	959	1 489	1 342	51,05	45,97	9,94
20	Sandile	Kagiso	Primary	917	27	33,96	944	368	196	12,82	6,83	46,74
21	Setlolamathe	Kagiso	Primary	720	20	36,00	740	385	185	17,10	8,22	51,95
22	Thembile	Kagiso	Primary	1 136	30	37,87	1 166	271	305	7,64	8,60	-12,55
23	Thusong	Kagiso	Primary	1 570	36	43,61	1 606	771	330	15,78	6,76	57,20
24	Thutolefa	Munsieville	Secondary	1 090	30	36,33	1 120	627	339	18,40	9,95	45,93
			Totals:	16 537	425	38,91	16 962	8 967	5 973	17,38	11,58	33,39

Table 2: Greater Boksburg day schools: Water usage before and after retrofitting

No	School name	Area	Level	No of learners	No of educators	Learners per educator	No of water users Ls plus Es	Water usage before (kl/mth)	Water usage after (kl/mth)	Water usage before (l/user.day)	Water usage after (l/user.day)	Saving (%)
1	Dithomo	Vosloorus	Primary	820	22	37,27	842	300	128	11,71	5,00	57,33
2	Masithwalisane	Vosloorus	Secondary	1 383	40	34,58	1 423	1 084	165	25,04	3,81	84,78
3	Erasmus Monareng	Vosloorus	Secondary	1 368	38	36,00	1 406	192	117	4,49	2,74	39,06
4	Ndlelende	Vosloorus	Primary	866	21	41,24	887	261	104	9,67	3,85	60,15
5	Zimele	Vosloorus	Primary	877	24	36,54	901	448	165	16,35	6,02	63,17
6	Fortune Kunene	Vosloorus	Primary	943	23	41,00	966	200	407	6,81	13,85	-103,50
7	Illinge High	Vosloorus	Secondary	1 280	40	32,00	1320	450	218	11,21	5,43	51,56
8	Khayelihle	Vosloorus	Primary Secondary	1 008	26	38,77	1 034	799	739	25,40	23,50	7,51
9	Vosloorus	Vosloorus	Comprehensive	1 441	46	31,33	1 487	780	1 377	17,25	30,44	-76,54
10	Thabang	Vosloorus	Primary	987	24	41,13	1 011	119	93	3,87	3,02	21,85
11	Abinala	Vosloorus	Primary	1 003	28	35,82	1 031	1 192	311	38,01	9,92	73,91
12	Mthimkulu	Vosloorus	Primary	885	23	38,48	908	200	284	7,24	10,28	-42,00
13	Reiger Park	Reiger Park	Primary	1 300	34	38,24	1 334	175	89	4,31	2,19	49,14
14	Wit Deep	Witfield	Primary	593	20	29,65	613	400	183	21,45	9,81	54,25
15	Freeway Park	Freeway Park	Primary	754	30	25,13	784	622	281	26,08	11,78	54,82
16	Baanbreker	Parkrand	Primary	750	27	27,78	777	918	200	38,84	8,46	78,21
17	Oosterlig	Sunward Park	Secondary	829	32	25,91	861	1 746	548	66,67	20,92	68,61
19	Mampudi	Vosloorus	Primary	545	14	38,89	559	56	43	3,29	2,53	23,21
22	Parkdene	Parkdene	Primary	718	27	26,59	745	2 559	1 142	112,93	50,40	55,37
26	Rebontsheng	Vosloorus	Primary	963	24	40,13	987	889	461	29,61	15,36	48,14
28	Hennie Basson	Boksburg North	Primary	587	18	32,61	605	194	216	10,54	11,74	-11,34
30	Voortrekker	Boksburg	Secondary	685	18	38,06	703	425	156	19,88	7,30	63,29
31	Bokssburg	Boksburg	Secondary	1 310	67	19,55	1 377	1 070	680	25,55	16,24	36,45
33	Van Dyk	Van Dyk Park	Primary	593	17	34,88	610	94	71	5,07	3,83	24,47
34	Summerfields	Impala Park	Primary	742	27	27,48	769	482	169	20,61	7,23	64,94
36	Westwood	Westwood	Primary	529	21	25,19	550	890	686	53,20	41,01	22,92
41	Sunward Park	Sunward Park	Secondary	1 019	42	24,26	1 061	795	600	24,63	18,59	24,53
43	Martin	Boksburg North	Primary	815	35	23,29	850	297	267	11,49	10,33	10,10
			Totals:	24 313	768	31,66	25 081	17 187	9 682	22,53	12,69	43,67

3. FINDINGS

3.1 Introduction

The findings are given in tabular form in tables 1 & 2. The school numbering is taken from the booklet *Leakage reduction projects undertaken by Rand Water* (McKenzie et al 2002). Some school numbers are missing because, for 30 of the 73 schools retrofitted, no water usage figures were taken before and after retrofitting. Thus, this report extends the usefulness of the earlier booklet by examining in more detail the water usage at a sample of 43 schools; 28 in the Greater Boksburg area and 15 in the Greater Krugersdorp area of Gauteng Province, South Africa.

3.2 Water usage per user before and after retrofitting

Figures 1 and 2 are a graphic representation of the water usage per user, in litres per day, before and after retrofitting at the schools in the Greater Krugersdorp and Greater Boksburg areas respectively. The schools in each area have been entered in ascending order of water usage after retrofitting. The particular schools can be identified from the lists in tables 1 and 2. The school labels without numbers on the x-axis of the figures (B, K and BK) show the average water usage in the two individual areas and in the combined areas.

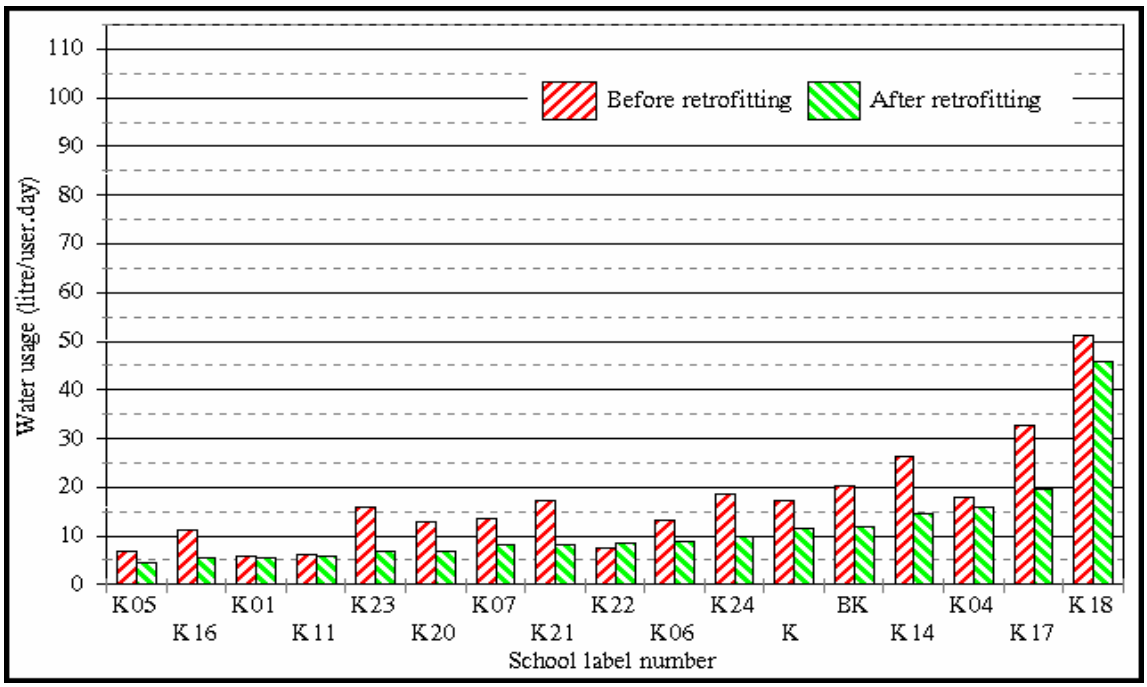

Figure 1: Greater Krugersdorp day schools: Water usage per user before and after retrofitting

Significant items that can be observed from figures 1 and 2 include:

- A large number of schools in both areas had low water usages before retrofitting and yet in the majority of these cases the usage decreased further after the retrofitting. This may be due to toilet facilities being poorly kept from a general hygiene viewpoint and learners thus being put off using them.
- Three of the schools, one in the Greater Krugersdorp area and two in the Greater Boksburg area, with high water usage before retrofitting, remained in this category after retrofitting. This reflects that additional efforts are required to overcome high water usage and/or wastage.
- Despite a considerable average reduction in water usage in both the areas being examined, in five out of the 43 schools water usage increased. This may be due to the toilet facilities being more hygienically acceptable to the users after retrofitting.

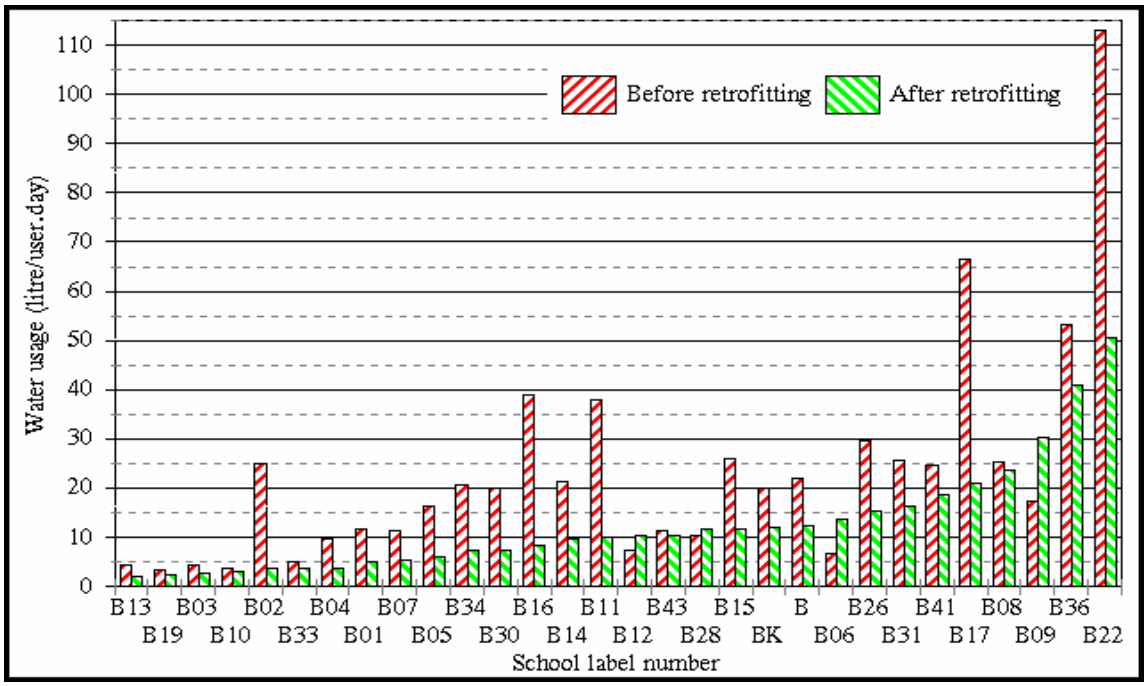

Figure 2: Greater Boksburg day schools: Water usage per user before and after retrofitting

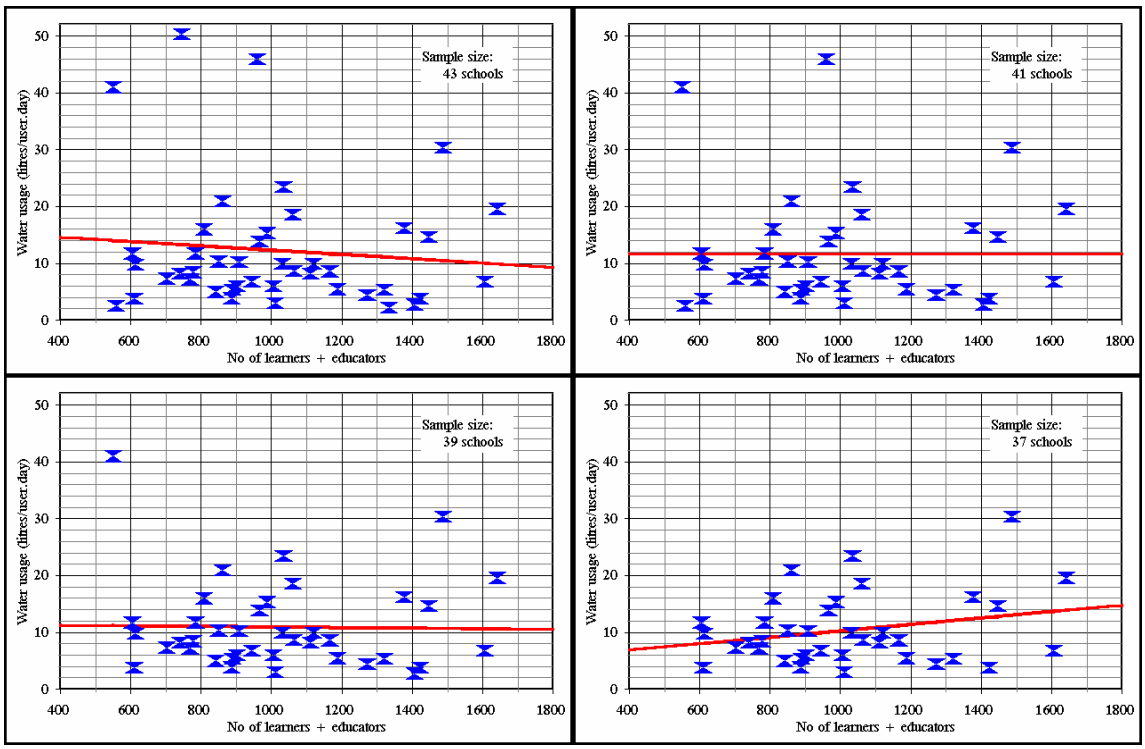

Figure 3: Greater Boksburg and Greater Krugersdorp day schools: Graphs, with decreasing sample size, of the water usage per user after retrofitting against the number of users

3.3 Water usage per user after retrofitting analysed against school size

Figure 3 examines the water usage per user after retrofitting against the number of users at the different schools. From tables 1 & 2, and figures 1 & 2, it can be seen clearly that even after retrofitting the water usage per user varies widely from approximately 2 to 50 litres per user per

day. Because of this wide variation, the basic graph has been plotted four times, reducing the sample size by two for each plot, to check the sensitivity of the best linear fit to the sample size. In each case, the pair of schools with highest and lowest water usage per user has been omitted.

Because of the small sample size and the wide variation in water usage per user, progressively omitting the pair of schools with highest and lowest water usage per user has a material influence on the slope of the best linear fit line. Thus, although the first graph shows a decrease in water usage per user as the number of users increases, the remaining three graphs show that this trend is not significant. Therefore, using the second graph as a typical indication, **the average water usage per user at the schools after retrofitting is 12 litres per day and the usage per user is independent of the size of the school.**

3.4 Water usage per user after retrofitting analysed against the number of learners per educator

Figure 3 examines the water usage per user after retrofitting against the ratio of learners to educators. Again, the basic graph has been plotted four times, reducing the sample size by two for each plot, to check the sensitivity of the best linear fit to the sample size.

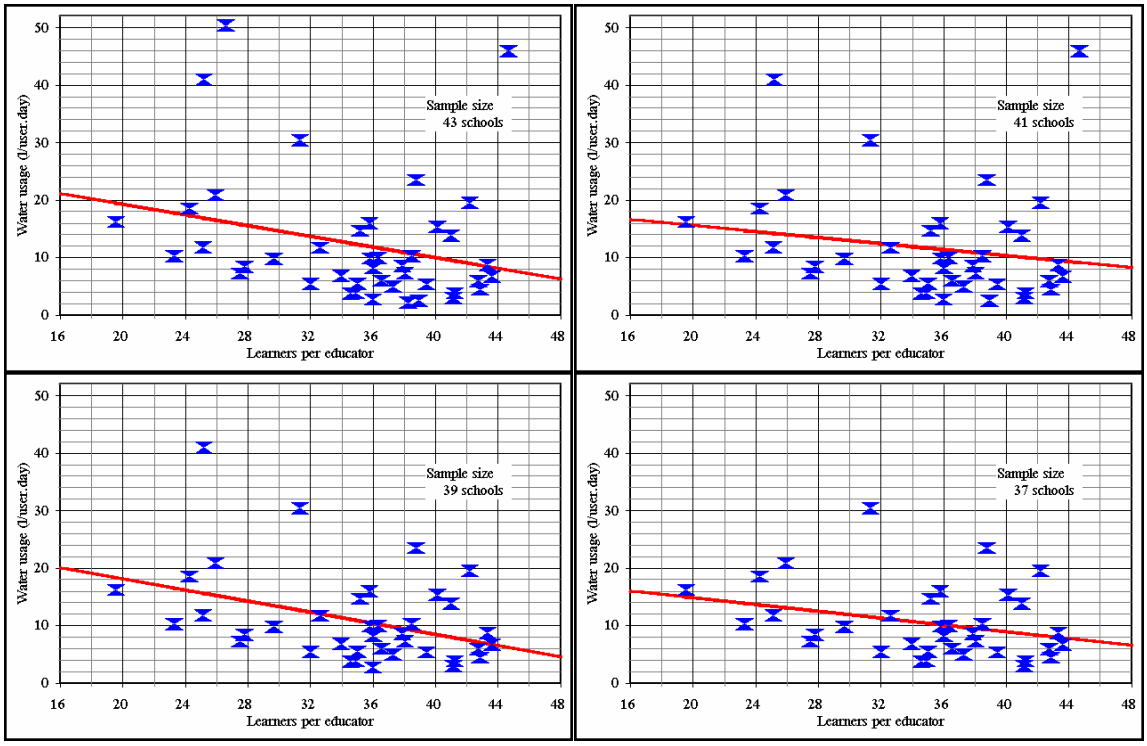

Figure 4: Greater Boksburg and Greater Krugersdorp day schools: Graphs, with decreasing sample size, of the water usage per user after retrofitting against the number of learners per educator

In contrast to figure 3, for figure 4 the water usage per user measured against the number of learners per educator is similar in each of the four graphs. Using the second graph of figure 4 as a typical indication, **the average water usage per user decreases from 16 to 8 litres per day as the number of learners per educator increases from 20 to 44.**

This correlation between water usage and the number of learners per educator is similar to that shown in figure 5, this latter figure having been derived in a slightly different manner. **The reason for this correlation is probably that a low number of learners per educator is a good indicator of a better-resourced school, which has an ample, hygienically-maintained water and sanitation infrastructure. This infrastructure is then more**

frequently used by the learners, because of smaller queues and more pleasant surroundings.

3.5 Water usage per user after retrofitting analysed against various other criteria

The average water usage per user in the Krugersdorp schools is on average less than in the Boksburg schools. Similarly, the average water usage per user in the primary schools is less than that used in the secondary schools, and the average water usage per user in the old Black (African) township schools is less than that used in the schools in the other townships. However, when individual graphs are drawn separating out the schools in terms of these three criteria, the only difference that can be detected is a lower usage that correlates with a higher number of learners per educator. **Thus, the underlying reason for the lower average usage per user is the overall situational difference that exists in schools with more learners per educator. It is not a direct function of the other criteria being examined.**

Therefore, instead of reproducing graphs similar to those in figures 3 and 4, which distinguish individual schools based on the particular pair of criteria being examined, a single graph, figure 5, has been produced in their place.

Figure 5 is a plot of the average water usage per user for each of eight groups of schools together with the best-fit straight line. The eight groups are arrived at by separating out the combinations of the three pairs of criteria originally considered to be worth analysing individually. Table 3 lists the groups, states the resultant sample size, and illustrates the marker styles used in figure 5 to distinguish each one.

Table 3: Explanation of the markers used in figure 5

■	1 Boksburg, primary schools, old Black township. Sample size: 10.
▲	2 Krugersdorp, primary schools, old Black townships. Sample size: 10.
▼	3 Boksburg, primary schools, all other townships. Sample size: 10.
⧗	4 Krugersdorp, primary schools, all other townships. Sample size: 1.
●	5 Boksburg, secondary schools, old Black township. Sample size: 4.
⊠	6 Krugersdorp, secondary schools, old Black townships. Sample size: 3.
⧖	7 Boksburg, secondary schools, all other townships. Sample size: 4.
○	8 Krugersdorp, secondary schools, all other townships. Sample size: 1.

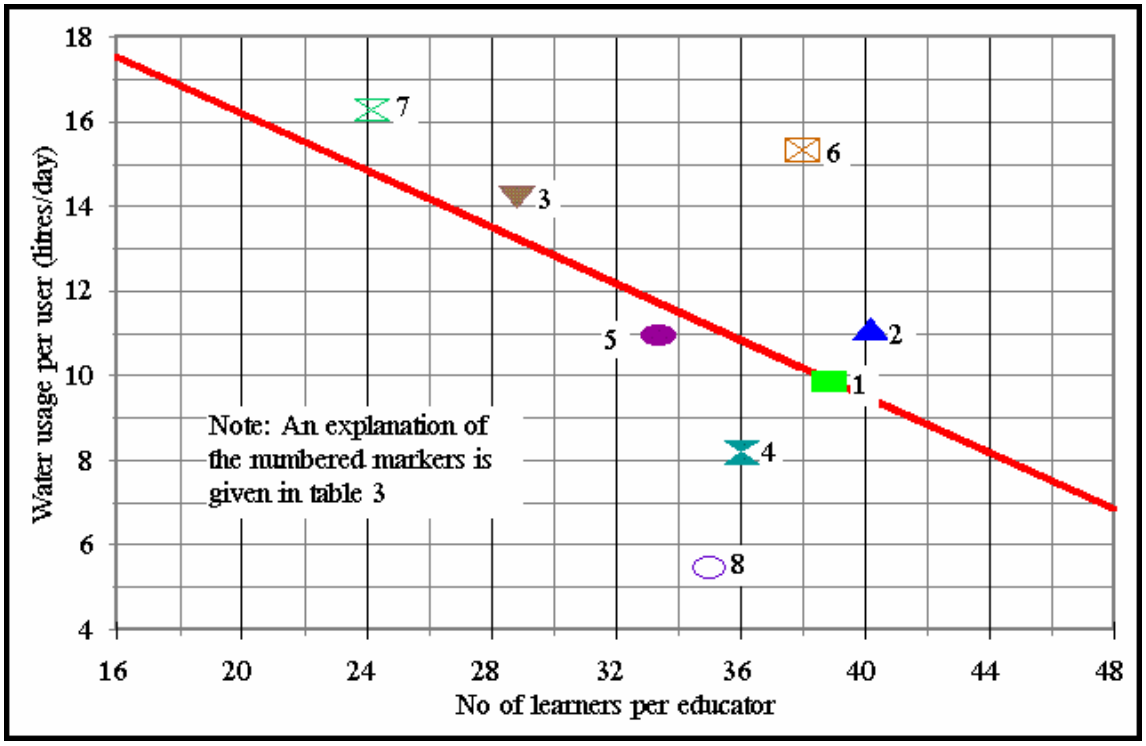

Figure 5: Greater Boksburg and Greater Krugersdorp day schools: Average water usage per user after retrofitting for different groups of schools against the number of learners per educator

It should be noted that the three points closest to the best fit line correspond to sample sizes of between four and ten, whilst the three points furthest from the best fit line correspond to very small samples ranging from one to three. Therefore, it cannot be assumed that the distance of these latter three points is significant. The two low points, however, both refer to single schools in a formerly Indian Krugersdorp township. This may suggest that the water usage in schools in old Indian townships is managed more carefully than in schools in other areas. On the other hand, the sample size is too small to draw any definite conclusions.

4. SUMMARY CONCLUSIONS

4.1 Overall conclusions

The water usage at the sample of 43 schools in the Greater Boksburg and Greater Krugersdorp Municipalities in Gauteng was reduced on average by 40% from 20 to 12 litres per person per day through the implementation of a retrofitting project in sections of the two municipalities. The project entailed the identification and repair of leaks in the internal water distribution and plumbing fittings in the schools. Very little education of staff or learners took place and it is suspected that at least some of the reduction will be not be sustainable.

Despite the large reduction in usage achieved through the retrofitting projects, even subsequently, water usage per user at individual schools varied widely from 2,2 to 50,4 litres per day. This spread is clearly shown in tables 1 & 2, and figures 1 & 2.

4.2 Other conclusions

The size of individual schools made no discernable difference to water usage per user. The water usage per user in Krugersdorp schools was on average lower than in Boksburg schools and a similar pattern was observed between all the primary schools and all the secondary schools, and between all the schools in the old Black (African) townships and all the schools in the other townships, **but no discernable difference in water usage could be attributed to any**

of these factors alone. The only variable found that provided a good correlation to explain the discernable differences was the number of learners per educator. This correlation is depicted in figures 4 and 5.

As the number of learners per educator increases from 20 to 44 the average water usage per user decreases from 16 to 8 litres per day. The correlation probably exists because a low number of learners per educator is a good indicator of a well-provided-for school with ample, hygienically maintained water and sanitation infrastructure.

5. RECOMMENDATIONS

5.1 For water services authorities

School is an important place for future generations to learn everyday life skills, and is even a source of help to parents that received a poor education, through their learning of new skills from their children. It is therefore recommended that schools be made to reflect the home environment as much as possible through, for example, **being included in municipalities' free basic amount of water programme.** Up to say 8 litres per user per day would be free, whilst schools using in excess of say 24 litres per user per day would be billed so that they created a small surplus for the water services provider.

Water services authorities could also **organise school competitions** in their area of responsibility. To qualify for being considered, a school's water usage would have to be regularly between 7 and 10 litres per day per user. Thereafter, awards would be based on the excellence of the sanitary surroundings maintained in the school, to promote hygienic behaviour, and of learners posters, displayed in prominent places, illustrating the wise use of water in school, and how it has been sustained.

5.2 For planners of new day schools

No school with water borne sanitation should be planned without **allowing for an average water usage per user of at least 10 litres per day.** Any significant lower usage only perpetuates an unhealthy environment. This is particularly unacceptable in schools, which, along with other aims, exist to present key life skills to young learners.

Planners should also carefully **consider the aspects of a school's design that help to reduce the demand for water whilst simultaneously promoting practices that will help learners to achieve the highest health benefits from the water infrastructure at the school.** For basic infrastructure, the former includes: a sufficient number of sectional isolating valves; push button urinals; a dual flush, or, better still, a simple flushing mechanism that only releases water whilst the handle is held down, installed in low volume toilet cisterns with matching pans; pressure controllers; and push button demand taps. The latter includes: the provision of robust holders for toilet paper and disposal bins for sanitary pads and rubbish, small wash hand basins with plugs, and the proper provision of soap and hand drying facilities.

After starting by allowing for an average water usage per user of at least 10 litres per day, planners need to examine the broader environment in which the school is being built. **In high-income areas, it will be necessary to consider increasing the design for average usages per user up to 16 litres per day.** Additional infrastructure may include, for example, some well-designed low discharge rate showerheads installed near the school's sports fields.

Schools may also plan to use the municipal supply **for watering flower gardens, playing fields, or educational vegetable gardens.** Before including such water demands in the design, planners need to consider alternatives such as rainwater harvesting, on site treatment and reuse of grey and/or black water and, perhaps, borehole water. Such alternatives should be considered with the participation of the local water services provider and a representative group of parents with an interest in the future sound functioning of the school.

The ratio between the maximum short duration water demand and average demand need special attention in designing day school water services infrastructure, because the users of the water services are only there for a part of the 24 hour day, for five days a week and with main access occurring whilst classes are not taking place. Determining this peak demand ratio was not part of the scope of this study, but it does need to be considered carefully.

5.3 For monitoring ongoing water usage by learners, educators and caretakers

Once a school has learners and educators, the governing body should **appoint a general caretaker to take a lead role in ensuring that the property is kept tidy and that the school's infrastructure, fittings, and equipment are kept in good working order.** The care of the school's water and sanitation infrastructure and consumable materials, such as toilet rolls and soap, should form a key duty in the caretaker's schedule of responsibilities.

However, **specific learners, school prefects or SRC representatives, and educators should be appointed** to ensure that all learners know how to make the best use of the water and sanitation facilities at the school to promote hygiene, whilst simultaneously using the water efficiently, and taking care of the infrastructure. In this way, the facilities become a part of the life skills learning process and the caretaker's duties become a support role, rather than an impossible task.

The school's life skills learning curriculum should include modules on:

- Water use in South Africa and in the municipality within which we live.
- **Why it is important to use water wisely and to prevent pollution.**
- **Reading our school's incoming water meter regularly and evaluating the water usage and water usage trends.**
- **Regularly checking and, if necessary, reducing water wastage in our school.** Wastage from leaking fittings or pipework can be checked and roughly quantified by measuring a school's minimum night flow. This should be done by someone, probably the caretaker, reading the incoming water meter, ideally every hour, over a period of at least six hours, between the time all extra-mural activities have finished and activities start the following morning. From these readings, the total wastage can be estimated. Thereafter, the wastage needs to be subtracted from the total usage, before any exercise is implemented, to quantify how much water is being used beneficially at a school.
- **Quantifying how much water is being used beneficially for different activities in our school and checking if it varies with the seasons and/or weather patterns.**
- **Hygiene promotion.**

The life skills learning process should be used in an ongoing way to manage the water usage at schools, as well as aiming to benefit the learners from both a health improvement and home water management viewpoint.

Figure 5 indicates the typical amounts of water used per user per day in different schools according to the number of learners per educator. Figure 6 converts these water usage figures into cumulative water usage figures per month, depending on the number of users in a school.

Just because a school uses an amount of water close to the typical amount reflected in figure 5, this does not necessarily mean that the water is being used efficiently. Thus ensuring efficient usage is one of the aims of introducing ongoing regular water monitoring into the life skills learning curriculum at all schools.

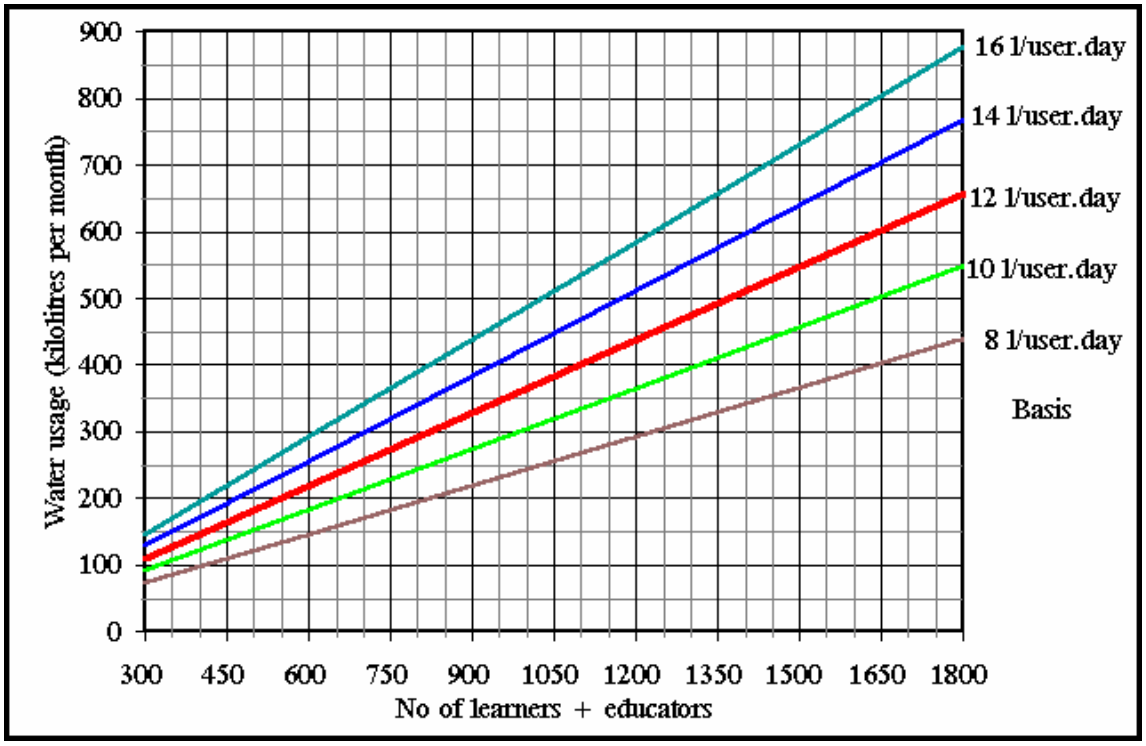

Figure 6: Water used per month in schools of different sizes for different rates of usage per user

REFERENCES AND FURTHER READING MATERIAL

DWAF (2001) *2020 vision for water project: A resource pack for active learning in water and environmental conservation in South African schools and communities.* Water Conservation Directorate, Department of Water Affairs and Forestry, Pvt Bag X313, PRETORIA, 0001 South Africa. pp 88.

McKenzie RS, Wegelin WA, & Meyer N (2002) *Leakage reduction projects undertaken by Rand Water*. Habitat/Rand Water/WRP, Rand Water Marketing and Communications, PO Box 1127, JOHANNESBURG, 2000 South Africa. Aug 2002. pp 113.

Soul City (2001) *Breaking the rules: New approaches to promoting health through water and sanitation in South Africa.* Soul City, The Institute for Health and Development Communication, PO Box 1290, HOUGHTON, 2041 South Africa. pp 239.