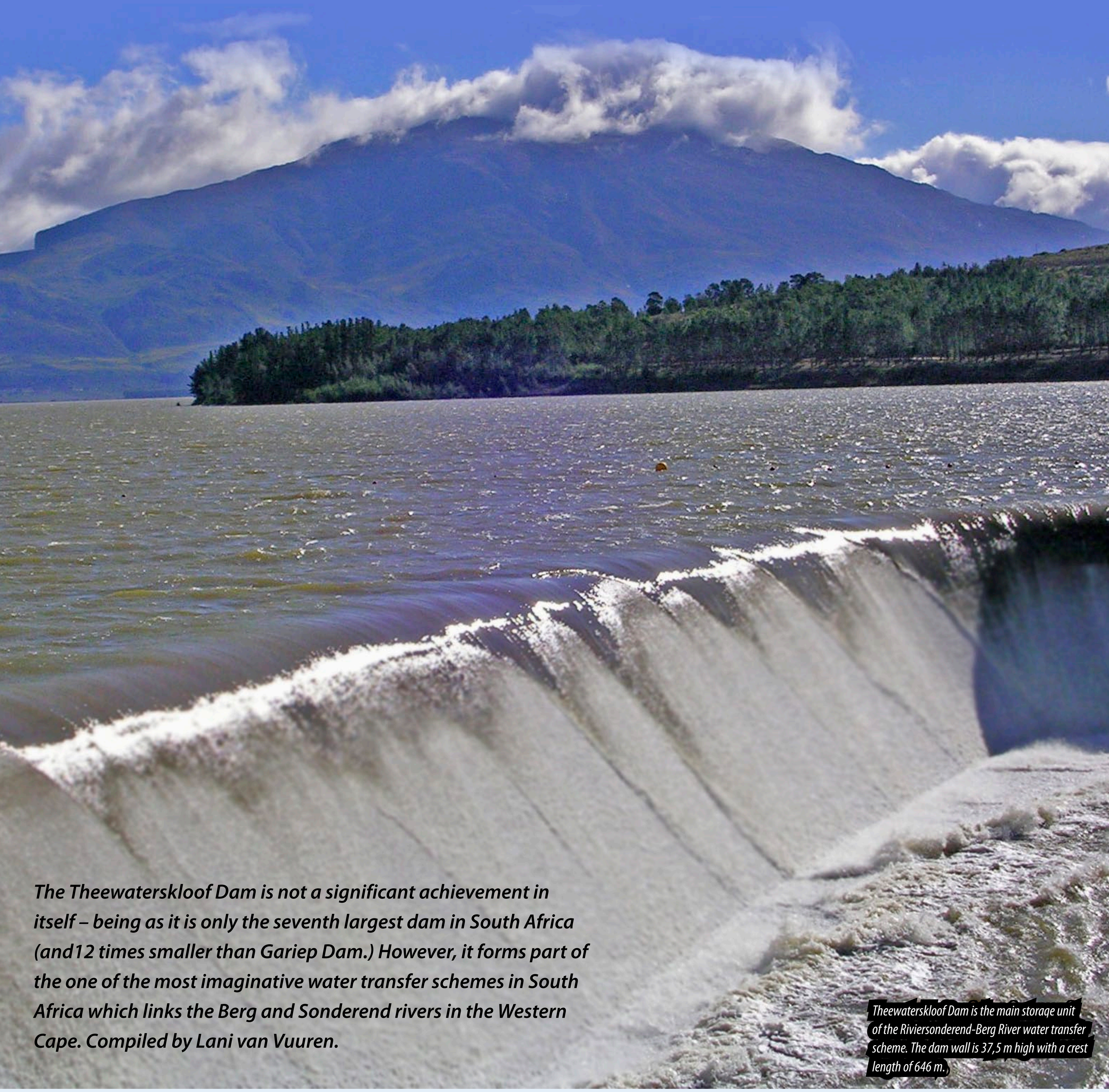
Blood, sweat and tears at Riviersonderend



The Theewaterskloof Dam is not a significant achievement in itself – being as it is only the seventh largest dam in South Africa (and12 times smaller than Gariep Dam.) However, it forms part of the one of the most imaginative water transfer schemes in South Africa which links the Berg and Sonderend rivers in the Western Cape. Compiled by Lani van Vuuren.

Theewaterskloof Dam is the main storage unit of the Riviersonderend-Berg River water transfer scheme. The dam wall is 37,5 m high with a crest length of 646 m.

The storage potential of the Riviersonderend was realised as far ago as the 1800s, but it was the Irrigation Department who started the first serious investigations into the possibility of a scheme here in 1929. This mountainous region has one of the highest rainfalls in South Africa (as much as 5 000 mm/year).

A provisional dam design had actually been completed by 1952, and by 1964 the focus has zoomed in on the Theewaterskloof as the best storage site available. When the Greater Cape Town again started experiencing water shortages following the construction of the Wemmershoek Dam, it was decided to go ahead with the Riviersonderend-Berg River scheme. The scheme would not only supplement water supply to Cape Town, but would also be used to provide irrigation water during the dry months to farmers in the Boland. The project was described as 'one of the most impressive civil engineering projects of the 1980s'.

The scheme essentially involved linking the two water-rich catchments of the Riviersonderend and the Berg River to discharge surplus winter runoff into one central storage dam. When the need for water arises, it is delivered by gravity through a series of tunnels to where it is needed.

The interesting feature of the scheme lies in the fact that the flow can be reversed so that water from the Berg River can in the first place be stored in the Riviersonderend Valley and then be conveyed back in the dry summer to provide irrigation water in the supply of the valley from where it originated.

The project was constructed in two phases. The first phase comprised the construction of the Theewaterskloof Dam (the central storage unit for the scheme), the Franschhoek tunnel and associated works, while the second comprised the Jonkershoek Tunnel system, including several shafts and balancing dams on the Eerste River at Kleinplaas and the Berg River at Assegaaibos. The White Paper for the provision of the first phase was laid before Parliament in 1968 and construction started in 1970. The project was planned, designed and constructed by DWA.

Theewaterskloof is a conventional earthfill dam. The structure, which was completed in 1979, is 37,5 m high above the lowest foundation, and has a crest length of 646 million m^3. The dam has a gross storage capacity of 482-million m^3. When full the dam water covers an area of 5 100 ha. A conduit through the embankment is divided into two chambers housing the low-level and normal outlets respectively. The low level outlet, which has a maximum capacity of 180 m^3/s is controlled by a slab gate at the upstream end of the culvert and the discharge energy is dissipated by means of a flip bucket.

In turn, the normal outlet pipes in the upper chamber are controlled from an inlet tower with draw-offs at different levels in the reservoir. The spillway, which is capable of handling a probable maximum flood of 394 m^3/s, is of the side-channel type and the chute ends in a stilling basin.

A subsidiary embankment inside the Theewaterskloof basin contains the Charmaine inlet and outlet. The embankment is a composite structure – a concrete spillway flanked by a 6 m-high earthfill of crest length 136 m – designed to create a sediment retention basin which allows the intakes to draw of clear water into the Franschhoek Tunnel.

The Franschhoek Tunnel is a reinforced concrete tunnel runing from the Charmaine outlet through the Theewaterskloof basin. The 4,3 m-diameter tunnel penetrates the Franschhoek Mountains for a distance of 7,9 km and breaks through at Assegaaibos in the Berg River Valley.

ENGINEERING FEATURES OF THE THEEWATERSKLOOF DAM

- **Type:** Earthfill
- **Height above lowest foundation:** 37,5 m
- **Gross storage capacity:** 482 million m^3
- **Crest length:** 646 m
- **Type of spillway:** Side-channel
- **Spillway capacity:** 390 m^3/s
- **Area at full supply level:** 5 100 ha

The Charmaine wall structure under construction in December 1976. The wall, which houses the Charmaine intake and outlet is situated inside the basin of the Theewaterskloof Dam.

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The Banhoek shaft under construction in 1979. The shaft is 162 m deep and 1,8 m in diameter.

Of the total length, 4,1 km was constructed as a reinforced concrete tunnel in an open cut, which was then later covered and the topsoil – which had previously been carefully removed and stored – replaced. This open cut required some 1,4 million m^3 of excavation. The tunnel has a maximum delivery capacity of 33,5 m^3/s. The remainder of the tunnel went through solid rock, 193 000 m^3 of which had to be removed.

At the end of the Franschhoek Tunnel, the Berg River is negotiated by means of a 33,5 m-diameter reinforced concrete siphon with supplementary intakes from the Assegaaibos Dam and outlets into the Berg River. Another tunnel, the Dasbos Tunnel, branches away from the main tunnel close to the 67 m-deep Wolwekloof shaft. This tunnel has a carrying capacity of 10,4 m^3/s.

The first phase of the project was completed in 1980.

Constructed in the second phase which took off in 1974, the Jonkershoek Tunnel system includes a total of 23 km of tunnels, and two diversion weirs connected with the main tunnels by shafts. In total, some 481 00 m^3 of excavation was required, while 236 000 m^3 of concrete was used.

Water spills of the Kleinplaas Dam concrete gravity spillway in 1982. The dam has a storage capacity of 377 000 m^3.


Frans Druyts

FACTS AND FIGURES

- Theewaterskloof Dam is the seventh-largest dam in South Africa, but 12 times smaller than Gariep Dam, the country's largest dam.
- If all the holes drilled for blasting on the Riviersonderend-Berg River project were to be joined into one continuous hole, it would reach over a distance of roughly 2 300 km.
- The 470 000 m^3 of concrete cast on the project was only 40% as much as that used to build the Vanderkloof Dam.
- Measured in 50 kg pockets, 3,4 million pockets of cement went into the various constructions on the project.
- If all the soil and rock excavated were to be placed on an area the size of a rugby field, the dump would be 12 storeys high.
- One and a half million kilograms of dynamite was used for blasting on the project.

Source: DWA

The main Jonkershoek tunnel cuts through the Groot Drakenstein and Jonkershoek mountains for 13 km to surface at the Kleinplaas Dam on the headwaters of the Eerste River in the Jonkershoek Valley. The Jonkershoek section contains two shafts connecting the tunnel to concrete diversion weirs, one the 67 m-deep and 4 m-diameter Wolwekloof shaft, which links the tunnel with a weir in the Wolwekloof River, and the other a 162 m-deep and 1,8 m-diameter shaft which links up the Banhoek diversion weir. Close to the Wolwekloof shaft, the Dasbos tunnel branches off from the main tunnel.

Between the Berg River and Wolwekloof the Jonkershoek Tunnel has an internal diameter of 4,3 m and a capacity of 33,5 m^3/s, but after Wolwekloof it narrows to a diameter of 3,5 m and a capacity of 15 m^3/s. The Kleinplaas balancing and diversion dam is fed by the

Jonkershoek River as well as by the tunnel system, and diverts water into the Stellenboschberg Tunnel as well as supplementing the flow in the Eerste River. A 200 m-long inverted siphon of 3,5 m diameter connects the Jonkershoek Tunnel system to the Franschhoek Tunnel.

The Jonkershoek tunnel was the largest tunnel project ever undertaken by the DWA up to that time without the help of outside contractors and the second largest in South Africa. The tunnelling side of the project presented immense challenges to the department's engineers and it demanded great ingenuity, patience and resolve to solve the problems encountered.

Ground conditions were found to be exceptionally bad in some places, with geological formations varying tremendously from hard to soft, sandy conditions. Any route through the mountains was going to be challenging and so the designers opted for the shortest. They ran into several serious fault planes, which severely hampered progress. Tunnelling was made even more difficult in some places by the fact that, in order to allow water from the various catchment areas to flow by gravity, it was necessary to tunnel below the water table.

Frans Druyts

The Berg River siphon under construction in 1981.

The soft formations encountered were very often outside the experience of even South African mining experts, and so experiments were conducted as work continued. Many a time tunnelling parties were forced back as sand and mud flooded into the working areas through faults. At one point during work on the Franschhoek Tunnel, operations broke through from granite into a plane of granite/sandstone.

The roof collapsed and tons of mud and water poured into the tunnel. It took 22 months to pass through this 50 m-wide fault, as it was necessary to undertake extensive diamond core drilling to determine the extent of the bad ground. When compared with the 45 m per week which the Berg River Tunnel team achieved, a concept of the extent of the problem can be formed.

In the process department engineers also had to develop new techniques to allow these faults to be crossed. Grouting failed hopelessly. After several months of high pressure grouting, using some 25 000 pockets of cement, the tunnel face, which had been closed by a 9 m concrete plug, was opened up to reveal that the grouting had been ineffective. Chemical grouting was also tried unsuccessfully.

Environmental conservation played an important part in the planning and execution of the project. Landscape architects were appointed for the whole project and disturbed areas were restored as naturally as possible. The open section of the Stellenbosch Tunnel from the Kleinplaas Dam is given as a fine example of the care with which environmental restoration was applied.

Here the surface soil was carefully removed and kept aside so that, after the concrete works were covered, it could be placed on top again. Attention was also paid to the combating of potential driftsand problems in the Theewaterskloof Dam basin area. Where possible stone quarries were sited in dam basins or in less conspicuous places.

In 1981, this project received an achievement award from the South African Institution of Civil Engineering. The project was officially concluded in 1982 apart from the Assegaaibos Dam, which was only completed a few years later. ❑

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