KOUGA DAM – Serving the fertile Gamtoos valley

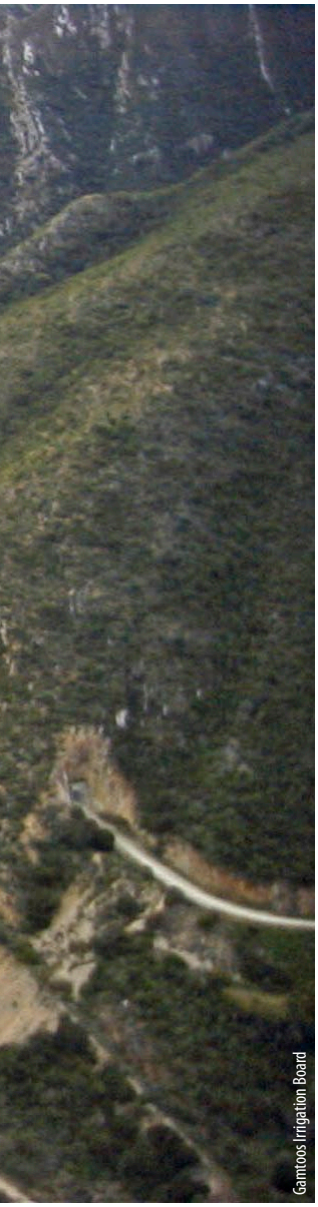
In one of the most fertile valleys of the Eastern Cape lies the Kouga Dam, which for more than 50 years has played a pivotal role in water supply and flood control in the region. Lani van Vuuren traces the history of the dam.

Situated between winter and summer rainfall areas the Gamtoos valley is known for its rich, fertile soils, its fresh water, and its subsequent agricultural bounty. The main river running through the valley is the Kouga River. Rising at Avontuur at a height of 1 500 m above sea level, the Kouga River flows through the Langkloof Valley, lying between the Tsitsikamma, Kouga and Winterhoek mountains. After joining up with its tributary, the Baviaanskloof River, it flows through a narrow gorge, the Kougapoort, to its confluence with the Groot River. After the confluence, the name of the river changes to Gamtoos.

The valley was originally populated by Khoisan communities. Trekboers first settled in the Gamtoos valley with their livestock in the era of Dutch occupation, and by 1770 the Gamtoos River was declared the eastern boundary of the Cape settlement. This remained so until 1804 when the area became part of the newly proclaimed Uitenhage district. Between 1816 and 1818 the first farms of around 1 713 ha each were officially handed over to European farmers.

THE START OF IRRIGATION

Irrigation in the valley started in the 1840s and gained momentum after the introduction of lucerne to bolster the production of ostrich feathers. Storage weirs and



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Above: Kouga Dam is located near the downstream end of the Gamtoos valley in a narrow gorge.

Right: The Kouga Dam wall during construction. Cocopans were used to bring concrete to the top of the wall. Here the rail can clearly be seen.

distribution canals were constructed by several farmers in the district who wanted a share of one of South Africa's most lucrative export products at the time. Where weirs were impractical steam and oil pumps were used to bring water from the river to the field.

Following a visit to the valley agricultural assistant to the Cape government wrote in 1904: "Some help is needed to simplify the present complicated system of distribution... The present system of using the water is wasteful to extreme. The temporary dams are inefficient and constantly being broken by floods. The water leading canals are small and long, badly laid out and far too numerous, owing to a lack of combination among the proprietors and it only requires organisation and a readier outlet for the produce to bring great prosperity.

"Should the government undertake the work of regulating and conserving the water supply of the Gamtoos valley the scheme that would meet the most general approval on the part of the inhabitants would be one for the construction of a series of dams in the bed of the river itself, from which the water might be brought on the land either by gravitation or by pumping."

These unorganised and primitive methods of extracting water led to numerous requests by community leaders and the farmers themselves for intervention by the State through the development of proper irrigation schemes. In 1910, the Cape Director of Irrigation, FE Kanthack, visited the valley. He called it "the most favourable part of the Union." Following the promulgation of the Irrigation and Conservation of Waters Act of 1912 several Irrigation Boards were established in the Gamtoos valley, including the Kougapoort, Reenen and Rademeyer Irrigation Boards. By the 1950s, there were some 4 798 ha of land under irrigation in the valley. The main crops under irrigation at that time were citrus, tobacco, vegetables, potatoes, wheat, maize and lucerne, with Port Elizabeth proving a convenient market.

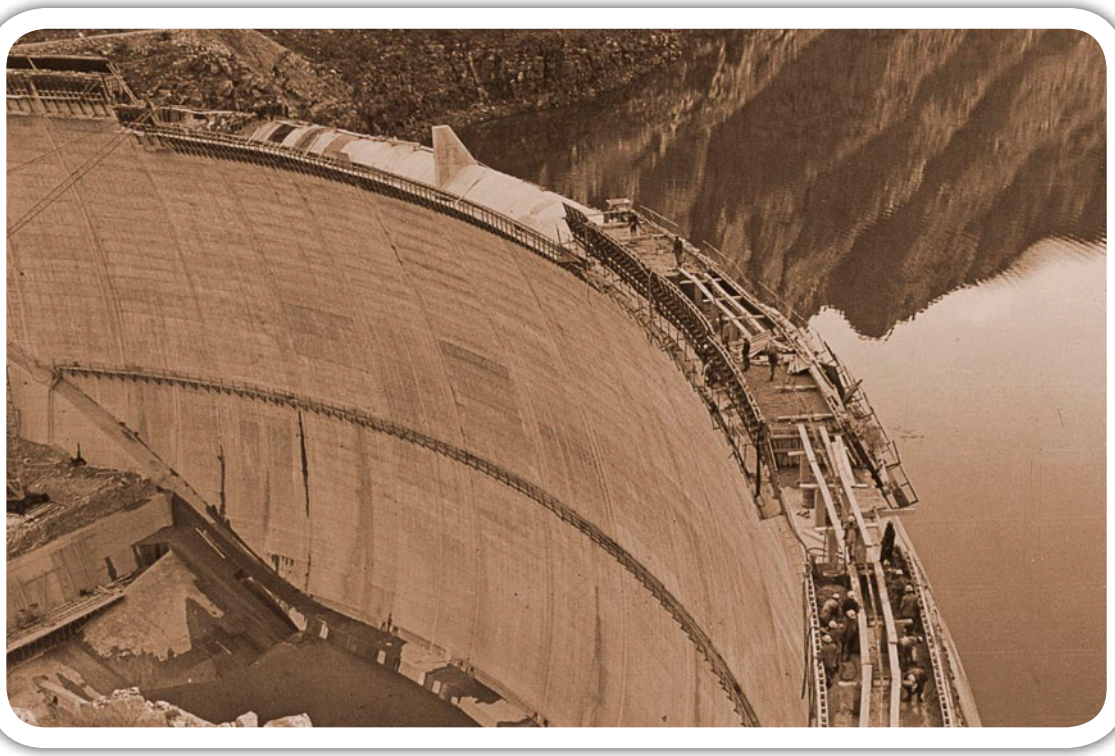
The boards immediately set to work improving irrigation infrastructure with significant loans from the government. One of these schemes, Reenen, was completed in 1916 and included a weir, 29 km-long canal and a tunnel of 163 m to irrigate 1 285 ha of land.

"Prisoners had a tendency to deliberately injure themselves on site so as to avoid the hard, physical work."

Periodical floods were the enemy of irrigation farmers in the Gamtoos valley. In May 1916, such an extreme event led to the death of 24 people. The Gamtoos River destroyed everything in its path, including the newly constructed irrigation infrastructure as well as 514 ha of scheduled irrigation land. Many of the farmers also lost their crops.

More loans had to be made to rebuild the works. Extreme measures were taken to protect the structures from further flood damage, including surrounding them with thorny branches and gabions of rock and steel. These were often simply washed away when the river came down. In long stretches of the river, no large rocks could later be found.

Another notable flood hit the region in 1932, this time destroying



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The Beervlei Dam during construction. The distinctive multiple arch structure comprises 15 cylindrical arches with gravity sections on its flanks.

932 ha of land and washing away weirs and canals. Thankfully the arrival of a telephone service years earlier meant that people could be forewarned and no loss of life occurred. At Hankey, known at that time for the quality of its apples and other fruit, most of the trees were lost. Following the flood the Irrigation Commission surveyed the damage in the valley and recommended the construction of dams to control these periodical floods.

When the farmers were not tormented by floods they had to contend with droughts. Available flow in the Kouga and Gamtoos rivers was insufficient for around a third of the time. Farmers upstream were better positioned than their downstream neighbours, especially in times of deficit.

A number of sites for storage dams in the Kouga River catchment had been investigated from time to time. As early as 1931 a site on the farm Kruisrivier, immediately below the confluence of the Kouga and Baviaanskloof rivers was surveyed, while in 1947 and 1953 further topographical surveys were made of alternative sites near Guerna, a short distance below the infall of the Witteklip River in the Kouga, and on the farm Tweerivieren in Kougapoort.

The latter site, located about 5 km above upstream of the Kouga/Gamtoos confluence, was eventually selected, and the dam was initially known as Tweerivieren Dam. Topographical surveys were carried out of the Gamtoos valley in 1952/1953. In 1956, the Department of Agriculture commissioned an investigation into the suitability of the soil in the valley for the expansion of irrigation.

BEERVLEI DAM

In 1946, the Union government rather unexpectedly decided to first construct a flood control dam at Beervlei on the Groot River near Willowmore, before making a final decision on a dam in the Gamtoos valley. The site, situated about 5 km below the confluence of the Groot River with the South and Kariega rivers, was first identified in the early 1920s.

Considered one of the best storage basins in the country, irrigators along the Groot River agitated for this dam for many years. However, because of the extremely irregular flow, high mineral content and silt load of the rivers, the government was at first reluctant until it was decided to use Beervlei mainly for flood control instead. Only around 2 190 ha of irrigated area would be regulated from this dam.

Construction of the multiple arch dam started in 1953. At that time it was government policy to make use of black convict labour on large public works projects and so a large prison labour camp was constructed at the site. Around 400 prisoners eventually worked on the dam.

Excavations for foundations started in July 1954, and the first concrete was placed in May, 1955. Due to the high mineral content of the water, a super sulphated cement was imported from Belgium and used in the preparation of concrete for the dam. The spillway was originally at two levels, the upper level was 1,8 m above the full supply level

KOUGA DAM ENGINEERING FEATURES

- **Dam type**: Double curvature arch dam
- **Maximum height above lowest foundation**: 94,5 m
- **Crest length**: 204 m
- **Maximum water depth:** 53 m
- **Gross storage capacity**: 133 million m^3
- **Surface area (at full supply level)**: 555 ha
- **Total quantity of concrete in wall**: 268 000 m^3
- **Maximum thickness of wall**: 10,2 m
- **Design flood (1:200 year)**: 4 249 m^3/s

and reached over three of the dam's 15 cylindrical arches.

The project was finally completed in September, 1957. In 1967, the full supply level of the dam was raised to the level of the upper spillway to increase the capacity of the dam from 52 208 million m^3 to 92 850 million m^3.

The dam wall has a height above lowest foundation of 31 m, and a crest length of 348 m. The volume content of the dam is 0,042 million m^3 and it has a gross capacity of 100 731 million m^3.

KOUGA DAM

In 1955, Paul Sauer, then Minister of Lands, stated that once Beervlei Dam was completed, a start would be made with a dam on the Kouga River. A White Paper proposing the building of the Kouga Dam was submitted to Parliament in 1957, and not long thereafter a construction team moved onto site. The Department of Water Affairs (DWA) team selected was the same one that had constructed the Beervlei Dam.

The original objectives of the project as stated in the document was to ensure a more assured supply of water to the existing lands under irrigation, permit the development under irrigation of an additional 3 770 ha of land for the purposes of government settlement, and to alleviate serious flood hazards in the Gamtoos valley.

Later it was realised that the dam also had the potential to supply water to Port Elizabeth and renowned water engineer Ninham Shand was appointed by the town council to report on this possibility. The town council resolved to proceed with the Kouga scheme on the basis of a supply drawn from the end of a canal system at Loerie. In 1963, Council negotiated an agreement with government for a water supply from the scheme which was redefined as dual purpose, namely irrigation and urban usage. The agreement provided for the supply by government to council at Loerie of a quantity of water not exceeding an annual average of 140 Mℓ/day.

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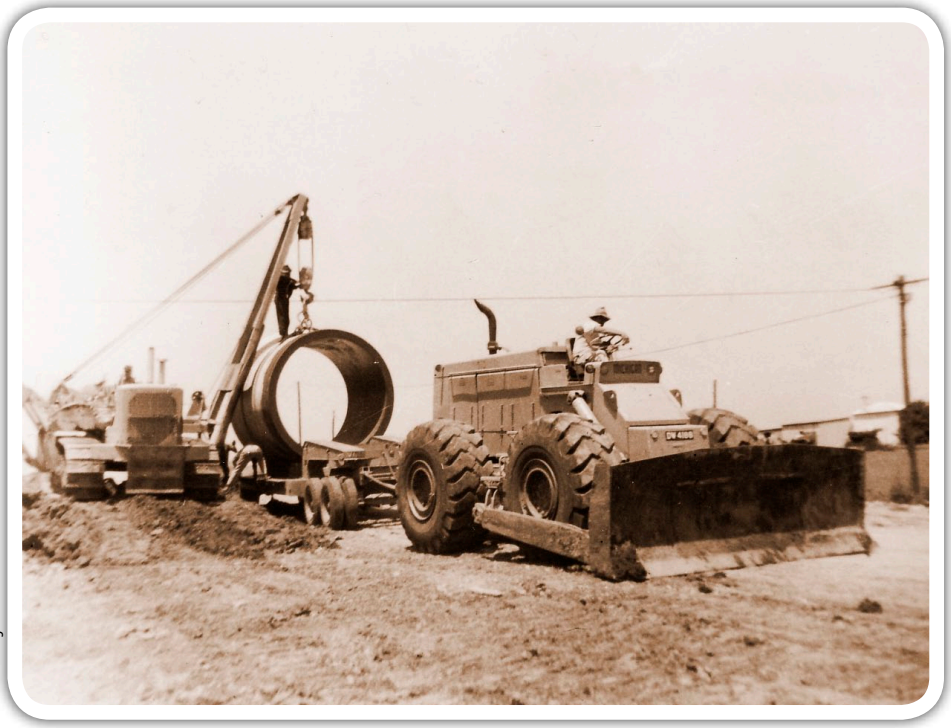
***Top**: An elaborately guarded prison camp was constructed on site at Kouga to house the approximately 400 black convicts that worked on site. A similar camp was constructed at Beervlei.*

***Above**: A close-up of the overspill section of Kouga Dam during construction.*

Similar to Beervlei, convict labour was used even though the prisoners tended to be far less productive than their free counterparts. It is reported that prisoners also had a tendency to deliberately injure themselves on site so as to avoid the hard, physical work. The department tried several methods of motivating the prisoners to improve their work output, including providing a ration of tobacco to those who reached a certain quota each day.

Original design and estimates were based on a concrete gravity dam, however, it was later decided to construct the dam as a double curvature thin ('cupola') arch instead as this would be less expensive.



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Pipes being offloaded during 1965 for distribution of water from the dam.

This was the first dam of its kind to be constructed in South Africa. The DWA project team developed a mathematical mesh model to obtain the optimal shape of the dam and ensure minimum bending within the shell. Solid model laboratory tests were also undertaken – another 'first' for the department.

The geological conditions at the site provided many challenges, and a number of measures had to be provided to safeguard the dam and its foundations. Among others, three tunnels, each 145 m long, were constructed in the right flank for drainage and pressure alleviation. In addition, a thick reinforced concrete slab was built against the downstream right abutment. This was post-stressed with cables extending to a depth of 40 m into the mountain. Lastly, a comprehensive set of observation points and instruments were incorporated on and inside the dam wall. The latter led to even more sophisticated instrumentation in other cupola dams such as the Pongolapoort Dam.

Huge volumes of water had to be diverted from the construction area, resulting in the construction of a substantial coffer dam. This dam was 302 m long and varied from 5 m to 9 m in height.

Excavation for the main wall started in August, 1958. Little over a year later the placing of concrete started. The wall was constructed to a maximum height of 94,5 m above the lowest foundation level. The maximum thickness of the shell is 10,2 m tapering down to 4,8 m at the non-overspill spill. A small hydroelectric power station was constructed on the right bank (it was later found to be non-economical).

In order for the dam to fulfil its flood control function, a radial gate-controlled chute spillway was installed on the left flank, making it possible to draw down to the level in the reservoir before a flood arrived and so alleviate the flood peak. The dam also features an uncontrolled spillway 64 m above apron level. The hydraulics of the dissipation of energy of the water passing over the spillway down to the apron gave rise to a number of problems. The impact forces on the apron were measured through a series of hydraulic model tests and reduced as far as possible using a deep water cushion. The apron was built to be a minimum of 3 m thick, and is heavily reinforced and anchored to the rock.

The dam was eventually completed in 1969. Today, several decades later, it still provides a valuable water supply function in this region.

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- Thanks to the Gamtoos Irrigation Board and eWISA for photographs