Key Issues:
1-Biological Diversity
12-Benefits due to Dam Function

Climate Zone:
Csb: Humid Subtropical (Mediterranean)

Subjects:
- Project Implementation in the Cape Floral Kingdom
- Inter-Catchment Transfer of Water

Effect:
- Conservation of the Cape Floral Kingdom
- Conservation of Indigenous Fish Species

Project Name: Palmiet Pumped Storage Power Plant
Country: South Africa

Implementing Party & Period
- Project: Eskom Holding Ltd. & Department of Water Affairs and Forestry (DWAF) 1983 (commencement of construction) -
- Good Practice: Eskom Holding Ltd. & Department of Water Affairs and Forestry (DWAF) 1983 -

Key Words:
Cape Floral Kingdom (Fynbos), Biosphere Reserves, Environmental Impact Control Plan, Stakeholders, Palmiet Visitors Centre

Abstract:
The scheme is unique that it is located in the Kogelberg National Forest, part of the smallest and most diverse of the world's six floral kingdoms – the Cape Floral Kingdom. The Palmiet Committee, a multi-disciplinary team including an independent environmental consultancy, was formed at the earliest planning stage. The overall approach was to implement environmental impact controls from the very outset, then rigorously follow them through the entire construction process. This proved an effective and economically viable approach.

1. Outline of the Project

The Palmiet Pumped Storage Scheme is situated on the Palmiet River in the Western Province of the Republic of South Africa. The scheme comprises two dams, the lower Kogelberg Dam on the Palmiet River south of Grabouw and the upper Rockview Dam on the watershed between the Palmiet and Steenbras rivers. A conduit between the two reservoirs conveys water to the reversible pump turbines in the 400 MW station on the banks of the Kogelberg reservoir.
During the off-peak period, water is pumped from Kogelberg to Rockview reservoir. From here, water specifically allocated to the Department of Water Affairs and Forestry for water supply, flows by gravity into the Steenbras reservoir via a separate conduit. This supplements Cape Town's annual water supply by an average of 25 million m^3.

The specifications of the Scheme are shown in Table-1, and the general plan and profile are shown in Fig. 1.

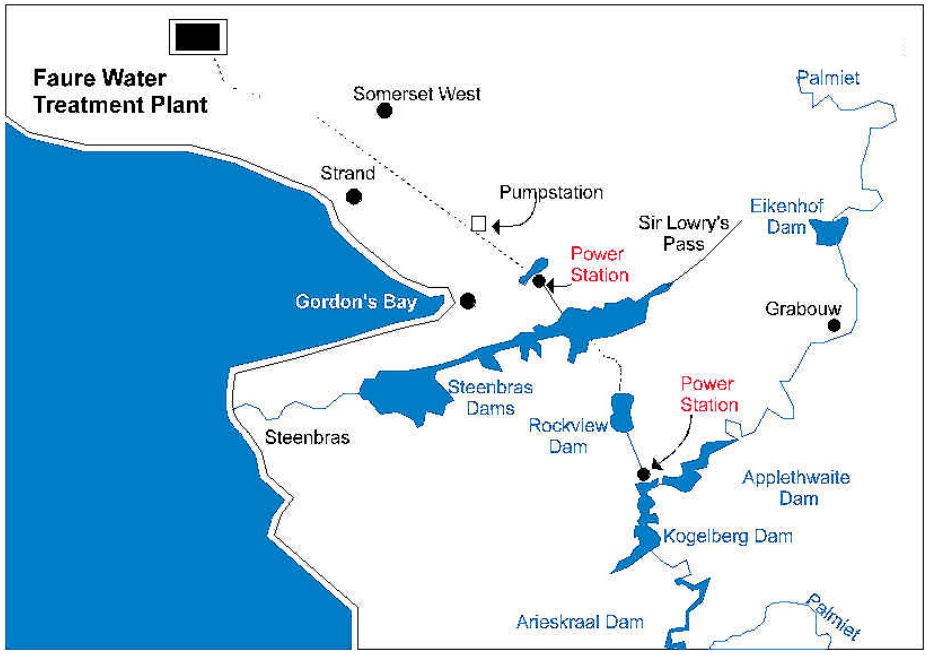

Fig. 1 Palmiet Pumped Storage Scheme layout

Table 1 Specifications of Palmiet Pumped Storage Scheme

Item		Specification
River System		Palmiet River
Power Plant	Commencement of Operation	July 1992
	Output	400 MW (200MW x 2)
	Maximum Turbine Discharge	185 m^3/s
	Effective Head	
Upper Dam and Reservoir	Dam	Rockview Dam
	Type	Rockfill and Earthfill
	Crest Length	1,250 m & 700 m
	Height	
	Storage Capacity	
Lower Dam and Reservoir	Dam	Kogelberg Dam
	Type	Concrete Arch
	Crest Length	
	Height	
	Storage Capacity	

The Upper Reservoir – Rockview Dam

The upper reservoir has virtually no natural catchment area as it is situated on the watershed between the Palmiet and Steenbras rivers. Its basin is formed by a rockfill and an earthfill walls known respectively as the main and northern embankments. The waterways lead from the main embankment to the power station. From the northern embankment, a canal and a pipeline connect the Rockview

reservoir to the upper reservoir of the Steenbras scheme. Water transfer to augment water supplies takes place along this route.

The Lower Reservoir – Kogelberg Dam

The Kogelberg Dam is designed with a mass gravity concrete arch wall. It has a separate earth saddle embankment on the left flank about 850m long at a maximum height of 19m.

The Power Station and Waterway

The power station is situated about 2km upstream of the Kogelberg dam wall and has a nominal generating capacity of 400MW. The two 200MW pump-turbine generator-motor sets and auxiliary equipment are located approximately 60m below ground level at the base of two 23m diameter concrete-lined vertical machine shafts.

In the generating mode, up to 185m³/s of water is admitted at the intake from the upper reservoir (Rockview Dam) through a surface cut-and-cover headrace tunnel, 750m long and 6,2m in diameter. It flows through a 55° inclined shaft, 130m deep and 6,2m in diameter, to a pressure tunnel, 487m long and 6,2m in diameter, which ends at a portal. From there water flows into a cut-and-cover penstock, 561m long and 5,4m in diameter, which bifurcates into two inclined penstock shafts, approximately 131m and 139m long respectively and 3,9m in diameter, tapering to 2,6m in diameter. The penstocks convey the water into the power station complex. From the power station, two inclined concrete-lined tailrace tunnels, 84m and 57m long respectively, link the machines to the tailworks in the Kogelberg reservoir.

The surge tank is situated at the end of the surface cut-and-cover headrace tunnel. A 34 m long conduit, 6,2m diameter, branches from the headrace tunnel to lead to the bottom of the surge tank. The cylindrical free-standing concrete structure of the surge tank is 61m high and 21m in diameter. To minimise visual pollution the surge tank was not constructed on the highest point of the terrain, but set back from the cliff so that it is less prominent to viewers from the Palmiet River area. The surge tank prevents excessive pressure fluctuations in the penstock during transient conditions. From the Rockview Dam wall, an access bridge leads to the headrace works which were constructed in the form of a 68m high headworks tower. This tower houses the 15m wide, 14m screened intake, the mechanically operated maintenance stop logs and the hydraulically operated emergency gate.

Within the headrace tower is a vertical duct with a spillway on top which makes it possible to close the emergency gate during any phase of surging in the waterways. This is a unique safety feature designed by Eskom engineers. The duct houses the emergency gate, provides for the discharge of the surplus volume of water during emergency closure and allows aeration of the headrace tunnel after closure of the gate. The outlet works on the bank of the lower reservoir consist of twin 45m high tailworks towers constructed next to the power station. Each tower houses an 8,7m wide and 9,5m high screened opening, a mechanically operated wheeled maintenance gate and a submersible pump which supplies the fire-fighting storage tank.

The power generated at the Palmiet Pumped Storage Scheme is fed into the national transmission network at the Bacchus substation near Worcester. In addition to regulating frequency on the Eskom National Grid by means of their generating and pumping activities, the units at Palmiet Power Plant are used to regulate network voltage.

2. Features of the Project Area

When the Dutch established a halfway station at the Cape in 1652, the plants they found there were unknown to them. Since so many had fine, needle-shaped leaves, they called them “fijn bosch” which means “fine leaved bushes” - hence what is today known as the Fynbos Plant Kingdom. Fynbos grows mainly on the mountains and plains of the southern and southwestern parts of the Western Cape. It consists of thousands of different kinds of plants, the three main plant families being the Protea, Erica and Restio. Almost 70% of the fynbos plant species are endemic and therefore not found naturally anywhere else on earth. Not only is the Fynbos Plant Kingdom unique, it is incredibly diverse.

The Kogelberg is regarded as a centre of endemicity, where roughly a fifth of all fynbos species are known to occur. There are approximately 1 500 different kinds of plants, 70 kinds of mammals, 43 kinds of reptiles, 22 kinds of frogs and a vast number of birds and insects. Of the plants, about 150 do not grow anywhere else in the world. It is justifiably known as the heart of the Fynbos Plant Kingdom.

Fig. 3 Protea Flower from the Fynbos Plant Kingdom

The uniqueness and biodiversity of the Kogelberg was recognized in 1998 when UNESCO registered the area as a biosphere reserve under its MAB (Man and the Biosphere) Programme. The Kogelberg State Forest is incorporated as the core of the Biosphere.

Eskom was one of the signatories to the application for biosphere status submitted to UNESCO. Eskom has also signed a Declaration of Commitment acknowledging the organisation’s responsibility to pursue the objectives identified in the UNESCO Action Plan for Biosphere Reserves as identified in the Seville Strategy.

Biosphere reserves are areas of terrestrial and coastal/marine ecosystems, within which land-use and resource management are undertaken to enhance conservation and development. Biosphere reserves are realized by the application of a zoning system:

Core: most ecologically sensitive and pristine area where nature conservation is a priority.

Buffer: less ecologically sensitive but mostly natural area where recreation and sustainable utilization of natural products can be accommodated.

Transition: least ecologically sensitive area where a great variety of land uses such as farms, commercial plantations and towns occur.

Such a reserve, therefore, can accommodate strictly conserved areas – such as the Kogelberg State Forest – as well as sustainably managed activities such as the generation of hydro electricity.

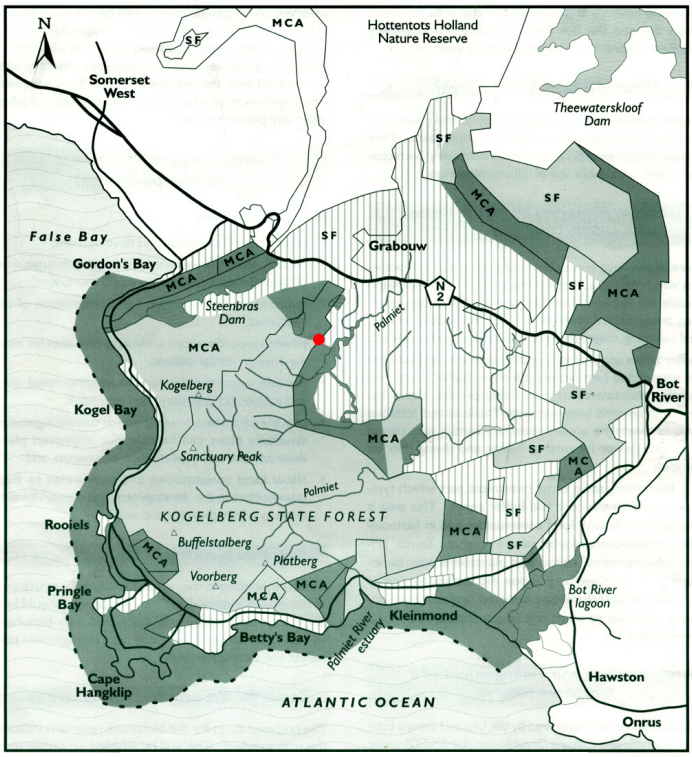

Fig. 4 Kogelberg Biosphere Reserve

3. Major Impacts

3.1 Impact of construction in the project area

Construction of the Palmiet Pumped Storage Scheme took place from 1983 until 1988, many years prior to the declaration of the Biosphere Reserve. At that time, current levels of environmental legislation had not been enacted in South Africa. However, Eskom recognized the unique ecological diversity of the Kogelberg, and an Environmental Impact Control Plan, considered a forerunner of its time, was developed and implemented. It is a prime example of how dedication to the preservation of nature during heavy construction activity can be achieved.

3.2 Impact of operation on the riverine environment

The Department of Water Affairs and Forestry is mainly responsible for the operation and maintenance of the water systems and decisions to transfer water from the Palmiet to the Steenbras catchments are taken in conjunction with Eskom.

Although the lower reservoir is located on the Palmiet River, the release of water during normal operation does not directly impact on the river downstream as the flow fluctuations are contained within the Kogelberg Dam.

With regard to the inter-catchment transfer of water, studies by members of the Cape Department of Nature and Environmental Conservation have shown that the same two indigenous fish species are to be found in both river systems. Both species have fairly wide distribution ranges which include most rivers of the South-Western Cape.

The Department of Water Affairs and Forestry, in conjunction with specialist consultants, have established the instream flow requirements for the Palmiet River in order to satisfy ecological needs.

The operating rules for the river have been established in consultation with Eskom and ensure that releases of water mimic the natural seasonal cycles and that extractions are such that instream flow requirements are not compromised.

4. Mitigation Measures

4.1 Environmental Impact Control Plan in Construction Phase

1) Fynbos rehabilitation

Factors relating to the preservation of the fynbos were given high priority.

- Top soil from construction areas was removed and carefully stored. Once the activities were completed, the original topsoil was then replaced, stabilized and indigenous plants re-established.
- To prevent uncontrolled, destructive fires from occurring, an effective "Fire Management Plan" was devised and very strictly enforced.
- All materials brought into the area were carefully inspected to prevent the introduction of alien vegetation which could upset the local ecological balance
- Gardening on the entire site was restricted to the cultivation of indigenous flora for the same reason.

2) Argentine Ant

One of the greatest threats to the Fynbos was the possibility of infestation of the site by the exotic Argentine ant. This ant eats the fleshy body off the fynbos seeds but, unlike the indigenous ant, does not bury them. It leaves them unprotected above the ground, thus exposing them to the danger of destruction by fire or other elements. To prevent the influx of these ants, unusually high standards of hygiene were set and adhered to. e.g specially constructed eating sectors were built for the workers and all food remains and refuse carefully removed on a daily basis. This effort was necessary because the Argentine ant is greatly attracted to such waste.

3) Wildlife protection

Rigid controls on the protection of wildlife were also enforced in line with the Nature Conservation Ordinance applicable to this part of the world. For instance, people on site were encouraged to observe and enjoy the large baboon population which abounds. However, they were forbidden to feed the animals as this upsets natural patterns of food foraging, which in time could lead to starvation or major behavioral changes.

4) Environmental training

Programmes to raise environmental awareness of workers on site were implemented in all the main language groups. This was re-enforced by implementing recognition schemes for achievements in this area.

4.2 Environmental Impact Management Procedure in Operational Phase

The success of the impact control measures was not limited to the construction phase.

1) The philosophy of sustainable use of resources was carried over into the operational phase of the power station in the form of a practical Environmental Impact Management Procedure governing day to day activities: The Procedure focuses on:

- Estate Management
    i. Access control
    ii. Control of alien vegetation
    iii. Soil erosion
    iv. Protection of indigenous fauna/birds
- Waste and Recycling
- Water and Sewage
- Air Pollution/Ozone depletion
- Training.

2) The Palmiet Visitors Centre was constructed in 1991 and delivers a message of sustainable utilisation of natural resources to the thousands of visitors who visit it annually.

3) Palmiet is represented on the Palmiet Catchment Management Committee in which stakeholders and users of the Palmiet River participate and which monitors the impact of local activities on the water and land use in the Palmiet catchment area.

Judged by our own internal audits, the current Palmiet Environmental Management Plan is ISO 14001 compliant and we are scheduled to be accredited by an international accreditation body as an ISO 14001 company by end 2003.

4.3 Palmiet Water Transfer Operation Rules

Surplus water is transferred from the Kogelberg Dam on the Palmiet River to the Rockview Dam. The Palmiet Pumped Storage Scheme is operated on a weekly cycle, with some 16,5 million m^3 being withdrawn from Kogelberg Dam over weekends and stored in Rockview Dam for release during the following week. An additional 3 million m^3 can also be stored in Rockview Dam for release to the Upper Steenbras Dam.

The Lower Palmiet River forms part of the Kogelberg Biosphere Reserve and the transfers to the Steenbras Dams can take place only once the instream flow requirements of the river are satisfied. A weir downstream of the Kogelberg Dam is used to check whether the river flows meet the environmental requirements. Currently, the following operating rules are used to control the transfer:

- Arieskraal Dam is situated immediately downstream of Kogelberg Dam and has an outlet capacity of only 2 m^3/s. As Arieskraal is always drawn down at the end of summer, the first winter inflows to Kogelberg Dam are released to fill Arieskraal Dam. Thereafter, environmental releases of up to 15 m^3/s can be made from Kogelberg Dam to supply the environmental flow requirements at the weir, as these releases spill over Arieskraal Dam.

- Releases are made from the Kogelberg Dam to supplement the flows at the weir, which are provided by natural runoff from the Klein Palmiet River and the Krom River, while surplus water accumulates in the Kogelberg or Rockview Dams. If the flow at the weir is less than 4,3m^3/s then up to 58% of the inflow into Kogelberg Dam is released.

- The operation of the Palmiet Pumped Storage Scheme requires 16,5 million m^3 of storage. If too much water is stored in the Kogelberg Dam, then there is a risk that the 156 m^3/s discharged through the turbines of the power station will cause spills downstream of Kogelberg Dam. Eskom is responsible for the management of the Kogelberg Dam and the additional volume stored for release to the upper Streenbras Dam is not allowed to exceed 3 million m^3.

- At the end of winter 3 million m^3 of water may be stored in Rockview Dam and released later into the Upper Steenbras Dam when spare capacity becomes available.

- Transfers from the Palmiet River could vary from 10 to 40 million m^3/annum and on average increase the yield of the Western Cape System by 22,5 million m^3/annum.

The Department of Water Affairs and Forestry has initiated a River Health Study. Various sites along the river have been identified and monitoring is taking place to determine what types of organisms are present in the eco-system. This will supply a basis of information against which the state of the river can in future be measured.

5. Reasons for Success

5.1 Cooperation with Local Communities

Prier to construction, meetings were held with local stakeholders to create awareness of the short-term and long-term impacts of the Scheme. Agreements were negotiated with neighboring farmers with regard to access roads affecting their properties, Cordial relations are maintained with farmers and common interests such as removal of alien vegetation are negotiated.

5.2 Palmiet Catchment Management Committee

Initiated by the Minister of the Department of Water Affairs and Forestry in 1996 - prior to the implementation of inter-catchment water transfer - the Committee's task was to draw up a Catchment Management Plan for the Palmiet River.

South Africa is in the process of implementing a new National Water Resources Strategy and the Catchment Management Plan drafted for the Palmiet River was a first, and may serve as a blue print for other catchments.

As a result of public participation meetings, representation was drawn from Eskom, local government, recreational organizations, farming organizations, industry/business, environmental bodies, government departments, tourism bureau, ratepayers associations, civic and farm workers organizations.

The committee serves as a forum and lobby group for local issues ranging from water matters to land use and includes stakeholders from source to estuary of the Palmiet River.

The vision of the Committee is "To manage the Palmiet River Catchment Area so that optimal use is made of the total resources (land, water and air) to sustain the ecological, social and economic requirements and to maintain the unique conservation status and scenic beauty of the area".

Palmiet Power Station has actively participated on the committee since its inception.

5.3 Palmiet Visitors Centre

Although the center is visited by tourists, a strong focus is maintained on social responsibility. Educating school children and communities about the environment, sustainable use of resources and technology is the main focus of the Visitors Center. Among school children from previously disadvantaged communities in South Africa, these are new concepts and experiences. To date approximately 70 000 people, the majority from schools and tertiary educational institutions, have visited the center and power station.

The visitors center is also used as a venue for community meetings, as facilities of this nature are not found elsewhere in the rural town of Grabouw. Such interaction with the community has contributed

towards a positive attitude to the power station's electricity generating activities.

6. Outside Comments

Palmiet Pumped Storage Scheme has achieved the following awards.

1) In 1987 Palmiet Pumped Storage Scheme was presented with the award for the Most Outstanding Civil Engineering Achievement by the South African Institute of Civil Engineers
2) In 1988 Palmiet won the EPPIC award from the Environmental Planning Professions Inter-disciplinary Committee for integrated environmental planning and management.
3) In 1997 Palmiet was presented with the Conserva Award for outstanding achievement towards effective conservation and sustainable utilisation of the environment to ensure a better quality of living for all South Africans by the South African Minister of Environmental Affairs and Tourism.
4) Palmiet Pumped Storage Scheme was awarded "The International Hydropower Association (IHA) Blue Planet Prize" in 2003. The Prize, awarded by IHA every two years, with evaluation support by UNESCO's International Hydrological Programme, recognises good practice and sound management in the development and operation of a hydropower scheme, on the basis of technical, economic, social and environmental criteria, and excellence in one or more of these aspects. The project is considered to be a first-rate ambassador for hydropower and demonstrates characteristics consistent with the Implementation Plan of the World Summit on Sustainable Development and the Ministerial Declaration of the recent World Water Forum.

7. Further Information

7.1 References

1) The Palmiet Pumped Storage Scheme Environmental Impact Control Plan
2) The Palmiet Technical Brochure
3) The Palmiet Environmental Impact Management Procedure
4) The Kogelbelg – Cape Nature Conservation Department

7.2 Inquiries

Mr. N D Bhula
Peaking Generation,
Generation Division, Eskom