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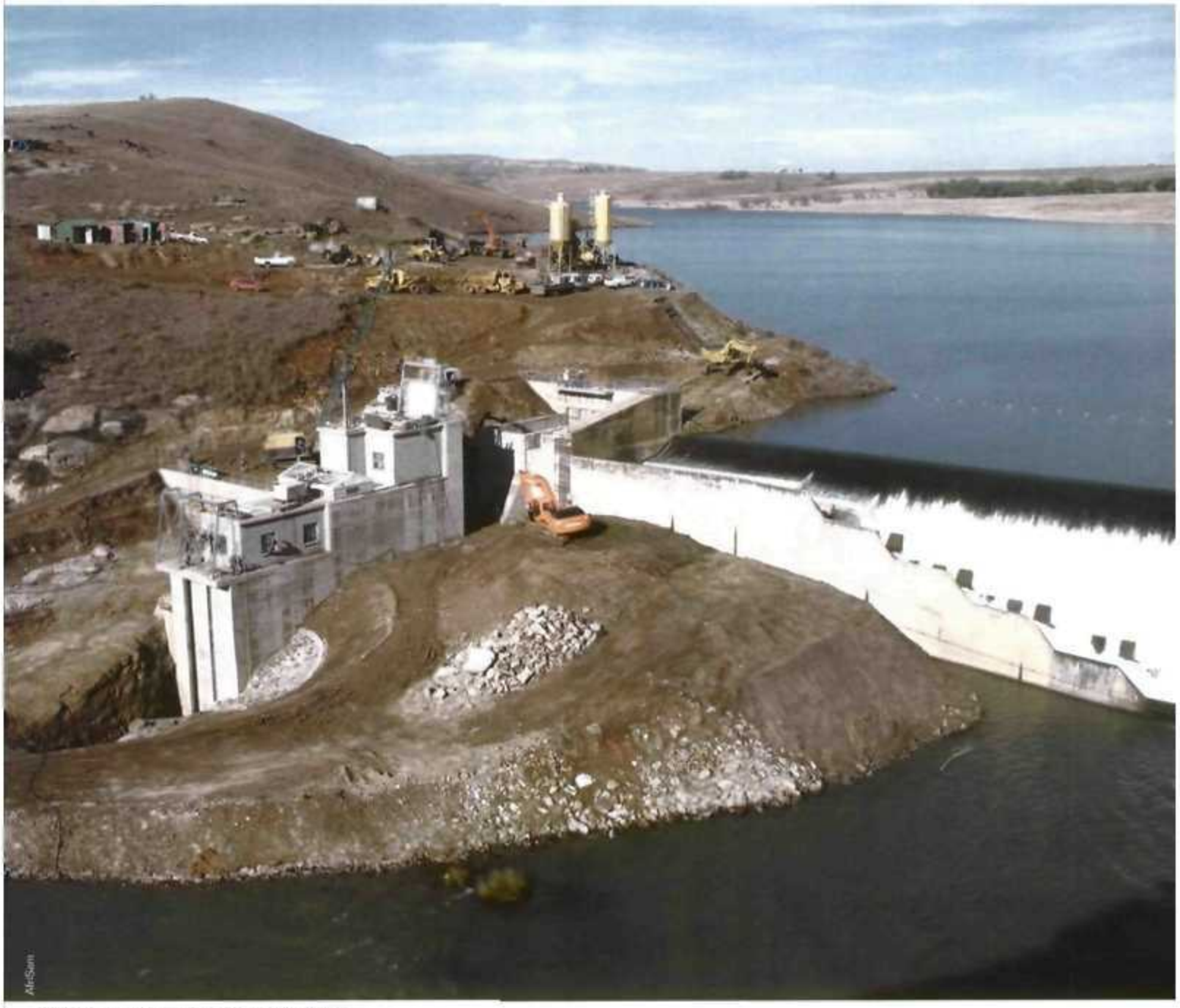
Mini hydropower, big on-site challenges

There is nothing small about breathing life into Bethlehem's new mini-hydropower project. The task at hand is huge, *Civil Engineering Contractor* learns.



AfriSam

Small structure, huge engineering
NuPlanet's 3 MW Sol Plaatje and 4 MW Merino hydropower plants will produce approximately 40 GWh of electricity yearly for the Dihlabeng Local Municipality. Constructing the mini-hydropower plant, however, proved to be a big challenge.

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Faced with greater emphasis on finding alternative energy sources, NuPlanet looked at the possibility of utilising water released from the Lesotho Highlands Water Project to generate electricity (hydropower). During a feasibility study in 2002, two sites were identified near Bethlehem in the Free State. The first scheme is located on the Merino Farm, along the Ash River, and the second is adjacent to the existing Sol Plaatje Dam.

Under the ownership and operation of the developer, Bethlehem Hydro, the 3 MW Sol Plaatje and 4 MW Merino hydropower plants will produce approximately 40 GWh of electricity yearly for the Dihlabeng Local Municipality. The carbon credits resulting from this clean-energy development will be sold to a European buyer.

Anton-Louis Olivier, MD of NuPlanet, says the company has also secured the rights to a 10 MW hydropower scheme in the same river system and is busy with the feasibility study.

South African hydropower know-how

Initial financing for the feasibility study of the scheme under construction was granted by the Dutch government while the implementation was debt-financed by the Development Bank of Southern Africa and through private equity.

"We appointed Aurecon because it has the most experience in terms of hydropower within the South African market," Olivier says. "After completing feasibility studies, the next stage was to secure all the necessary statutory licences. This, in itself, was a difficult challenge as the last private hydropower station to be connected to the national grid was constructed in the mid-1980s.

The next challenge was to find a buyer for the electricity generated in order to make the project financially viable and power-purchase agreements had to be drafted from scratch to comply with the current legislation as no precedent had been set."

Powerful project team

Developer and project manager: NuPlanet
Consulting engineer: Aurecon
Mechanical engineer: BWG Hydro
Electrical engineer: Merz & McLellan
Civil contractor: Eigenbau
Mechanical and electrical contractor: Boving Fouress

Photographs courtesy of AfriSam

Mirror images

Both powerhouses are approximately 16 m high, 22 m long and 8 m wide. Each power station comprises a generator floor, the switchgear and control rooms, and external transformer yard.

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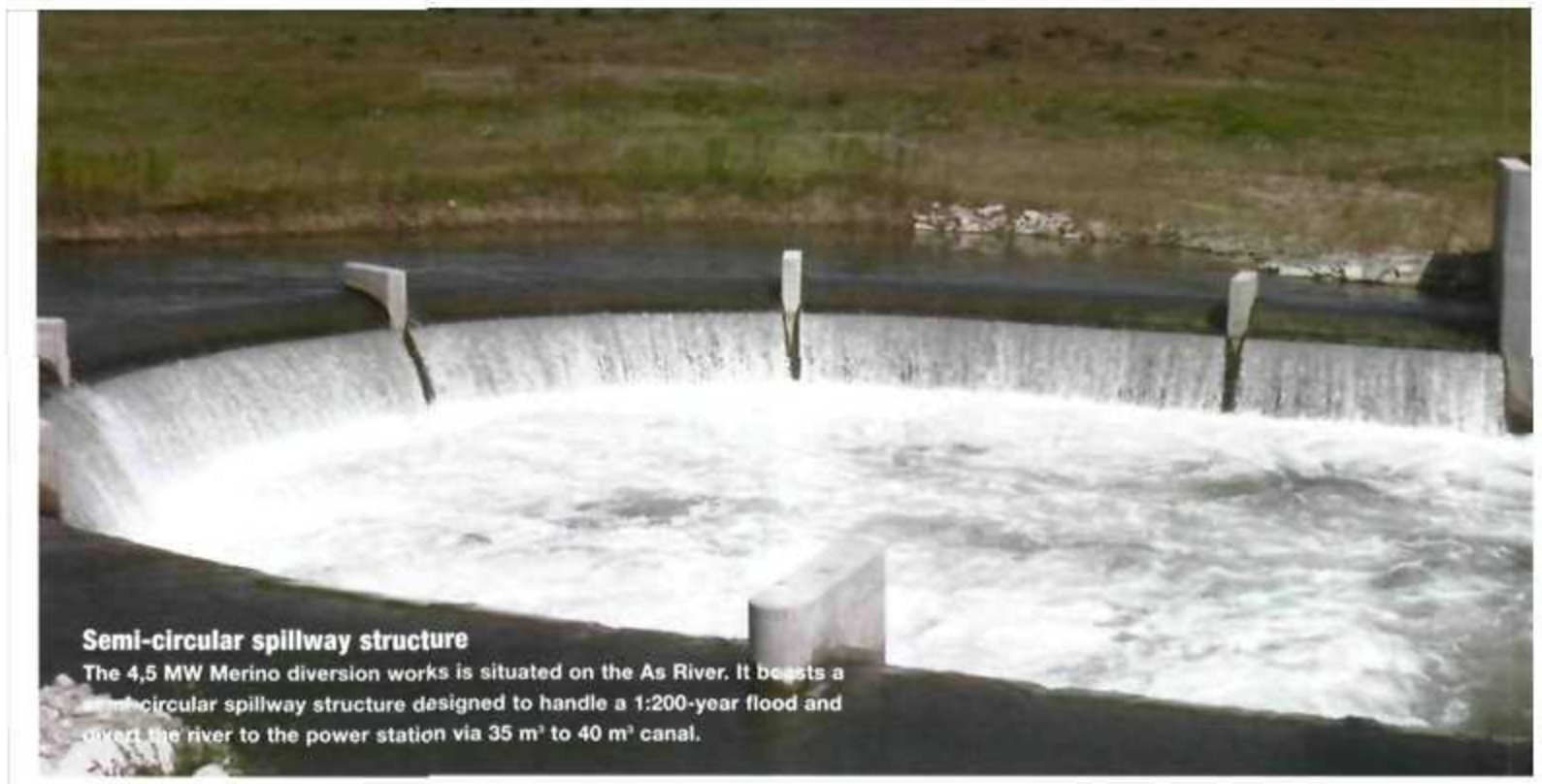
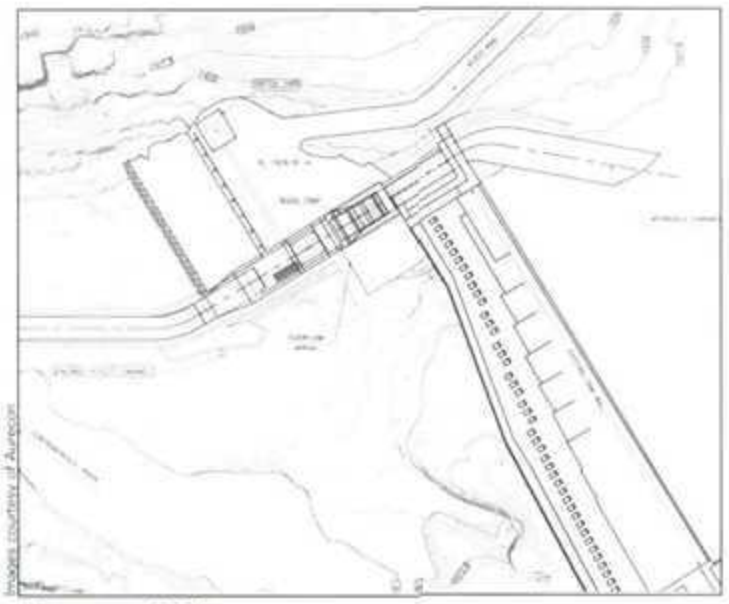
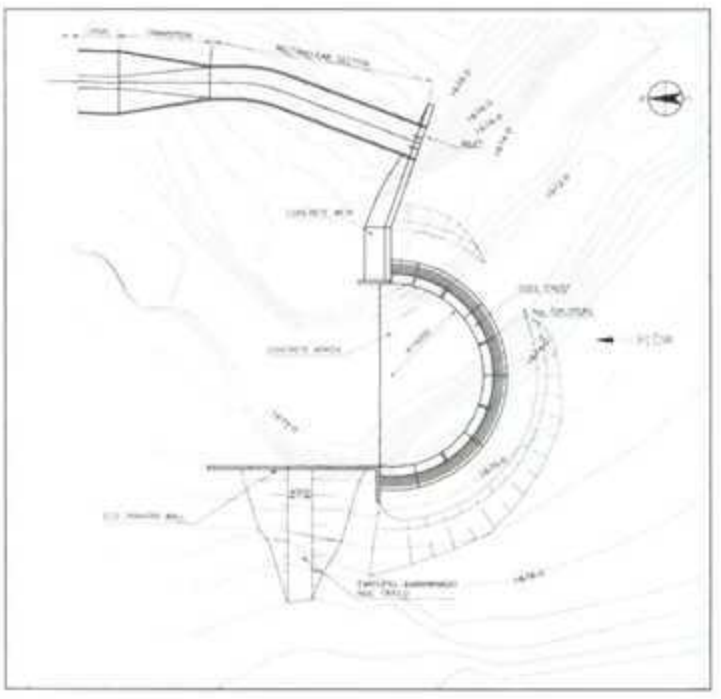


Semi-circular spillway structure
The 4,5 MW Merino diversion works is situated on the As River. It boasts a semi-circular spillway structure designed to handle a 1:200-year flood and divert the river to the power station via 35 m³ to 40 m³ canal.



Images courtesy of Aurecon

The second site
The other 2,5 MW power station is located at the Sol Plaatje Dam.



Two powerhouses

Bertrand Collet, senior engineer at Aurecon, says that the power plants are mirror images of one another. Both powerhouses are approximately 16 m high, 22 m long and 8 m wide. Each power station comprises a generator floor, switchgear and control rooms, and external transformer yard.

At the power plant on the Sol Plaatje Dam, up to 29 m³/s of water is diverted through the power station instead of the continuous spill from the dam. At Merino, a small diversion weir was built across the river to a 650 m-long canal. The canal ends in a forebay, dropping to the power station intake and thus maximising the 16 m head available on this site while minimising water loss.

The project was technically challenging so it required engineering expertise and design flexibility in order to ensure successful completion.

Deep excavations

Eigenbau, the main contractor on site, has vast experience in the construction of water-treatment plants, bridges and general civil-engineering construction. It was, therefore, able to address the challenges faced on this project.

Ed Ross, MD of Eigenbau, says that the major challenge faced by the company was the sheer depth of the excavations required. "The excavations were up to 23 m deep, which included digging 8 m to 10 m below the level of the flanking river. This required constant pumping due to the natural groundwater, naturally increasing the risk and the cost on a contract of this nature.

"We decided early on that we would have to use hydraulic hammers to break the rock in the excavation," Ross says. "If we had used blasting, it would have opened up fissures to the river and resulted in a much larger flow of water into the works. Naturally, we had to factor in extra contract time because of this decision. When excavations started on the Merino site, we discovered that the sandstone and mudstone were interlayered. This meant that the exposed areas of mudstone in the excavated area had to be protected to avoid early decomposition. This was achieved by using AfriSam high-strength cement (HSC) in a concrete mix, together with reinforcement and anchors, to clad the mudstone. There are two mudstone layers at Merino, approximately 2 m thick over the entire power station and forebay area. This required some 200 m³ of concrete."

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Excavation of the tailrace at Sol Plaatje

Steps to machine hall at Sol Plaatje

Photographs courtesy of JPGlam

Climate conundrum cracked

A total of 3 500 m³ of concrete was poured at Merino and 2 200 m³ at Sol Plaatje. On both sites, the climatic conditions played a huge role in mixing and casting of the concrete.

Still deeper

The original site for the Merino Power Station had to be abandoned because the founding material was not suitable and would have increased the cost of the project. "The subsequent redesign of the power station and realignment of the canal necessitated deeper excavations in solid rock," Ross adds.

He says that the company has also taken on the installation of the mechanical equipment. "While this was not originally in our scope of work, we have the necessary experience in our mechanical-engineering division. The turbines and generators were sourced directly from Boving Fouress of Bangalore, India."

The Merino plant also required the construction of a coffer dam to divert the river to facilitate construction. "The river was diverted through the completed intake works and through a section of the canal to allow for the construction of the weir on the river bed," Ross explains. "The canal was then closed using the bulkhead gates and the water was returned back to the river." Collet says: "The canal had to be realigned when it was decided to relocate the power station. It became apparent, when excavations began, that suitable founding conditions were much deeper than expected. As a result, the design was changed to extend the canal and move the power station.

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which was then positioned in the existing rock abutment. During the feasibility study for Sol Plaatje Power Station, we investigated the possibility of drilling a hole into the existing concrete wall. This would have required the construction of a sophisticated steel coffer structure to allow for dry drilling. The power station was then located on the left bank. We determined that siting the power station on the right-hand bank was more advantageous from the point of view of space and access, which would mean easier and safer construction. And it would eliminate the need to 'drill' a hole in the existing dam wall."

Two batch plants

The Merino and Sol Plaatje power plants are situated about 30 km apart and it was necessary for each site to have its own concrete batch plant as the amounts to be poured would have been too expensive if supplied as ready-mix. "We chose AfriSam's HSC as general-purpose cement is not available in bulk, which we deemed as a contract consideration based on the volumes required," Ross adds. "In addition, AfriSam was able to guarantee supply capability."

AfriSam sales consultant, Gijon van Wyk, says that the company supplied approximately 85 truck loads of cement to site with a total mass of 2 835 t from its Ulco factory in the Northern Cape via its Bloemfontein depot. "The client conducted tests on the product to ascertain its suitability for the variable temperatures encountered on site and the cement passed these tests with flying colours. A blended cement extended with limestone, HSC has a strength of 42,5 N. The typical high early-strength of AfriSam HSC offers outstanding benefits in terms of saving time and meeting production deadlines, especially in fast-track construction and concreting in cold weather."

The extremely fine particles of the mineral components act as nuclei for the formation of calcium silica hydrate; giving a fine-filler effect to produce a denser, more homogenous microstructure in the hardened cement paste and in the aggregate paste interfacial zones.

"We poured 3 500 m^3 at Merino and 2 200 m^3 at the Sol Plaatje site," Ross says. "On both sites, the climatic conditions played a huge role in mixing and casting of the concrete. In Bethlehem, early-morning winter temperatures are between -8 °C and 5 °C; rising to about 16 °C during the day. This meant that concrete could only be cast at certain times of the day and we needed to provide for contraction and expansion joints in construction due to temperature differentials. In addition, the temperature of the water was so low and often frozen that we could only start batching after 09:00."

While power was available at Sol Plaatje, generators had to be used for batching at the Merino site, which obviously added to the contract costs.

"In spite of the large number of challenges and obstacles the team faced, the positive attitude and high levels of professionalism exhibited by all contractors and suppliers has resulted in the satisfactory completion of the project," Collet says. ❖

For more information on this project, refer to the June 2007 edition of Civil Engineering Contractor!