SECTION 6 : WEIR SITES

6.1 OBJECTIVES

The following conditions relating to the selection of possible weir sites had to be satisfied before a more detailed investigation of the weir sites could be undertaken:

- It must not be constructed on the lip of the Popa Falls,
- It must not be visible to tourists visiting the falls,
- It must not affect the flow over the falls,
- It must minimise the area of inundation of sensitive habitats, land uses and cultural heritage sites,
- It must minimise the amount of social and economic disruption,
- It must not inundate Angolan Territory over and above the maximum flood level without a weir in place, and
- It must not inundate the Andara Mission and the Frans Dimbare Youth Centre.

6.2 PREVIOUSLY IDENTIFIED SITES

Three dam sites were identified in the 1969 study. The positions of these sites are shown in **Figure B6-1** of **Appendix B** of **Volume 2** of this report.

Site A, which is located on the lip of the falls, has a short embankment on the right bank and a long embankment on the left bank because there is no high ground close to the river's edge.

Site B is located approximately 1,2 km upstream of the falls. It's alignment passes diagonally across the river and crosses a large island. An alternative to Site B, which promised better founding conditions, was identified approximately 250 m downstream of Site B and was called Site D.

Site C is located a further 800 m upstream of Site B and was known as the "Short Site"
An economic analysis carried out at the time, based on alternative dam heights and spillway lengths, indicated that Site B with a dam built to a height of 9,5 m (elevation 1009,50 m.a.m.s.l.) would result in the lowest unit cost of energy. The storage capacity of this dam would be approximately 57 Mm^3.

6.3 NEW SITES IDENTIFIED FOR THIS STUDY

For the location of sites identified for this study, refer to **Figure 6-1** below. For a detailed map of the project area from the Popa Falls to the Angolan border showing the position of the alternative weir sites, the location of the Frans Dimbare Youth Centre, the Andara Mission Station and the Mukwe gauging station refer to **Figure B1-1** of **Appendix B** in **Volume 2** of the report.

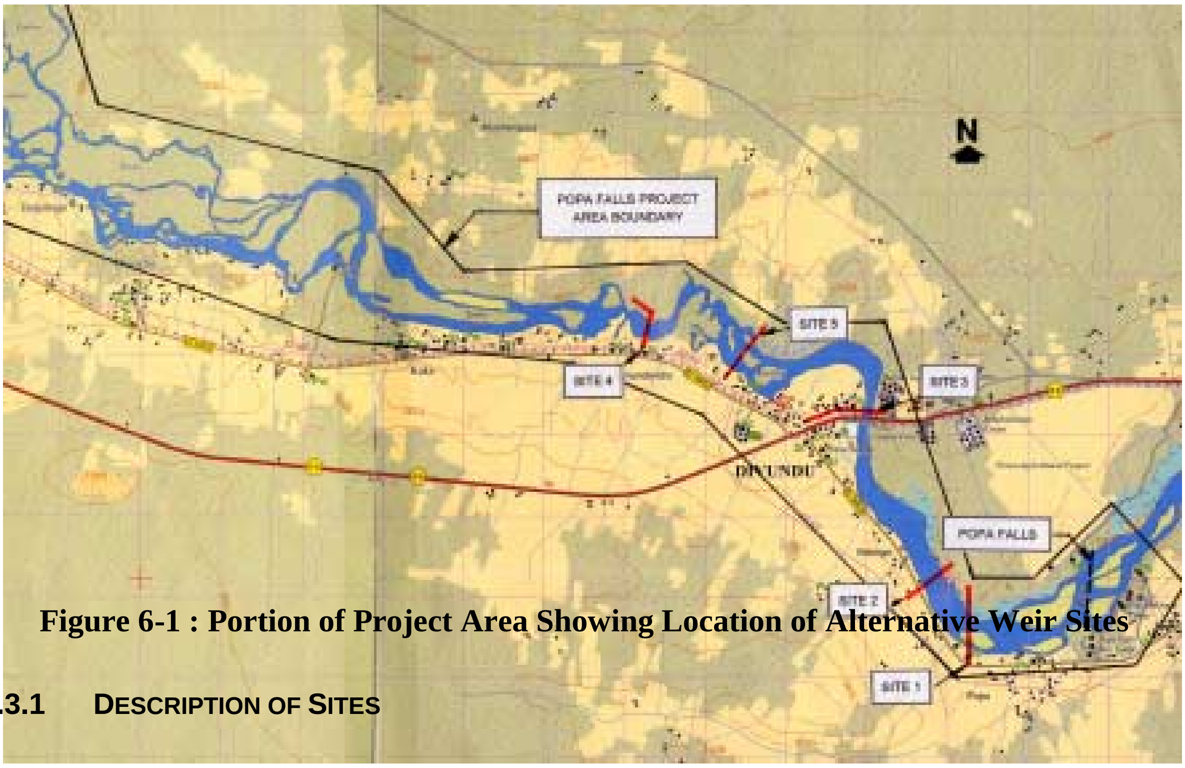

Figure 6-1 : Portion of Project Area Showing Location of Alternative Weir Sites

6.3.1 DESCRIPTION OF SITES

The following five alternative weir sites, which are located in the reach of the river between a point approximately 1,2 km upstream of the Popa Falls and a point some 9 km upstream of the Popa Falls, were consequently identified which satisfied the objectives listed in **Section 6.1**. Sites further upstream would have significant impacts on the Andara Mission and Dimbare Youth Centre, and the area of islands with rare natural habitats that would be submerged, would increase significantly.

Site 1 is located 1,2 km upstream of the Popa Falls and corresponds to Site B identified in the 1969 study. The alignment of the weir axis passes over a large island, which would be destroyed if a weir were to be constructed at this site. The axis of the weir crosses the river at a point where the river channel makes a nearly 90° turn to the left towards the falls. In relation to the river reach upstream of this site, the alignment is almost diagonally across the river, which is necessitated by the higher lying terrain at the extremities of the weir axis.

Site 2 is located approximately 2 km upstream of the Popa Falls and corresponds approximately with Site C identified in the 1969 study. This site was selected on account of the wide river section permitting the construction of cofferdams around the concrete section works area. It has a relatively short left flank and a somewhat longer right flank.

Site 3 is located approximately 80 m upstream of the Divundu bridge and 4.3 km upstream of the Popa Falls This site was selected on account of the good founding conditions against a steep rocky left bank.

Site 4 is located approximately 4 km upstream of the Divundu bridge and 8.3 km upstream of the Popa Falls, in an area were the river has a gradient approximately ten times steeper than the river section between Sites 1 and 3.

Site 5 is located approximately 7.3 km upstream of Popa Falls and 1 km downstream of Site 4, at the foot of some rapids. The site therefore offers the opportunity to increase the weir height by 0,75 m for the same FSL, which holds significant benefits for power generation.

6.4 GENERAL DESIGN CONSIDERATIONS

6.4.1 SPILLWAYS

In the design of the spillway section it was necessary to take cognisance of the environmental requirements, which require that any releases from the weir basin should be spread as uniformly as possible across the width of the river to avoid scouring effects if water releases are concentrated at isolated places across the river. This applies to the positioning of the Hydromatrix turbine modules **(see Section 7)** as well as to the spillway gates. As the discharge from the proposed TOPS spillway gates **(see Section 9)** will be different to that from the Hydromatrix turbine modules, the turbine modules were interspersed with the spillway gates. Since more spillway gates are required than turbine modules, it was not possible to alternate between the turbine modules and spillway gates on an equal basis. After careful consideration being given to the placing requirements, it was decided to adopt the positions of the different types of gates/modules shown on **Figure B6-4**.of **Appendix B** in **Volume 2**. This arrangement was therefore also used for Sites 4 and 5.

The layout of the spillway section allows for a roadway for installation and maintenance purposes only, pedestrian and operators walkway and gantry. The total length of a pier will vary between 33 m and 35,5 m for Sites 2, 4 and 5 respectively. Typical preliminary sections through the weirs show the anticipated positions of these components.   The position of the TOPS gates is defined by the installation and operational clearances, as well as locations of the gate trunnions. A 2 m deep chute is provided for each turbine module to maintain the minimum tailwater level required by the turbines.

Preliminary calculations have shown that 12 spillway gates, each 10 m long will be required to pass the flood during the sluicing period, if required. The optimum number of Hydromatrix turbines was found to amount to 9 Hydromatrix turbine modules each with three turbines per module giving a total of 27 turbines Each turbine module will have a total width of 7 m. The total length of the spillway section, allowing for 3 m wide piers, is therefore 249 m.

In the case of Site 2, the spillway section will be located up against the right bank of the river (refer to **Figure B6-4** of **Appendix B** of **Volume 2**) in order to allow sufficient space for constructing a cofferdam around the end of the spillway section and to have sufficient room to pass a 1:5 year flood, which is considered to be the norm applied to a cofferdam design during the construction period.

In the case of Site 4, the spillway will be placed centrally in the main channel of the river. (Refer to **Figure B6-8** of **Appendix B** of **Volume 2**). The river will be diverted through a side channel during construction, which is located on the northern side of the river.

In the case of Site 5, the spillway section will also be located up against the right bank of the river, as will be the case for Site 4 (Refer to **Figure B6-11** of **Appendix B** of **Volume 2**). The river will be diverted around the north-eastern end of the spillway section during the construction period. A cofferdam will therefore need to be constructed around this end of the spillway section.
In the case of Site 5 for the sediment bypass option, the number of gates will be reduced to 6 with no change to the number of Hydromatrix turbine modules. The spillway section will be placed centrally in the main channel of the river with the river being diverted via the left bank. The total length of the spillway section for this alternative is reduced to 171 m. A section along the weir for this alternative is shown in **Figure B6-12** of **Appendix B** of **Volume 2**.

6.4.2 ABUTMENTS

Two alternative types of weir abutments, i.e. those parts of the weir that connect on to either end of the spillway, have been considered, namely earth embankments and mass gravity concrete walls.

6.4.2.1 Earth Embankments

A typical cross section of an earth embankment is given in **Figure B6-5** of **Appendix B** in **Volume 2**. The section shown is that which was used for Calueque Dam in Angola. It provides for a central clay core and slightly plastic[1] earthfill up against the clay core on both the upstream and downstream sides of the core. Filter layers are provided on the upstream and downstream faces and a rip-rap layer on the upstream face.

Whilst slightly plastic material is relatively abundant in the area, suitable clay material is difficult to find. Enquiries with the local population have indicated that there is very little clay in the area. Further investigations will therefore have to be carried out during the detailed feasibility stage to establish if suitable clay core material is available.

It is known that clayey material can be found in the Omuramba Omatako, which is approximately 120 km from the weir sites. In the event that it is found that this material is suitable for the embankment core, then the overhaul costs would be excessive. In the absence

[1] The term "plastic" is used extensively in the field of Soil Mechanics and refers to the type of soil. The higher the plasticity the higher the clay content in the soil.

of any better information, it was assumed that this material would be used for the construction of the core. Cost estimates were consequently based on an overhaul of 120 km.

Suitable rock/stone for filter layers and rip-rap can be quarried from rock outcrops in the area. The rock is weathered on the surface but dense quartzite is expected to be found between 1,5 and 2 m below the surface of the rock. As suitable aggregate for concrete will also need to be quarried, the stone filter layers and rip-rap is likely to be available as a by-product of the quarry workings for concrete aggregate. Further detailed field investigations and core drilling during the detailed feasibility stage will need to be undertaken to confirm, or otherwise, the availability of suitable material and in the required quantities.

6.4.2.2 Mass Gravity Abutments

Mass gravity abutments were considered as an alternative to earth embankments. A typical cross section through the mass gravity wall is given on **Figure B6-4** of **Appendix B** in **Volume 2**. This type of wall becomes economical when the height of the wall is relatively low. Cost estimates prepared for the two alternatives, using an overhaul of 120 km for hauling clay material to the site, shows that there is very little difference in the costs of the two alternatives.

6.4.3 FLANK WALLS AND COFFER DAMS

Flankwalls will need to be constructed at each end of the spillway section in the case of the earth embankment alternative. However, in the case of the mass gravity wall alternative, flankwalls would not be required. In the case of Sites 2 and 5, consideration will, however, have to be given to the construction of concrete flankwalls at the end of the left end of the spillway to which the cofferdams can be tied during the construction stage. These can be either a permanent feature or temporary, in which case they would not need to be constructed to the full height of the weir nor would the finish and the concrete strength have to comply with the requirements of the permanent concrete works. From a cost point of view, the latter alternative would be the best option to pursue.

Material for cofferdams may have to borrow from suitable areas or quarried from suitable sources located below the FSL. Suitable material may also be available from excavations of the abutment foundations. Additional material will become available from excavations in the spillway section, provided sufficient suitable material to construct the initial lift of the cofferdams is obtained from other sources, and provided further that excavations in the river are programmed to commence when the flow in the river is at its lowest, i.e. in October and November.

6.5 SITE EVALUATION (TECHNICAL/FINANCIAL, SOCIAL, ENVIRONMENTAL)

The advantages and disadvantages of the various weir sites are summarised in **Table 6.1**.

Table 6-1 : Advantages and Disadvantages of Selected Weir Sites

Site	Advantages	Disadvantages
Site 1	• The utilisation of the additional head of the Falls for power generation, could improve power generation benefits. • Storage capacity is less than 2% of the MAR.	• The site is too close to the falls, • The construction of a weir would destroy the island over which the weir axis passes, • The site requires a very long left flank embankment, • The costs for a weir at this position would be greater than for a weir at Site 2.
Site 2	• Wide river channel which allows the construction of cofferdams around the concrete works, • Has a short left flank and relatively short right flank, • Would inundate less island habitat than sites 4 and 5, • The utilisation of the additional head of the Falls could improve power generation benefits. • Storage capacity is less than 2% of the MAR.	• Too close to the Falls, • Would be visible to tourists approaching the Popa Falls from upstream of the falls, • Would inundate large tracts of land, • Weir height is limited to 7,5 m, • Major relocation of households and businesses etc. required.
Site 3	• Has a short left flank with good founding conditions against a steep rocky bank, • This site is located sufficiently far upstream of the Falls so as not to affect the pristine natural environment around the Popa Falls area. • Tourists visiting the area of Popa Falls would not see the hydro power station, • Storage capacity is less than 2% of the MAR.	• Weir height is limited to 7,5 m. A higher weir would result in the submergence of approach ramps of Trunk Road TR8/4 leading to the Divundu bridge, • Would inundate large tracts of land, • Major relocation of households and businesses etc. required, • The river width is inadequate to accommodate the required number of spillway gates.
Site 4	• Weir height can be increased to 9,0 m to a FSL of 1010.0 m.a.m.s.l, • Secondary channel is available for flood diversion during construction, • Embankment in secondary channel can accommodate a fuse plug as an additional safety factor against extreme floods, • Less relocation of households etc required, • Good founding conditions expected in a rocky river channel, • Length of basin at FSL is less than for Sites 1, 2 and 3, • Lowest storage capacity of all sites considered, • Storage capacity is less than 2% of the MAR.	• Weir height is limited to a FSL of 1010.0 m.a.m.s.l. Higher weirs would inundate the Frans Dimbare Youth Centre, • 29% of the total area of islands as determined for January 2003, will be submerged at FSL conditions, • Sections of District Road D3402, the 33kV powerline, and telephone line will need to be relocated to higher ground, • Construction costs would be high due to additional embankment/wall in the secondary channel.
Site	**Advantages**	**Disadvantages**
Site 5	• Weir height can be increased to 9,75 m to a FSL of 1010.0 m.a.m.s.l. as the river bed is approximately 0.75 m lower than at Site 4, • Less relocation of households etc. required, • Good founding conditions expected in a rocky river channel, • Length of basin at FSL less than for Sites 1, 2 and 3, • River channel is wide enough to construct the concrete section within cofferdams leaving sufficient river width to accommodate low frequency floods,	• Weir height is limited to a FSL of 1010.0 m.a.m.s.l. Higher weirs would inundate the Frans Dimbare Youth Centre, • 30% of the total area of islands as determined for January 2003, will be submerged at FSL conditions, • Sections of District Road D3402, the 33kV powerline, and telephone line will need to be relocated to higher ground, • Storage capacity only slightly greater than for Site 4 but is still far less than the maximum figure 2% of the MAR at which point sluicing

	• Storage capacity is less than 2% of the MAR.	would not be effective.

6.6 SITES SELECTED FOR DETAILED ANALYSIS

Weir Sites 1 and 3 have been excluded from further analysis as these pose major disadvantages over the other three sites, in that Site 1 is too close to the falls and would result in the destruction of a large island, and Site 3 has been rejected on account of the narrow channel width which would not allow the installation of the required number of spillway gates and Hydromatrix turbine modules.

Sites 2, 4 and 5 were consequently selected for further detailed analyses and optimisation.

Site 2, which is located approximately 2.2 km upstream of the Popa Falls, coincides approximately with the Short Site C identified in the 1969 study. Site 4 is located approximately 4 km upstream of the Divundu bridge and Site 5 approximately 1 km downstream of Site 4. Only slight changes were made to the alignment of the centreline of Site 2 from that selected in 1969, and, in the case for Sites 4 and 5, large scale airborne laser survey mapping allowed the consultant to select the optimum alignment, with due consideration being given to the possible flood diversion works during the construction period and minimising the total length of the weir. **Figures B6-2**, **B6-6**, and **B6-9** of **Appendix B** in **Volume 2** show the proposed alignments of the weirs at the respective sites.

6.6.1 SITE 2

The analysis of **Site 2** was limited to a weir height of 7,5 m (elevation 1007,50 m.a.m.s.l.) because a higher weir would endanger the approach ramps to the Divundu bridge and a number of homesteads and several businesses at Divundu would have to be relocated.. The storage capacity of the basin created by a 7,5 m high weir amounts to 22,5 Mm³ which represents 0.24% of the MAR (9 585 Mm³/a). This site is on a section of river that is about 380m wide, which is much wider than average, and therefore lends itself to the construction of a coffer dam around the weir during construction.

The area of islands inundated at FSL amounts to 0.455 km², or 7.07% of a total island area, measured between a point 3 km downstream of the Popa Falls and the point where the Okavango River enters the Caprivi Strip.

6.6.2 SITE 4

In the case of **Site 4**, weir heights of 6,5 m, 9,0 m and 11,5 m (FSL elevations of 1007,50, 1010,00 and 1012,50 m.a.m.s.l respectively) were investigated. The latter alternative was investigated purely to establish the sensitivity of weir height to the economic viability of the project. At a full supply level of 1010 m.a.m.s.l. the upper reaches of the impoundment would not reach the Andara Mission station. The site is in a section of river that has a gradient 10 times greater than at Site 2. It has the engineering advantage that it is possible to construct an auxiliary embankment with a fuse plug in a side channel, which can also be used for diverting the river during construction of the weir. It is also possible to construct a higher weir than at Site 2 due to the steeper gradient. It is proposed that a weir at this site could be as high as 9 m (from the bed at 1001.0 m.a.m.s.l.) which significantly increases the power generation potential.

The storage capacity of the basin created by a 9.0 m high weir amounts to 16.9 Mm³ which represents 0.18% of the MAR. The area of islands inundated at FSL amounts to 29% of the total island area in the study zone.

6.6.3 SITE 5

In the case of **Site 5**, weir heights of 9.75 m, and 10.75 m and 12.25m (elevations 1010.00, 1011.00 and 1012.50 m.a.m.s.l.) were investigated. Here again, as in the case of Site 4, the latter weir height alternative was investigated to establish the sensitivity of weir height to the economic viability of the project. Site 5 has the engineering advantage that the weir height could be increased to 12.25 (from the bed at 1000,25m). The FSL would be at 1012,5 m.a.m.s.l. This alternative increases the power generation potential even further compared to Site 4.

The storage capacity of the basin created by a 9,75 m high weir amounts to 24,4 Mm³ which represents 0.26% of the MAR and is only slightly greater than for Site 4. The area of islands inundated at FSL amounts to 30% of a total island area.

6.6.4 SITE SPECIFIC DATA

The site specific data for each of the three preferred sites for the preferred FSL elevations is given in **Table 6-2** on the following page:

Table 6-2 : Site Specific Data for Preferred Weir Sites

Data Item	Unit	Site 2	Site 4	Site 5
Full supply level	m.a.m.s.l.	1007.5	1010.0	1010.0
Maximum depth at full supply level	m	7.5	9.0	9.75
Weir height to crest level	m	9.7	11.2	10.45
Weir length	m	790	1490	1200
Storage capacity	mil m³	22.5	16.9	24.4
Storage capacity as a % of MAR	%	0.24	0.18	0.26
Surface area of the reservoir at FSL	km²	8.12	6.29	8.18
Length of reservoir at FSL measured along river	km	12.4	9.4	10.3
Area of islands inundated at FSL	km²	0.46	1.37	1.38
Percentage if total islands inundated	%	7.07	21.24	21.46

The full supply levels for Sites 2, 4 and 5 are shown on **Figures B6-3**, **7** and **10** of **Appendix B** of **Volume 2** respectively.

6.7 RELOCATION OF HOUSEHOLDS, BUSINESSES AND OTHERS

As it will be unavoidable that several households, businesses, supermarkets, service stations, schools, clinics, lodges, the Frans Dimbare Youth Centre, and certain sections of District Road 3402, telephone lines and the 33 KV power line will be submerged during peak flood conditions, allowance must be made in the financial analysis for relocating these to above the maximum flood level which is taken, for the purpose of estimating these costs, to be 2 m above the FSL of the respective sites.

The Ministry of Finance has prepared a policy document entitled "*Policy for the Payment of Compensation to Occupiers of Land in Communal Areas such as those in the Kunene, Omusati, Oshana, Ohangwena, Oshikoto, Kavango and Caprivi Regions*" which authorises the payment of compensation to affected parties in the above mentioned Regions.

The Government generally requires that their policies be complied with in order not to create precedents. The issue of compensation to affected parties will consequently need to be addressed during the full feasibility study phase and suitable recommendations submitted to the appropriate authorities for approval.

The unit rates applied to compensation calculations are those determined by the Authorities and are as follows:

Expropriation of land	N$ 1 000.00/ha
Thatched roof structure without walls	N$ 50.00/m²
Thatched roof structure with pole walls	N$ 100.00/m²
Solid brick type structure	N$ 400.00/m²
Fences	N$ 30.00/m
Cuca shops with zinc roof and concrete floor	N$ 125.00/m²

For the purpose of this study it has therefore been assumed that the average expropriation costs for households would amount to the following:

Expropriation of land	0.2 ha @ N$ 1 000.00	N$ 200.00
Average price per building	60 m² @ N$ 200.00	N$12 000.00
Fencing	100 m @ 30.00	N$ 3 000.00
Total per household		**N$15 200.00**

The number of units that will need to be relocated for each alternative are therefore listed below. The number of units falling within the high flood area of each basin were abstracted from the 1:4 000 and 1:10 000 topographical maps. The detail on the maps was not clear enough to distinguish between households, businesses or shops. They have therefore all been listed together under households. In addition to the above, certain sections of District Road 3402, telephone lines and the 33 KV power line will also need to be relocated in order not to be submerged during high flood periods.

In the case of a weir being constructed at Site 2, a total length of 3.2 km of the gravel road would need to be relocated at an estimated cost of N$ 250.00/m. In the case of Sites 4 and 5 a total length of 4.2 km of gravel road would need to be relocated at a cost of N$ 400.00/m. In the latter case the road is more costly as it has to be diverted over a small hill which requires higher fill in some sections.

A major structure that created some concern is the Frans Dimbare Youth Centre. Enquiries have revealed that the Centre is currently in its third phase of development. The architects involved on this project have advised that the total amount spent on the project is in excess of N$ 20 000 000. For the purpose of this study it was therefore feared that the centre would have to be relocated at a cost of approximately N$ 25 000 00. However, discussions with the Director of Youth of the Ministry of Higher Education, Training and Employment Creation, have revealed that they had no intention of moving the Centre. As an alternative, it was suggested that a concrete wall be built along the river's edge to keep the water out of the property. The wall could be designed with outlook platforms for tourists. This alternative was accepted by the Director of Youth. The estimated cost of the wall amounts to N$ 5 000 000. The costs are much the same for each of the sites as the height is determined by the FSL plus the additional free board required for the regional maximum flood. The flood protection wall would be required for all three alternatives.

A further major structure would be the fuel service station located to the north of the approach road to the bridge. Although it would seem as though the service station is located outside the high water mark, the service station would be very close to the water edge during these periods. In addition, access would be problematic and it is doubted whether the Roads Authority would allow the construction of an off-ramp to the service station. In any event, enquiries have shown that a provisional amount of N$ 5 000 000 to relocate the service station should be made. The service station would only need to be relocated in the case of Site 2.

Table 6-3 on the following page summarises the relocation costs as determined for the preferred FSL elevations for each of the sites:

Table 6-3 : Estimated Relocation Costs

Item Description	Unit	Rate N$	Quantity	Amount N$
SITE 2				
Households	No.	15 200	260	3 952 000
Schools	No.	3 000 000	-	-
Clinics	No.	1 500 000	1	1 500 000
Churches	No.	1 500 000	1	1 500 000
Lodges	No.	1 500 000	1	1 500 000
Service Stations	No.	5 000 000	1	5 000 000
Flood protection wall at the Frans Dimbare Youth Centre	No.	5 000 000	1	5 000 000
District Road 3402	km	250 000	3.2	800 000
Telephone line	km	100 000	3.2	320 000
33 KV Powerline	km	200 000	4.8	960 000
Total Site 2				20 532 000
SITE 4				
Households	No.	15 200	80	1 216 000
Schools	No.	3 000 000	-	-
Clinics	No.	1 500 000	-	-
Churches	No.	1 500 000	-	-
Lodges	No.	1 500 000	-	-
Service Stations	No.	5 000 000	-	-
Flood protection wall at the Frans Dimbare Youth Centre	No.	5 000 000	1	5 000 000
District Road 3402	km	350 000	4.2	1 470 000
Telephone line	km	100 000	4.0	400 000
33 KV Powerline	km	200 000	4.0	800 000
Total Site 4				**8 886 000**
SITE 5				
Households	No.	15 200	100	1 520 000
Schools	No.	3 000 000	-	-
Clinics	No.	1 500 000	-	-
Churches	No.	1 500 000	-	-
Lodges	No.	1 500 000	-	-
Service Stations	No.	5 000 000	-	-
Flood protection wall at the Frans Dimbare Youth Centre	No.	5 000 000	1	5 000 000
District Road 3402	km	350 000	4.2	1 470 000
Telephone line	km	100 000	4.0	400 000
33 KV Powerline	km	200 000	4.0	800 000
Total Site 5				**9 190 000**

6.8 WEIR SITE EVALUATION

Using the key criteria listed above, the three preferred sites were evaluated to determine which site best fulfils the principles of sustainability. The results of the evaluation are shown

in **Table 6-4**. Each site was scored using a simple scale in which 1 indicates poor achievement of the objective, 2 = fair and 3 = good.

The table shows that Site 5 is the best from a technical and financial point of view, but scores poorly in terms of environmental and social impacts.

Site 4 scores less well in relation to sites 2 and 5 against the technical, financial and environmental criteria, but has less impact on the social environment than Site 2.

Overall, Site 5 is better than Site 2, the main difference lying in the fact that Site 5 is better than Site 2 based on technical criteria.

Table 6-4 : Weir Site Evaluation

Criteria	Site 2	Site 4	Site 5
TECHNICAL			
Good founding conditions	1	3	3
Presence of construction materials	1	1	1
Storage capacity	3	1	3
Lack of fault structures	3	1	1
Ease of construction	3	3	3
Sub-total (Rank)	**11 (1)**	**9 (3)**	**11 (1)**
FINANCIAL			
Minimum impact on infrastructure	2	1	1
Minimise construction costs	3	1	2
Maximise power generation capacity	1	2	3
relocation Costs	1	3	2
Sub-total (Rank)	**7 (1)**	**7 (2)**	**8 (3)**
ENVIRONMENTAL			
Minimum impact on islands	2	1	1
Minimum impact on riverine vegetation	3	1	1
3Minimum construction impact	3	1	2
No impact on RDB species	2	1	1
Minimum disruption on ecological processes	1	2	1
Sub-total (Rank)	**11 (1)**	**6 (2)**	**6 (2)**

Criteria	Site 2	Site 4	Site 5
SOCIAL			
Minimum relocation of houses	1	2	2
Minimum relocation of businesses	2	3	3
Minimum impact on institutions	1	3	3
Minimum impact on agriculture and rural livelihoods	1	2	2

Minimum impact on tourism and sense of place	1	3	3
Minimum impact on archaeological and cultural sites	2	2	2
Relocation of households, Businesses and others	1	3	2
Sub-total (Rank)	**9 (3)**	**18 (1)**	**17 (1)**
TOTAL (RANK)	**38 (3)**	**40 (2)**	**42 (1)**