BURNSIDE

Appendix G.1
Sediment Transport Desk Study

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1. INTRODUCTION

BACKGROUND

AES Nile Power (AESNP), a joint venture between AES Electric Ltd a UK wholly owned subsidiary of the AES Corporation (a US company), and Madhvani International of Uganda, has submitted a formal proposal to the Government of Uganda and the Uganda Electricity Board (UEB) to develop a 250 MW hydroelectric power plant on the River Nile at Bujagali.

The project site is located at Dumbbell Island, near the source of the Victoria Nile in Uganda and about 2.5 km downstream from Bujagali Falls. The project will comprise a 250 MW Power Station housing 5 x 50 MW Kaplan turbine generation units with associated 30 m high embankment and spillway works. The construction phase will involve diversion of the entire river flow either side of Dumbbell Island, firstly through the eastern channel (while the western embankment and powerhouse are being constructed) and then through the western channel, while the eastern embankment is being constructed).

In 1998, AESNP commissioned WS Atkins International to undertake an environmental impact assessment of the proposed project. This was carried out to comply with Ugandan and International Finance Corporation (IFC) standards. The Ugandan EIA procedures are detailed in the guidance prepared by the National Environment Management Authority (NEMA) in July 1997 and the Environmental Impact Assessment Regulations, 1998. The World Bank/IFC requirements are detailed in their sectoral guidelines for hydropower schemes (1990) and EIA studies (OP4.01).

The final Environmental Impact Statement (EIS) was submitted to NEMA in March 1999. Following a Public Hearing held in Jinja during August 1999, NEMA issued a Certificate of Approval of Environmental Impact Assessment dated 1 November 1999. Condition 5 of this approval stated that 'AES Nile Power undertakes to [*inter alia*] meet all the technical requirements with regard to control and regulation of water flows downstream to the dam, and to meet any other requirements as will be prescribed by the Directorate of Water Development with regard to hydrology of the Nile and other water quality concerns. The development of the project shall also be in conformity to international agreements applicable to development of the nature proposed on the River Nile'.

In order to discharge its obligations under Condition 5 with respect to water quality, AESNP commissioned WS Atkins International to carry out a desk study to investigate the potential for elevated suspended sediment (SS) concentrations downstream of the site during construction. It is during the construction phase that there will be greatest potential for inputs of SS to the River Nile.

This study is based upon river morphometry, hydrological and geotechnical data that have been gathered during the Bujagali Feasibility Study and Environmental Impact Assessment. The focus of the study is upon water quality in the reaches of the Victoria Nile between Dumbbell Island and a point downstream of Kalagala Falls, some 18 km downstream.

APPROACH TO THE STUDY

A three-stage approach has been used for carrying out the desk study, as follows:

(i) Collation of data on river physical characteristics (long and cross-sections), river flows, existing water quality and potential sediment sources.

(ii) Calculation of the magnitude and duration of SS inputs to the Nile from each identified source

(iii) Calculation of SS concentrations in the Nile downstream of the site. This has used a simplified version of the MIKE 11 one-dimensional hydrodynamic model, produced by the Danish Hydraulics Institute.

2. METHODOLOGY

DATA UTILISED AND ASSUMPTIONS

River Physical Characteristics

Longitudinal sections of the Nile giving river bed elevation between Owen Falls and Kalagala Falls (approximately 18 km downstream of Dumbbell Island) were available from the Bujagali Feasibility Study (Knight Piesold, 1998*a*; 1998*b*). Downstream of Kalagala, the river slope for each subsequent 10 km reach was estimated from contours shown on 1:50,000 scale topographic maps of the Nile Valley, which were based on aerial photography carried out in 1998 as part of JICA-sponsored surveys.

Consultation with the Directorate of Water Development (Entebbe) indicated that no bathymetric survey data are available for the Victoria Nile between Dumbbell Island and Lake Kyoga. The only relevant survey data were for river cross-sectional profile in the vicinity of Dumbbell Island, collected in 1997 as part of the Feasibility Study (Knight Piesold, 1998*a*, 1998*b*). Cross-sections were not available further downstream. Consequently, for the reach of the Nile between Dumbbell Island and Kalagala Falls, cross sectional area was estimated based on channel widths shown on 1:50,000 scale topographic maps, assuming the same cross sectional profile as had been reported for the Dumbbell Island area in the Feasibility Study.

Cross-sectional profiles used for the modelling exercise are included in Appendix A.

The channel morphometry and flow characteristics of the Nile change significantly downstream of Kalagala Falls, with the river channel becoming less steep-sided, the gradient of the river decreasing and wetland areas appearing, mainly along the east bank. For this reason it was not considered appropriate to apply the Dumbbell Island channel cross-sections further downstream than Kalagala Falls, which had been the original aim of the exercise. This approach allowed the sediment load and deposition for the 18 km of river between

Dumbbell Island and Kalagala to be estimated, which would give a good indication of downstream load.

River Flow Data

River flow scenarios used for calculation of erosion, transport and deposition of SS were based on those previously calculated for daily peak and average discharge from Owen Falls power station, after completion of the Owen Falls Extension (Table G.1).

Table G.1 – Daily average and peak flows from Owen Falls powerstations

Sluice Gate Operating Condition	Daily Peak Turbine Flow (m^3s)	Peak Sluice Gate Flow (m^3/s)	Average Sluice Gate Flow (m^3/s)	Peak Flow Occurrence	Peak Flow (m^3/s)
Owen Falls (260 MW)					
Continuous	1407	670	670	Daily	2077
5/10 days	1407	1339	670	5/10 day	2746
Owen Falls (300 MW)					
Continuous	1623	529	529	Daily	2152
5/10 days	1623	1058	529	5/10 day	2681

Data from Knight Piesold (1998*b*).

Existing Water Quality

The calculations carried out as part of this assessment enabled the increase in suspended sediment load above the baseline situation to be estimated. In order to set this increase in the context of the natural 'baseline' situation, it is necessary to have historical suspended sediment data for the areas likely to be affected, i.e. the immediate Bujagali area and downstream. With this information the tolerance of species to any elevation in suspended sediment concentration, and the importance of the downstream suspended sediment load can be estimated.

Initial data from the baseline aquatic ecology and water quality surveys being undertaken on the upper Victoria Nile by the Fisheries Research Institute (FIRI), Jinja, indicate that natural concentrations in the period February to April 2000 were in the range of 2-14 mg/l.

Suspended sediment concentrations are measured regularly by the Directorate of Water Development at Masindi Port, downstream of Lake Kyoga. According to Norplan (1999), the average SS value measured at the surface, mid-depth and near-bottom is 8.67 mg/l. The difference in SS concentrations between the upper Victoria Nile and Masindi Port indicates that considerable SS loss occurs between these two points. This is most probably due to sedimentation in Lake Kyoga itself, and in reaches of the Victoria Nile immediately upstream of Lake Kyoga, which are relatively wide and have a small gradient, and therefore are slow flowing.

Sediment Sources

Inputs from inundated river banks

Increased erosion of the river banks as a result of raised water levels and localised increases in flow velocity during diversion works represents a potentially significant source of suspended sediment downstream of the construction site.

In order to estimate the importance of this source, data were required on the following:

- Depth of readily-suspendible material (silt, soil, sand and/or clay)
- Particle size distributions
- Extent of inundation

As part of the Feasibility Study (Knight Piesold, 1998*a*; 1998*b*) a total of 21 drillholes were installed on the river banks and islands in the vicinity of the proposed hydropower facilities. Of these, nine were deemed to fall within the area to be inundated during the construction phase. The depth of suspendible material (silt, soil, sand and/or clay) at these nine drillholes was taken from records presented in Knight Piesold (1998*b*), and are outlined in Table G.2 below.

Table G.2– Depth of suspendible material at drillhole sites

Drillhole No.	Eastings	Northings	Depth (m)
DH2	515081	55338	3.10
DH3	515244	55310	2.20
DH6	515739	55361	2.40
DH9	515750	55216	2.50
DH10	515176	55318	0.00
DH11	515182	55305	0.00
DH12	515132	55428	5.80
DH14	515222	55332	1.00
DH20	515585	54690	8.50

From the data presented in Table G.2, the average thickness of suspendible material in the area to be inundated during the construction phase was taken to be 2.83 m.

Particle size distributions were taken from interpretation of the description of drillhole logs presented in Knight Piesold (1998*b*). Material described in the logs as silt, clay/silt, clay, sand, gravel, cobbles or boulders was allocated to a particle size range (Table G.3) according to the table in Appendix D.2 of Knight Piesold (1998*b*).

Table G.3 – Particle size ranges of suspendible material

Fraction	Size Range (mm)
Clay	<0.0006
Clay/silt	0.0006-0.002
Silt	0.002-0.06
Sand	0.06-2
Gravel	2-60
Cobbles	60-200
Boulders	>200

Total depth of each size fraction was calculated from information in the logs presented for drillholes in the vicinity of Dumbbell Island, as follows.

Table G.4 – Depth of overburden size fractions at drillhole sites near Dumbbell Island

Category	DH2	DH3	DH6	DH9	DH10	DH11	DH12	DH14	DH20	Total for 9 DHs	% composition
					Depth in metres						
Clay	1.0	0.55	1.2	1.25			0.71	0.50	6.50	11.71	45.9
Clay/silt	1.05	1.1								2.15	8.4
Silt							0.59			0.59	2.3
Sand							2.55		2.0	4.55	17.8
Gravel							0.85			0.85	3.3
Cobbles										0	0.0
Boulders	1.05	0.55	1.2	1.25			1.10	0.50		5.65	22.2

The water level produced by maximum flows expected at the site during construction was calculated in order to size the cofferdams and assess the safety of the site, as part of the Feasibility Study (Knight Piesold, 1998*b*, Annexe B). Following completion of the installation of the first two turbines currently under construction at Owen Falls Extension (OFE), daily peak generation flow through the two powerstations may amount to some 1400 m^3/s. The flow resulting from an inflow event to Lake Victoria with a 1 in 100 year return period has been estimated at 2000 m^3/s.

Figures B12 and B13 from Knight Piesold (1998*b*) show water levels in the eastern and western channels adjacent to Dumbbell Island, with the temporary diversion arrangements in place. From comparison of the present and predicted water levels, it is apparent that the area of elevated water level will be confined to the vicinity of Dumbbell Island. Key data used for calculation of suspended sediment load from this source are given in the table in Appendix B.

Inputs from cofferdam construction materials

It is anticipated that the hydropower development will be constructed in two stages. In Stage 1, the river will be diverted through the channel on the eastern side of Dumbbell Island by construction of a cofferdam in the western channel at the upstream end of the island and a second cofferdam at the downstream end. The intervening area between the cofferdams will be dewatered to allow construction of the embankment, power station and ancillary works.

During Stage 2, the Stage 1 cofferdams will be removed and the western channel reopened to allow water to pass through temporary ports constructed in the main spillway structure. The eastern river channel will then be closed off by cofferdams at the upstream and downstream end of Dumbbell Island. Following dewatering, the final closure section of the embankment will be constructed.

The cofferdams will comprise earth/rock embankments placed directly on the riverbed, which is believed to be relatively free from alluvial deposits. Initially, rockfill will be end-tipped across the river channel, but it will be necessary to place large boulders or pre-cast concrete unit to effect final closure of the Stage 1 upstream cofferdam. The cofferdams will be made watertight by placing an impervious earthfill blanket material on the waterside faces.

If this earthfill blanket material is eroded to any degree, it will represent a source of suspended sediment to downstream reaches. Data given by Knight Piesold (Alan Bates, pers. comm.) showed that about 120,000 tonnes of material will be used to form the coffer dam in the East Channel. The placement will occupy about 90 days and it is estimated that at most 1% will be lost as input to the sediment load in the river. The average rate is therefore very small. However, the maximum loss will occur shortly after each load of material is placed. There will be a short period during which a portion of the placed material will be washed out and a pulse of sediment produced. For the purposes of estimating the resultant sediment load we have assumed that this period lasts 30 seconds.

Table G.5 – Quantification of SS input from cofferdam earthfill blanket

Parameter	Dimension
Mass of material to be placed	120,000 tonnes
Duration of placement works	90 days
Maximum loss proportion	1%
Average sediment load	0.4 g/sec
Material load each placement	15 tonnes
Washing period	30 seconds
Pulsed sediment load	5 kg/s

Inputs from the river bed

Bedrock is exposed at river level, and the riverbed is believed to be relatively free of alluvial deposits (Knight Piesold, 1998*a*). This is assumed to be due to the rapid river flow being greater than the deposition velocity, thus preventing sedimentation on the riverbed. Consequently, this potential source of suspended sediment is not considered to be important in the context of other sources, and this factor is not included in subsequent calculations.

Figures used for calculation of the overall sediment load from the two identified sources are included in Appendix B.

CALCULATION METHODS

Calculation of Flow Velocities

Sediment transport estimates required a longitudinal velocity profile. A simple one dimensional model was set up in order to compute these. Models of this type require cross sections at key points, inflows at the upstream boundaries and a downstream boundary condition, as described above. An inflow rate of 1000 m^3/s was selected as being representative of the long-term discharge at Ripon/Owen Falls (Knight Piesold, 1998*b*).

Particularly in view of the sensitivity of sediment movement to velocity the hydraulic model should be calibrated. However, very little data was available and some locally observed surface flow velocities were used as a guide.

The model was developed using the MIKE11 1D modelling system produced by the Danish Hydraulics Institute. During development it became clear that the cataracts have a strong influence on water levels, and that as a result local velocities are very high. The predicted water levels are clearly too low and as a consequence the velocities predicted to occur in between the cataracts are higher than indicated observations in the field.

The model would be improved by modelling the cataracts as rough weirs and calibrating these to obtain realistic water levels and velocities. This was not possible within the scope of the present study, however we anticipate that the accuracy of the velocity distribution would improve should the model be upgraded in this way.

Calculation of Suspended Sediment Inputs

The present situation in the vicinity of Dumbbell Island is that river flow velocities are sufficient to remove all of the overburden from submerged areas. As the diversion will locally increase flow velocities, it is assumed the all of the newly-submerged river banks will be completely stripped of suspendible material within the first month of inundation. The total potential input has been input in the model at a constant rate over this one month period. The instantaneous pulses of sediment into the river from placement of materials for coffer dams has not been considered in this exercise, as this input represents a much smaller total load than that from diversion of the flow through each river channel in turn.

Calculation of In-River Suspended Sediment Concentrations

A steady state sediment transport model was developed. Sediment grades in the construction area range from clays (<0.06 µm) to cobbles and boulders. Very fine sediments are generally 'cohesive' while fractions larger than silts and sands are 'non-cohesive'. Electrostatic interactions between cohesive sediment particles means that these sediments tend to consolidate and thus behave differently to non-cohesive sediments. For example small non-cohesive sediment particles (e.g. sand) may have a lower critical erosive shear velocity (above which particles will move into the water column) than either smaller cohesive particles, or larger non-cohesive particles. In order to simulate the complete range of sediments both cohesive and non cohesive models were developed.

For the fine fractions the model is based on critical velocities for erosion and deposition. The erosion rate is dependent on an erodability parameter which ideally should be derived from measurements. The deposition rate is a function of local concentration and settling velocities. In the absence of these data default values cited in the MIKE 11 manual (DHI, 1992) were used (see Table G.6).

For fractions with particle diameter >1 mm a standard Ackers and White sediment (Ackers & White, 1973) model was used. The sediment mass flux is a function of a dimensionless grain diameter and a sediment mobility factor. The latter is a function of bed slope, water depth, local water velocity, shear velocity and grain diameter. In the present model the sediment carrying capacity for each sediment size fraction is computed for each cross-section of the river. If this decreases for the next downstream cross section it is assumed that the difference has been deposited on the river bed. There are no sediment calibration parameters as such within this model as the forms of the empirical equations are fixed.

The model assumes that in the reach below the dam construction site the sediment regime was in equilibrium before the influence of any construction work. This merely implies that there is no erosion in this area and sediment transported from the construction site and then deposited remains stable and is not re-eroded.

Since it was recognised that the velocities were generally very over predicted the complete longitudinal velocity profile was scaled to be in line with observed data.

The hydraulic and sediment parameters used in the model are as follows:

Table G.6 – Hydraulic and sediment deposition parameters used in MIKE 11 model

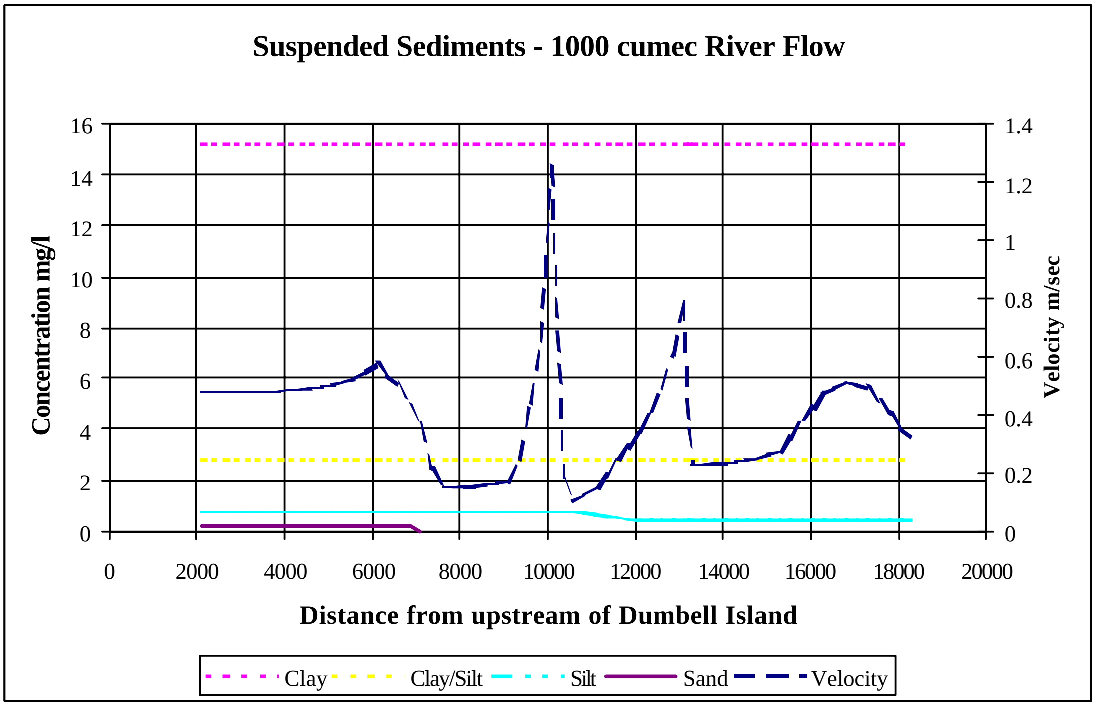
Parameter	Value
Sediment specific gravity	2.65
Mannings Number	0.030
Clay particle settling velocity	0.0005 m/s
Clay/silt particle settling velocity	0.001 m/s
Silt particle settling velocity	0.005 m/s
Erodability factor	0.005

The settling velocities and erodability parameter are taken from the MIKE11 Manual (DHI, 1992).

3. RESULTS

3.1 The MIKE 11 model was run assuming the sediment input outlined in Section 2, and assuming a constant discharge of 1000 m^3/s at the upstream boundary of the model. Figure - G.1 below shows the longitudinal distribution of water flow velocities and concentrations of a range of suspended fractions, from clay particles to boulders.

Figure G.1 – Longitudinal profile of current velocity and suspended sediment concentration, between Dumbbell Island (0 m) and Kalagala Falls (18000 m)



Although no measured flow velocity data are available against which the model can be calibrated or validated, the predicted velocities accord roughly with flow velocities estimated from observations of water movements in the study reaches. The largest peak that can be seen in the longitudinal velocity profile represents Busowoko Falls.

Coarse sediment fractions are not transported downstream any significant distance, and downstream of chainage 2000 m, the suspended concentrations of gravel, cobbles and boulders are all zero, while elevated sand concentrations to not extend past chainage 7000 m. However, the finer fractions (silt, silt/clay and clay) reach considerable distances downstream, and the concentrations of the finer fractions barely reduced even at the downstream limit of the model, approximately 18 km downstream of Dumbbell Island. The implication of this is that the coarser particles will be deposited on the river bed immediately downstream of Dumbbell Island, while the majority of finer particles will be transported at least 18 km downstream.

For a flow of 1000 m^3/s channelled only down one side of Dumbbell Island, the load generated by additional bank inundation and erosion is 33.1 kg/s. For a storm flow channelled down one side of 2000 m^3/s the load with one coffer dam in place is an additional 26 kg/s, resulting in a calculated additional increase in SS of 12.8 mg/l immediately downstream. Concentrations of the sum of the fine fractions does not exceed 33.1 mg/l.

The total material placed for a coffer dam will be approximately 120,000 m^3. If it is assumed that 1% is lost downstream during the 90 days required for placement, then an average increase in SS concentration of 0.41 mg/l will result. However, this assumes a constant sediment input rate, which is unlikely to occur in practice.

In practice there will be a pulse of sediment input as each load of material is placed and then washed by the flow. Even if it assumed that each load is washed out in 10 seconds, the downstream load of sediment amounts to only 40 kg/s for this short period of time. This material will be dispersed downstream and concentrations will be reduced from the initial cross sectional average of about 40 mg/l.

It should be borne in mind that the loads from the two identified sediment sources will not occur simultaneously, therefore the maximum calculated increase in SS immediately downstream does not exceed 46 mg/l.

4. CONCLUSIONS

This desk study of water quality impacts downstream of the Dumbbell Island site has indicated that there will be releases of small quantities of suspended sediment into the Nile as a result of construction activities. The main activity responsible for this release will be diversion of the river flow either side of Dumbbell Island as the two sections of the embankment are constructed. This will inundate an estimated area of some 60,800 m^2 of river bank, and the flow velocities in the area of the diversion are predicted to be sufficiently rapid to cause en elevated suspended sediment concentration of up to 33 mg/l immediately downstream of the works. Increased erosion of the river bed and of the earth facing on the coffer dams are predicted to cause relatively minor suspended sediment inputs.

A simple MIKE 11 model of the 18 km stretch of the Nile downstream of Dumbbell Island was constructed using longitudinal profiles reported in the Bujagali Feasibility Study and taken from 1:50,000 scale topographic maps. A limited number of channel cross-sections were available from the feasibility study, and in the absence of further measured profiles for the downstream section of the model, these profiles were also assumed to apply downstream. Given the abrupt change in channel morphometry downstream of Kalagala Falls, it was not considered appropriate to extend the model further downstream without direct measurements of the channel profile.

The sediment transport model predicted that the coarsest sediment fractions (gravel particles and larger) will settle out of the water column within 2 km of Dumbbell Island and sand particles will settle out within 7 km. However, finer particles (< 1 mm, i.e. silt, silt/clay and clay) are predicted to be transported through the length of the modelled reach of the river, with only a small change in concentration within the 18 km below the site.

It should be borne in mind that the loads from the two identified sediment sources will not occur simultaneously, therefore the maximum calculated increase in SS immediately downstream does not exceed 46 mg/l. Although the worst-case SS inputs appear high against a baseline of up to 14 mg/l, the resultant SS concentration is still much less than published thresholds for impacts on freshwater fish species (e.g. 100 mg/l, Alabaster and Lloyd, 1982).

Consequently, the scope for adverse effects appears to be insignificant, either in the immediate vicinity of the construction site, or further downstream.

5. REFERENCES

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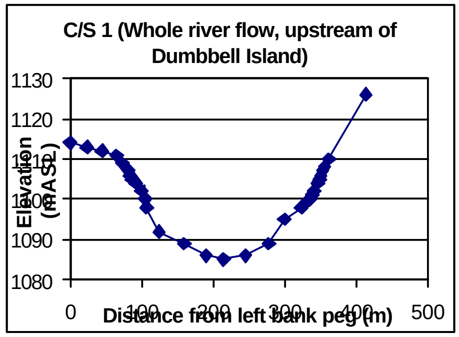
Appendix A.

River Channel Profiles

Chainage from u/s Dumbbell Is 0 m

	Eastings	**Northings**
Left Bank Peg:	516600	54200
Right Bank Peg	516900	54500

Distance across c/s (m)	Elevation (mASL)		
0	1114	1.00	
24	1113	1.00	
45	1112	1.00	
65	1111	1.00	
67	1110	1.00	
73	1109	1.00	
77	1108	1.00	
82	1107	1.00	
84	1106	1.00	
87	1105	1.00	
92	1104	1.00	
96	1103	1.00	
100	1102	1.00	
103	1102	1.00	
105	1100	1.00	
107	1098	1.00	Waterline
125	1092	1.00	
160	1089	1.00	
190	1086	1.00	
215	1085	1.00	
245	1086	1.00	
278	1089	1.00	
300	1095	1.00	
323	1098	1.00	Waterline
330	1099	1.00	
336	1100	1.00	
338	1101	1.00	
341	1102	1.00	
343	1103	1.00	
346	1104	1.00	
349	1105	1.00	
351	1106	1.00	
353	1107	1.00	
355	1108	1.00	
358	1109	1.00	
362	1110	1.00	
414	1126	1.00	



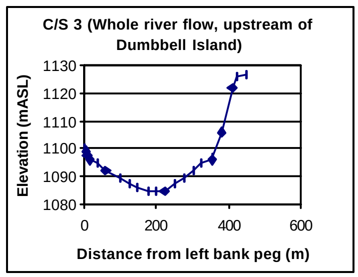
Note: C/S 1 and C/S 3 profiles below waterline estimated from C/S 40 profile, due to absence of collected dated in this reach.

Bujagali Hydropower Project, Uganda
Siltation Study

Cross-section No: 3
Chainage from u/s Dumbb 334 m

	Eastings	Northings
Left Bank Peg:	516400	54400
Right Bank Peg	516600	54800

Distance across c/s (m)	Elevation (mASL)		
0	1100	1.00	
4	1099	1.00	
7	1098	1.00	
11	1097	1.00	
15	1096	1.00	
38	1095	1.00	Waterline
60	1092	1.00	
100	1089	1.00	
125	1087	1.00	
145	1086	1.00	
175	1085	1.00	
200	1085	1.00	
220	1085	1.00	
250	1087	1.00	
275	1089	1.00	
300	1092	1.00	
323	1095	1.00	Waterline
352	1096	1.00	
355	1097	1.00	
380	1106	1.00	
410	1122	1.00	
422	1126	1.00	
450	1126.6	1.00	

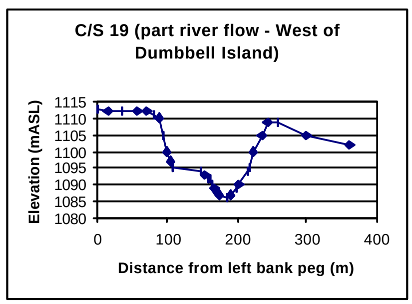


Bujagali Hydropower Project, Uganda
Siltation Study

Cross-section No: 19
Chainage from u/s Dumbl 944 m

	Eastings	Northings
Left Bank Peg:	516000	54500
Right Bank Peg	515800	54800

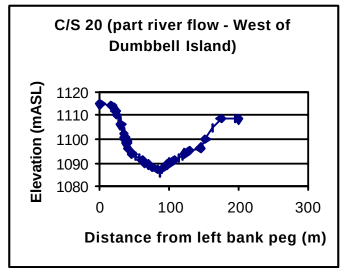
Distance across c/s (m)	Elevation (mASL)		
0	1112.4	1.00	
15	1112	1.00	
34	1112	1.00	
58	1112.2	1.00	
71	1112	1.00	
82	1111	1.00	
89	1110	1.00	
94	1105	1.00	
100	1100	1.00	
105	1097	1.00	
108	1095	1.00	Waterline
148	1094	1.00	
154	1093	1.00	
158	1092	1.00	
162	1092	1.00	
165	1090	1.00	
168	1089	1.00	
171	1088	1.00	
175	1087	1.00	
185	1086	1.00	
192	1087	1.00	
200	1089	1.00	
203	1090	1.00	
215	1094	1.00	
218	1095	1.00	Waterline
224	1100	1.00	
236	1105	1.00	
243	1109	1.00	
259	1109	1.00	
300	1105	1.00	
362	1102	1.00	



Bujagali Hydropower Project, Uganda
Siltation Study

Cross-section No: 20
Chainage from u/s Dumbbell Island 1064 m

	Eastings	Northings	
Left Bank Peg:	515800	54500	
Right Bank Peg	515800	54700	
Distance across c/s (m)	Elevation (mASL)		
0	1114.9	1.00	
15	1114	1.00	
20	1113	1.00	
22	1112	1.00	
24	1111	1.00	
25	1110	1.00	
26	1109	1.00	
27	1108	1.00	
28	1107	1.00	
29.5	1106	1.00	
31	1105	1.00	
32	1104	1.00	
33	1103	1.00	
34	1102	1.00	
35	1101	1.00	
36	1100	1.00	
37	1099	1.00	
38	1098	1.00	
39	1097	1.00	
40	1096	1.00	Waterline
41	1095	1.00	
45	1094	1.00	
49	1093	1.00	
55	1092	1.00	
60	1091	1.00	
63	1090	1.00	
69	1089	1.00	
75	1088	1.00	
82	1087	1.00	
85	1086	1.00	
88	1087	1.00	
92	1088	1.00	
95	1089	1.00	
100	1090	1.00	
106	1091	1.00	
112	1092	1.00	
117	1093	1.00	
122	1094	1.00	
128	1095	1.00	
143	1096	1.00	Waterline
152	1100	1.00	
161	1105	1.00	
174	1109	1.00	
194	1109	1.00	
200	1108.5	1.00	

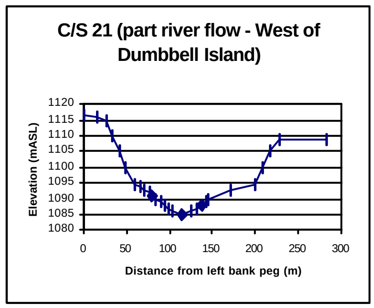


Bujagali Hydropower Project, Uganda
Siltation Study

Cross-section No: 21
Chainage from u/s Du 1188 m

	Eastings	**Northings**
Left Bank Peg:	515600	54500
Right Bank Peg	515800	54700

Distance across c/s (m)	Elevation (mASL)		
0	1116.7	1.00	
16	1116	1.00	
27	1115	1.00	
33	1110	1.00	
42	1105	1.00	
49	1100	1.00	
59	1094.5	1.00	Waterline
65	1094	1.00	
71	1093	1.00	
76	1092	1.00	
80	1091	1.00	
84	1090	1.00	
89	1089	1.00	
94	1088	1.00	
99	1087	1.00	
104	1086	1.00	
115	1085	1.00	
125	1086	1.00	
132	1087	1.00	
137	1088	1.00	
142	1089	1.00	
144	1090	1.00	
171	1093	1.00	
200	1094.5	1.00	Waterline
209	1100	1.00	
217	1105	1.00	
229	1109	1.00	
282	1108.5	1.00	
		1.00	
		1.00	
		1.00	
		1.00	
		1.00	
		1.00	
		1.00	
		1.00	

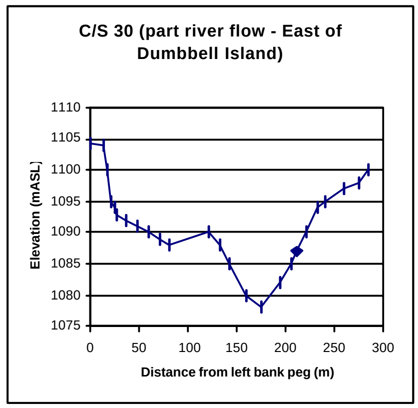


Bujagali Hydropower Project, Uganda
Siltation Study

Cross-section No: 30
Chainage from u/s Dumb 1364 m

	Eastings	**Northings**
Left Bank Peg:	515600	55000
Right Bank Peg	515800	55200

	Distance across c/s (m)	Elevation (mASL)		
	0	1104.4	1.00	
32	13	1104	1.00	
1	17	1100	1.00	
1	21	1095	1.00	
3	24	1094	1.00	Waterline
3	27	1093	1.00	
9	36	1092	1.00	
12	48	1091	1.00	
11	59	1090	1.00	
11	70	1089	1.00	
11	81	1088	1.00	
20	121	1090	1.00	
6	132	1088	1.00	
3	142	1085	1.00	
4	160	1080	1.00	
8	175	1078	1.00	
5	195	1082	1.00	
3	205	1085	1.00	
3	211	1087	1.00	
3	221	1090	1.00	
3	232	1094	1.00	Waterline
8	240	1095	1.00	
10	260	1097	1.00	
16	276	1098	1.00	
5	285	1100	1.00	

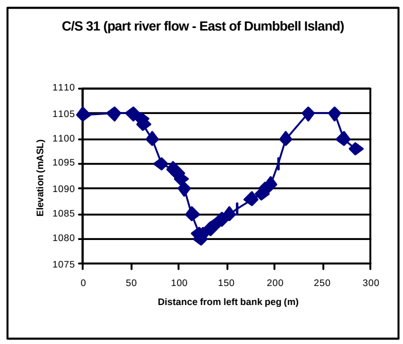


Bujagali Hydropower Project, Uganda
Siltation Study

Cross-section No: 31
Chainage from u/s Dumbb 1799 m

	Eastings	Northings
Left Bank Peg:	515400	55400
Right Bank Peg	515600	55600

	Distance across c/s (m)	Elevation (mASL)		
	0	1104.8	1.00	
160	32	1105	1.00	
#DIV/0!	52	1105	1.00	
9	61	1104	1.00	
2	63	1103	1.00	
3	72	1100	1.00	
1.8	81	1095	1.00	
13	94	1094	1.00	
5	99	1093	1.00	
3	102	1092	1.00	
1.5	105	1090	1.00	Waterline
1.8	114	1085	1.00	
1.5	120	1081	1.00	
2	122	1080	1.00	
3	125	1081	1.00	
7	132	1082	1.00	
6	138	1083	1.00	
7	145	1084	1.00	
7	152	1085	1.00	
8	160	1086	1.00	
7.5	175	1088	1.00	
11	186	1089	1.00	
4	190	1090	1.00	Waterline
5	195	1091	1.00	
2	203	1095	1.00	
1.6	211	1100	1.00	
4.8	235	1105	1.00	
#DIV/0!	262	1105	1.00	
1.8	271	1100	1.00	
6.5	284	1098	1.00	

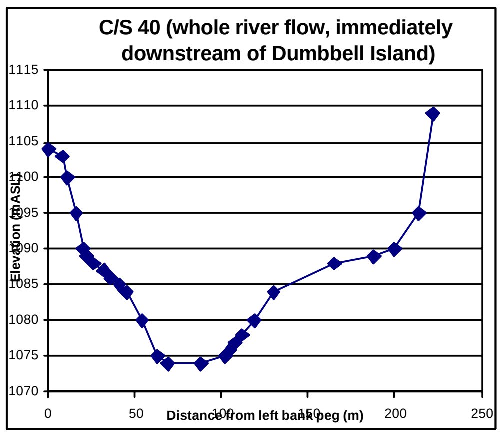


Bujagali Hydropower Project, Uganda
Siltation Study

Cross-section No: 40
Chainage from u/s Dumbb 2129

	Eastings	Northings
Left Bank Peg:	515200	55700
Right Bank Peg	515400	55800
Water surface level:	1090 m	

S	Distance across c/s (m)	Elevation (mASL)		
	0	1104	1.00	
8	8	1103	1.00	
1	11	1100	1.00	
1	16	1095	1.00	
0.8	20	1090	1.00	Waterline
2	22	1089	1.00	
4	26	1088	1.00	
6	32	1087	1.00	
4	36	1086	1.00	
5	41	1085	1.00	
4	45	1084	1.00	
2.25	54	1080	1.00	
1.8	63	1075	1.00	
6.0006	69	1074	1.00	
190000	88	1074	1.00	
14	102	1075	1.00	
3	105	1076	1.00	
3	108	1077	1.00	
4	112	1078	1.00	
3.5	119	1080	1.00	
2.75	130	1084	1.00	
8.75	165	1088	1.00	
23	188	1089	1.00	
12	200	1090	1.00	Waterline
2.8	214	1095	1.00	
0.571429	222	1109	1.00	

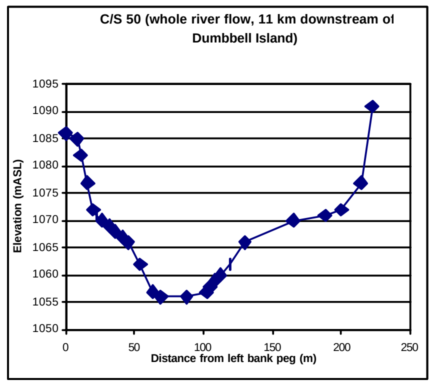


Bujagali Hydropower Project, Uganda
Siltation Study

Cross-section No: 50
Chainage from u/s Dumbb 13100 (between Bukasa & Nabukosi)

	Eastings	Northings	cl Easting	cl Northings
Left Bank Peg:	508000	63000		
Right Bank Peg	508300	63250	508150	63125
Water surface level	1072			

Distance across c/s (m)	Elevation (mASL)		
0	1086	1.00	
8	1085	1.00	
11	1082	1.00	
16	1077	1.00	
20	1072	1.00	Waterline
22	1071	1.00	
26	1070	1.00	
32	1069	1.00	
36	1068	1.00	
41	1067	1.00	
45	1066	1.00	
54	1062	1.00	
63	1057	1.00	
69	1056	1.00	
88	1056	1.00	
102	1057	1.00	
105	1058	1.00	
108	1059	1.00	
112	1060	1.00	
119	1062	1.00	
130	1066	1.00	
165	1070	1.00	
188	1071	1.00	
200	1072	1.00	Waterline
214	1077	1.00	
222	1091	1.00	

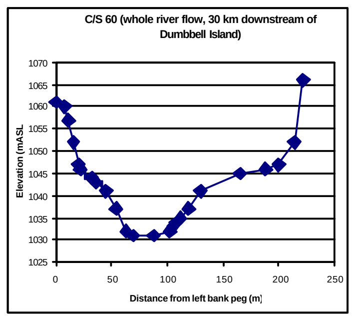


Bujagali Hydropower Project, Uganda
Siltation Study

Cross-section No: 60
Chainage from u/s Dumbbe 32129 m (between Kiteredde & Bukasa)

	Eastings	**Northings**
Left Bank Peg:	505300	82200
Right Bank Peg	506150	82400

Distance across c/s (m)	Elevation (mASL)		
0	1061	1.00	
8	1060	1.00	
11	1057	1.00	
16	1052	1.00	
20	1047	1.00	Waterline
22	1046	1.00	
26	1045	1.00	
32	1044	1.00	
36	1043	1.00	
41	1042	1.00	
45	1041	1.00	
54	1037	1.00	
63	1032	1.00	
69	1031	1.00	
88	1031	1.00	
102	1032	1.00	
105	1033	1.00	
108	1034	1.00	
112	1035	1.00	
119	1037	1.00	
130	1041	1.00	
165	1045	1.00	
188	1046	1.00	
200	1047	1.00	Waterline
214	1052	1.00	
222	1066	1.00	

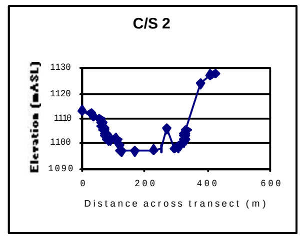


Bujagali Hydropower Project, Uganda
Siltation Study

Cross-section No: 2
Chainage (left bank): 141 m

	Eastings	Northings
Left Bank Peg:	516500	54300
Right Bank Peg	516800	54600

Distance across c/s (m)	Elevation (mASL)	
0	1113	
25	1112	
37	1111	
56	1110	
60	1109	
63	1108	
65	1107	
68	1106	
70	1105	
72	1104	
74	1103	
76	1102	
80	1101	
85	1101	
87	1102	
104	1102	
109	1101	
115	1100	
118	1099	
120	1098	
122	1097	LB (main channel)
168	1097	
228	1097.5	
250	1098	RB (main channel)
270	1106	
296	1098	bank (island)
306	1098	bank (island)
311	1099	
323	1100	
325	1101	
327	1102	
328	1103	
329	1104	
331	1105	
377	1124	
408	1127	
424	1128	(RBP)



APPENDIX B. BASIS FOR CALCULATION OF SEDIMENT INPUTS

Inputs Due To Diversion Arrangements

	Normal (1000 m^3/s)		Storm Flow (2000 m^3/s)		
Parameter	**Original**	**Diverted**	**Original**	**Diverted**	
Width	240	285 m	285	290 m	
Flow	500	1000	1000	2000	
Velocity	0.43	0.53 m/sec	0.53	0.78 m/sec	
Elevation	1092	1095 m	1095	1099 m	
Reach length		1785 m		1785 m	
New erodable area		80325 m^2		8925 m^2	(over and above that at 1000 m^3/s flow)
Typical Side slope		0.15		0.15	
Characteristc depth		1.50 m		2.50 m	Typical near-margin depth of water
Erodability		0.005 kg/ms		0.005 kg/ms	Taken from MIKE11 model
Lateral velocity factor		0.5		0.5	Factor to account for ratio between area averaged and lateral velocities
Critical Velocity		0.25 m/sec		0.25 m/sec	Critical velocity for erosion - see Shield's diagram
Erosion rate		0.00041 kg/m^2s		0.00287 kg/m^2s	
Total load		33 kg/sec		26 kg/sec	
Increase in concentration immediately downstream*		33.1 mg/l		12.8 mg/l	

INPUTS DUE TO COFFER DAM CONSTRUCTION
(estimates of %age losses: from Alan Bates of Knight Piesold, Ashford UK)

Average sediment inputs		
Volume of material to be placed	120,000 m^3	
Density	2650 kg/m^3	
Time required to place	90 Days	
Percentage loss on placement	1 %	
Average sediment production	0.41 kg/sec	
Increase in concentration immediately downstream*	0.41 mg/l	Based on loss %age from uniform placement rate

Instantaneous sediment inputs		
Volume of material	15 m^3	
Density	2650 kg/m^3	
Time required to place	10 Seconds	
%age loss	1 %	
Average sediment production	39.8 kg/sec	Based on a %age loss from 15 m^3 dumper loads
Increase in concentration immediately downstream*	39.8 mg/l	with each load taking 10 seconds to release fines

*outside of mixing zone

BURNSIDE

Appendix G.2

Status Report from UIA

INVESTMENT PROMOTION

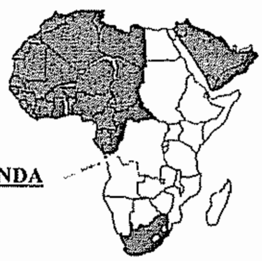
BY

Issa Mukasa

PRESENTATION TO NEW AMBASSADORS
AND
HIGH COMMISSIONERS

December 9, 2005

UGANDA'S STRATEGIC LOCATION IN THE HEART OF AFRICA



MARKET

Uganda - 26.8 million
East Africa - 90.2 million
Great Lakes Region-159 million
COMESA
- 20 member countries
- 370 million people

AGOA
EU – Preferential Treatment of Exports

Source: Statistical Abstract 2005

UGANDA AT A GLANCE

Area	241,550 sq km
Land	194,881 sq km
Water (Lakes, Rivers Swamps)	46,669 sq km
Population	26.8 million
Temperature	15 - 30°C
Official Language	English
Literacy (2003)	70%
Corporate Tax	30%
VAT	18%
Import Duty	0%, 15% 25%

Source: Statistical Abstract 2005

Major Economic Reforms

- Liberalization of current/capital a/cs
- Removal of export taxes
- Replacing state monopolies with free markets
- Removal of price controls
- Ending controls on interest rates.

RESULTS OF ECONOMIC REFORMS IN UGANDA

	1990/91	2003/04
Total GDP (US$ Billion)	3 73	6
GDP Growth rate	5 0%	5.9%
GDP Per Capita (US $)	150	290
Total Investment as % GDP	13.5%	22.3%
Inflation	243%	3 7%
Lending rates	40-60%	6-14%
Exports (m US$)	510	665.1
Imports (m US$)	531	1,726.1
Poverty	56%	37 7%

Source: Statistical Abstract 2005

COMPARISON OF SELECTED UGANDA'S POVERTY INDICATORS

Indicator	1992	2004
Poverty line (% Pop)	56	37 7
Life expectancy (years)	48	48.1
Inf. Mort. Rate/1000	122	83
Fertility rate	7.1	6 9
HIV prevalence rate	29	7
Population growth rate	2.5	3.3
Literacy rate	51	70
Pupil/Teacher ratio	35	50
Pupil/classroom ratio	98	79
Access to safe H_2O(% rural)	37	55.6

COMPARISON Contd.

Indicator	2000	2004
Primary enrolment (Mill)	6 5	7.4
Number of P/Sch	12,480	13,371
Number of vehicles	189,105	247,045
Fixed Telephone	58,261	82,495
Cellular Phone	72.602	1,165,034
Private FM station	100	148
Private TV stations	19	31
Imports($ mill)	958 5	1,726 1
Exports	401 6	665 1

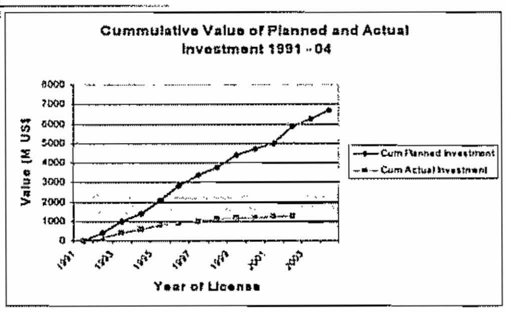
UIA – VISION, MISSION AND ROLE

- VISION

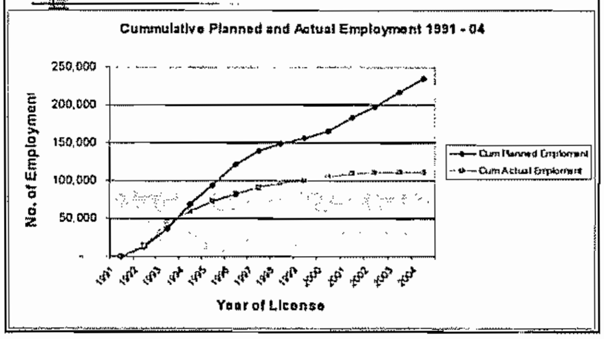
  "Make Uganda the leading Investment destination".
- MISSION

  "Make a significant and measurable contribution to Uganda's development process by promoting private Investment".
- ROLE
  - *To promote, facilitate and monitor investment in Uganda*
  - *To provide advisory services to Government on policies which affect investment*

SOME UIA ACHIEVEMENTS

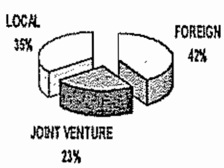


ACHIEVEMENTS Contd.



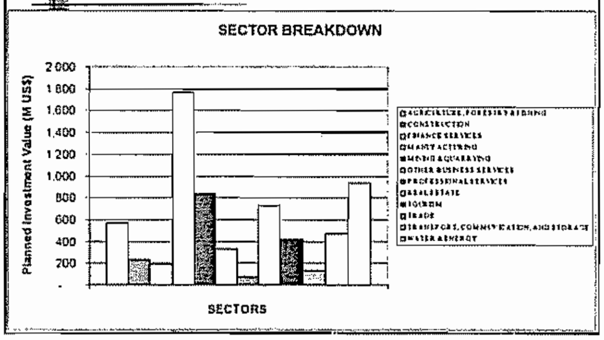
ACHIEVEMENTS Contd.

OWNERSHIP OF PROJECTS LICENSED (1991-2004)



1 United Kingdom
2 USA
3 Kenya
4 South Africa
5 Canada
6 India
7 Egypt
8 Norway
9 Mauritius
10 China

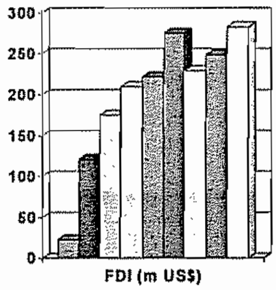
Sector Performance 1991 - 2004



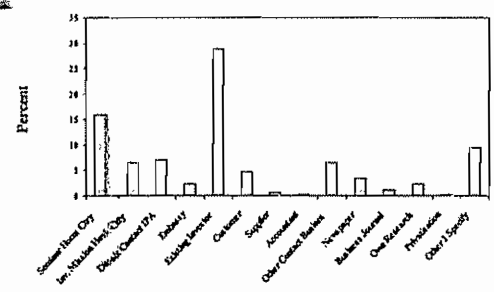
FDI inflows to Uganda (1989 – 2003)

Year	FDI m$
1989/94 (avg)	23
1995/96	121
1997	175
1998	210
1999	222
2000	275
2001	229
2002	249
2003	283

- *Source: WIR 2004 UNCTAD*



How was your company originally made aware of Investment Opportunities?



CONSTRAINTS IN THE PRIVATE SECTOR

1996	2001	2003
▪ Electricity	Access to Finance	Tax Rates
▪ Tax Policy	Tax Administration	M/Econ Inst
▪ Tax Admin	Corruption	Interest rate
▪ Cost of Finance	Transport costs	Corruption
▪ Access to Finance	Tax Policy	Electricity
▪ Corruption	Discriminatory incentive	Access to Finance

INVESTMENT PROMOTION

PROMOTIONAL TECHNIQUES (Input)

- Direct mail shots
- Website
- Existing investors
- Foreign missions accredited to Uganda
- Conference delegations
- International consultants/Fairs/Exhibitions
- Outward mission
- Delegate programme
- Friend of Uganda
- Uganda Embassies abroad

PROMOTION (Output)

- Inquiries
- Inward mission
- FDI

INVESTMENT OPPORTUNITIES

- Agriculture(Crops and Livestock)
- Services (Finance, Education and Medical)
- Tourism
- Packaging, Printing and Publishing
- Mining & Energy
- Information & Communication Technology
- Manufacturing

CDM PROJECT OPPORTUNITIES

- Energy - Renewable Energy (Hydro, Solar, Wind and Geothermal sources)
  - Use of forest and agricultural wastes to generate electricity
- Agriculture - Grow upland rice
  Organic farming
- Forestry - Reforestation
  Afforestation
- Transport - Improved pub/transport
  Improved urban planning & traffic management
  Improve vehicle efficiency
  Vehicle fuel switching
  Switching from road to rail transport
- Waste Mgt - Landfills
  Sewerage

INCENTIVE REGIME

1.0	Investment Capital Allowances	
1.1	Initial Allowance on plant and machinery located:	
	Entebbe-Kampala-Jinja Area	50%
	Upcountry (other districts)	75%
	Start up costs spread over the 4 years	25% p.a.
	Scientific research expenditure	100%
	Training expenditure	100%
	Mineral exploration expenditure	100%
1.2	Initial Allowance on Hotel and Industrial buildings	20%
2.0	Deductible Annual Allowances (depreciable assets)	
	Depreciation rates of assets range[1]	20-40%
	Depreciation rate for Hotels, Industrial Buildings and Hospitals	5%

[1] Example: Computer & data handling equipment 40%; Locomotives, office furniture 20%.

INVESTMENT PROTECTION AGREEMENTS

Uganda is Signatory to:

- Multilateral Investment Guarantee Agency (MIGA)
- Overseas Investment Insurance (OII)- UK
- Overseas Private Investment Corporation (OPIC)- USA
- Africa Trade Insurance Agency (ATIA)
- Islamic Corp" for the Insurance of Investment and Export Credit (ICIEC)

Bilateral agreements also signed with many countries:

- Italy
- India
- United Kingdom
- Netherlands
- Egypt

DOUBLE TAXATION AGREEMENTS

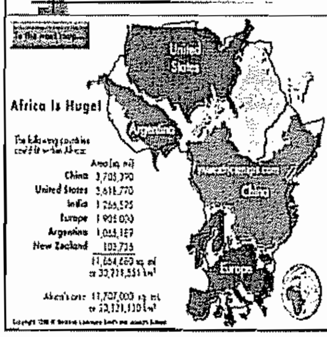
Already Signed

- Tanzania
- Kenya
- South Africa
- United Kingdom

To be signed

- Italy
- India
- Mauritius
- Egypt

The 21st Century belongs to Africa?



Population

- Africa
- U/States
- India
- China
- Europe
- Argentina
- N/Zealand
- UK

COMPARISON OF KEY ECONOMIC INDICATORS

	Singapore	Uganda
Area Land (Sq Km)	669	241,550
Population (2004)	4 24	26.8
Annual Pop growth (%)	1.3	3 3
Total dependence ratio	39.1	54
Total Fertility rate	1 24	6.9
Infant Mortality rate ('000)	2.0	83
Life Expectancy	79 3	48 1
Literacy rate (%)	94.6	70
GDP Per Capita ($)	42,581 0	290
Inflation rate	1.7	3.7
Exports ($ Mill)	303,476.3	665.1
Imports	276,894.1	1,726.1
Visitors arrival ('000)	8,328 6	512 379

Role of Ambassadors

- Image Building
- Trade/tourism promotion
- Investment promotion
- Capacity building (lobbying)
- Technical assistance (lobbying)

- **APPEAL**

  "Make a significant and measurable contribution to Uganda's development process by promoting private Investment"

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- Email: info@ugandainvest com
- Website: www ugandainvest com

THANK YOU

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Tel: 234105, 251561/5, Fax: 256-41-342903
e-mail: info@ugandainvest com htpp://www ugandainvest com

13th January 2005

Attn: The Business Editor

PRESS RELEASE

UIA 2005 Performance

Uganda Investment Authority (UIA) has, for the year 2005, registered success despite the global economic activity going through a challenging time. The rising fuel prices, the tragic tsunami, Katrina, and other disasters have no doubt had their effect on private business from which we expect foreign direct investment.

UIA exceeded its 134 projects per year valued at US $ 340 million per year target, as indicated in the Authority's Strategic Plan for the period 2004 to 2009.

In 2005 there was a 47% increase in the number of projects licensed. We licensed 284 projects, while 193 projects were licensed in 2004. The 284 projects in 2005 were valued at US $ 878,629,631 in planned investment creating 28,698 planned jobs. These figures indicate a 110% improvement in investment value from last year when UIA licensed 193 projects with a planned investment value of US $ 417,779,400 creating a planned employment of 17,047 jobs.

The attachments give a breakdown of the totals per sector, as well as the country (FDI source) totals for 2005.

For further information please contact the undersigned:

Dr Maggie Kigozi
EXECUTIVE DIRECTOR
Tel: 041 301000 or 075 717475

COUNTRY TOTALS JANUARY - DECEMBER 2005

COUNTRY	PLANNED INV. (USD)	PLANNED EMPT	NO.OF PROJECTS
UGANDA	567,527,131	1,042	3
INDIA	37,567,500	479	4
DENMARK	36,038,000	2,309	17
TANZANIA	32,000,000	586	4
UNITED KINGDOM	28,174,000	985	1
KENYA	27,911,000	38	1
CHINA	25,933,000	99	3
PAKISTAN	24,996,000	25	1
SUDAN	14,189,000	2,914	36
KOREA	13,552,000	143	1
CANADA	10,770,000	30	3
SAUDI ARABIA	9,300,000	52	2
JAPAN	7,569,000	63	2
USA	7,460,000	110	2
SWITZERLAND	6,085,000	1,050	19
BELGIUM	3,441,000	224	5
IRAN	3,000,000	170	3
LEBANON	2,963,000	248	2
SOUTH AFRICA	2,906,000	136	2
GERMANY	2,898,000	163	3
IRELAND	2,340,000	573	11
NOT SPECIFIED	2,302,000	464	3
ETHIOPIA	2,188,000	852	8
NETHERLANDS	1,844,000	3	1
MALAYSIA	1,729,000	256	2
ISRAEL	971,000	8	1
DR CONGO	703,000	229	4
TURKEY	626,000	50	1
TAIWAN	550,000	238	4
ZIMBABWE	432,000	30	1
ITALY	222,000	12,945	110
SWEDEN	184,000	2,030	18

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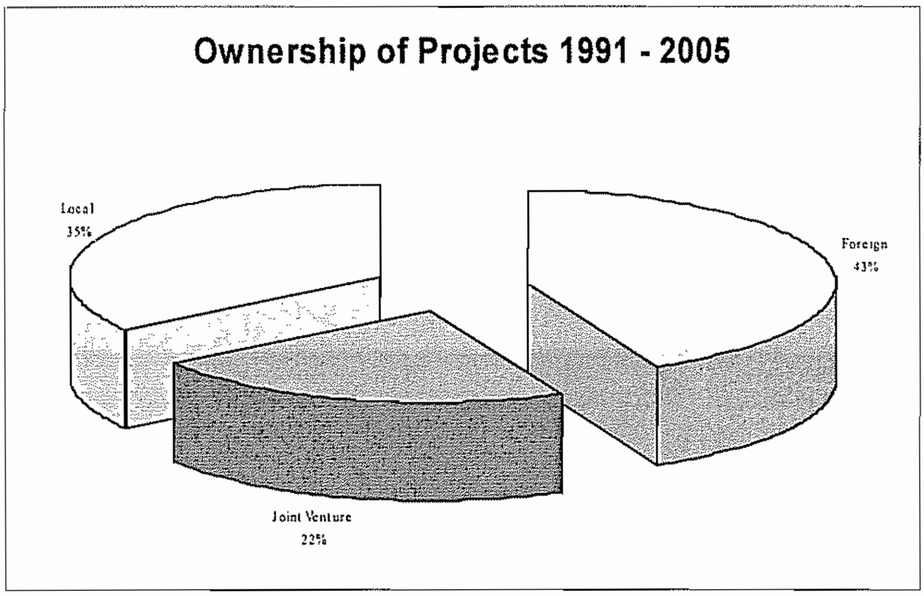
Sector Totals January - December 2005

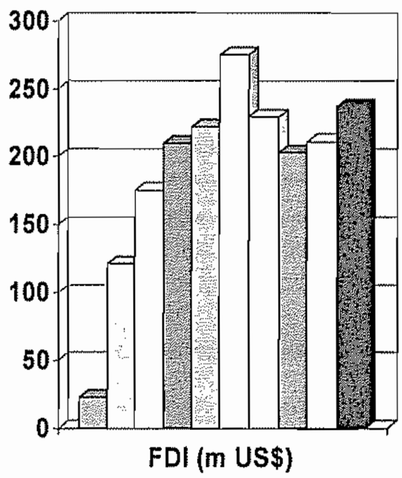
Sector	No. of Projects	Planned Inv. (USD)	Planned Empt
AGRICULTURE, FORESTRY & FISHING	60	85,518,500	5,554
CONSTRUCTION	19	35,987,000	2,183
FINANCE SERVICES	4	1,939,000	44
MANUFACTURING	93	197,733,131	7,324
MINING & QUARRYING	6	20,575,000	1,236
OTHER BUSINESS SERVICES	34	31,736,000	2,477
PROFESSIONAL SERVICES	13	27,645,000	1,045
REAL ESTATE	10	48,898,000	1,153
SOCIAL SERVICES	1	9,608,000	1,370
TOURISM	22	17,391,000	1,762
TRANSPORT, COMMUNICATION, AND STORAGE	13	94,803,000	1,785
WATER & ENERGY	9	306,796,000	2,765
TOTALS	**284**	**878,629,631**	**28,698**

UIA LICENSED PROJECTS



FDI inflows to Uganda (1989 – 2004)

Year	FDI m$
1989/94 (avg)	23
1995/96	121
1997	175
1998	210
1999	222
2000	275
2001	229
2002	203
2003	211
2004	237



Source WIR 2005, UNCTAD

BURNSIDE

Appendix G.3

Greenhouse Gas Study

(Source: Appendix G.4 - AESNP Hydropower Facility

EIA, March 2001)

BUJAGALI HEPP - CO_2 EMISSION

Egon Failer
Lahmeyer International, Germany

This paper examines the Bujagali Hydroelectric Power Project (HEPP) in and provides the basis for an assessment of its contribution to controlling the emission of CO_2 while generating ‘low priced and reliable energy to support economic growth. The CO_2 emissions resulting from the project’s construction activities and the decomposition of biomass in the project reservoir are quantified and compared with the potential CO_2 emissions from generating the same electrical energy through burning fossil fuels. The comparison shows the generation of electrical energy at Bujagali will release over its life time 125 to 250 times less CO_2 into the atmosphere than generation through fossil fuels. The implementation of the Bujagali HEPP is thus consistent with Uganda’s response to global environmental concern, particularly those related global warming.

2. THE CO_2 EMISSION BY THE BUJAGALI HEPP

The CO_2 emission associated with a hydroelectric power project are those produced during the manufacture and construction of the project structures equipment and those produced by slowly decomposing biomass in the during the project’s lifetime.

2.1 CO_2 Emission related to Construction

It is well known that ‘the implementation of a hydroelectric powerplant involves considerable construction activities and large quantities of construction materials which, in turn, require a large energy input. For the construction of Bujagali HEPP the required quantities of major construction materials and consumables are summarized in Table 1.

Table 1: Quantities of major Construction Materials and Consumables

MATERIALS / CONSTRUCTION	QUANTITIES
Civil Works	
Soil Excavation/Fill	225,000 m3
Rock Excavation/Fill	700,000 m3
Concrete	235,000 m3
Reinforcement Steel	23,000 tons

Diesel Fuel	13,000 tons
Eleciro-Mechanical Equipment	
Steel	3.000 tons

Based on the volume of concrete and other construction activities such as grouting, shotcreting, etc. a cement requirement of about 75,000 tons is calculated. The production of one ton of cement requires approximately 4 GJ energy. Hence the energy input for all concrete works results in approximately 300,000 GJ.

The weight of reinforcement steel, hydraulic steel structures and steel for the electro-mechanical equipment totals about 26,000 tons. It takes approximately GJ of energy to produce one ton of steel. Therefore, the energy input into steel and equipment is about 1.04 million GJ.

The energy requirement for the excavation, transport and placing of soil and rock material is covered under the diesel fuel requirements of 13,000 tons.

If it is assumed that the energy required to produce the cement and steel is generated by a thermal mix as described below (lignite/coal/oil/gas = per cent) then some 47,850 tons of lignite, 11,550 tons of coal, 8,170 tons of oil and 7,610 tons of gas would be needed. The burning of these fossil fuels ultimately lead to a CO_2 emission of approximately 120,900 tons.

The burning of 13,000 tons diesel fuel will result in a CO_2 emission of about 42,000 tons. The total emission of CO_2 associated with the construction of the Bujagali HEPP will thus be approximately 162,900 tons.

2.2 CO_2 Emission caused by the Biomass with the future reservoir

The Bujagali HEPP will inundate a gross area of about 430 ha, which, after exclusion of the existing river channel, will result in a net area of about 155 ha land. Addition of some 155 ha, which is also required for the project works, results in a conservative estimate of affected area totalling about 260

According to literature the biomass of forest (10 to 20 years of age) is in the order of 400 t/ha dry weight. In order to derive at conservative values it is assumed that 50 % of the inundated land is covered with forest although most the land is used for agricultural purposes. Based on this conservative assumption a total biomass of about 52,000 tons (dry weight) is estimated.

All living plants grow by absorbing water and carbon dioxide to form reserves carbohydrate, known as biomass. This process is fuelled by sunlight and is termed photosynthesis. In simple terms the process is as follows:

$$6\ CO, + 6\ H_2O > C_6H_{12}O_6 + 6\ O_2^{\wedge}$$

When plants die, decomposition by oxidation takes places which is the photosynthesis process in reverse:

$$C_6H_{12}O_6 + 6\ 0, > 6\ CO, + 6\ H_2O$$

The same amount of CO_2 absorbed during photosynthesis is released during complete oxidation of the biomass.

By considering molar weights, one ton of carbohydrate produces 1.47 tons of carbon dioxide during complete decomposition as follows:

$$180g\ C_6H_{12}O_6 + 192g\ 0, = 264g\ CO, \wedge + 108g\ H_2O$$

$$1\ t\ C_6H_{12}O_6 + 1.07\ t\ 0, = 1.47\ CO, \wedge + 0.6\ H_2O$$

Using the same relationship on the total estimated quantity of biomass by the Bujagali HEPP the decomposition of the biomass in the reservoir area could lead to a maximum CO_2 emission of about 76,500 tons.

2.3 The total CO_2 Emission of the Bujagali HEPP

Approximately 162,900 tons of CO_2 will be produced with the construction of Bujagali HEPP. The CO_2 emission associated with the decomposition of the biomass located in the reservoir is estimated to be approximately 76,500 tons. Thus the implementation of Bujagali HEPP will lead to a total CO_2 emission of about 240,000 tons.

The following section quantifies the CO_2 emissions resulting from generating same average energy as Bujagali but by burning fossil fuels.

3. THE CO_2 EMISSION BY THERMAL POWERPLANTS

Present thermal plant technology does not include the recovery of carbon dioxide from flue gases. Hence the carbon content of the fuel and the characteristics of the thermal plant are the governing parameters in CO_2 emission levels. The following formula may be used to compute the CO_2 emission from fossil fuels:

$$CO_2 = A \times (B + C \times HV)$$

Where:

CO_2 = emission of CO_2 in metric tons per ton of fuel
A = multiplier for indirect emissions (exploration,
B, C = regression constants for the particular type of fuel
HV = lower calorific value of fuel in GJ/ton

Typical CO_2 emissions for various type of fossil fuel are shown in Table 2. Approximate CO_2 values per MWh delivered to the grid would be as shown in Table 3 for various types of powerplant.

Table 2: Typical CO, Emissions for various Type of Fuel

Fuel Type	A	B	C	HV (GJ/ton fuel)	CO_2 (ton/ton fuel)
Lignite	1.08	0.20090	0.08693	7	0.87
Coal	1.06	0.20090	0.08693	29	2.90
Oil	1.04	2.50291	0.01494	41	3.24
Gas	1.01	0.55159	0.04463	44	2.53

Table 3: Approximate CO_2 Emission per MWh for various Types of Thermal Powerplants

Plant Type	HV (GJ/ton fuel)	CO_2 (tons/ton fuel)	Efficiency (per cent)	CO_2 (ton/MWh)
Lignite-fired steam	7	0.87	36	1.24
Coal-fired steam	29	2.90	37 - 39	0.97
Oil-fired steam	41	3.24	38 - 40	0.75
Gas-fired combined cycle	44	2.53	48 - 52	0.43

Note: Efficiencies shown include station consumption.

According to the feasibility study the following range of Annual Average Energies are possible to be generated by the Bujagali HEPP:

Flow Series 1896 - 1997: 1,397 GWh
Flow Series 1961 - 1997: 1,868 GWh

For the calculation of the corresponding CO_2 emissions the lower energy taken into consideration representing a conservative approach.

Under the assumption that the annual average energy of 1,397 GWh generated by the Bujagali HEPP would be generated by a thermal mix consisting of 2.5 cent lignite-fired, 25 per cent coal-fired, 25 per cent oil-fired and 25 per cent fired combined cycle power plants, some 18 million tons of CO_2 would be discharged to the atmosphere annually.

Table 4: Approximate CO_2 Emission of equivalent Thermal Power Mix

Plant Type	Annual Energy GWh	CO_2 tons
Lignite-fired steam	349.25	433,070
Coal-fired steam	349.25	338,773
Oil-fired steam	349.25	261,937
Gas-fired combined cycle	349.25	150,177
Total	1,397	1,183,957

It is noted that the CO_2 emission of 18 million tons annually is related purely to the fuel consumption (equal proportions of lignite, coal, oil and gas) and does not include the CO_2 emission related to the construction of the thermal power plants.

Assuming that the annual average energy generated by the Bujagali HEPP be generated by an "environmentally friendly" gas-fired combined cycle power plant only, which is a most optimistic scenario, then the annual CO_2 emission into the atmosphere would be approximately 0.60 million tons.

4. CONCLUSIONS

The energy sector is the greatest single source of CO_2 emissions into the atmosphere and within that sector the burning of fossil fuels to generate electricity accounts for some 25 per cent of global warming. In order to future economic growth, the Government of Uganda has decided to implement the Bujagali Hydroelectric Power Project. This decision will not only secure a reliable and renewable source of electrical energy for the nation but it will represent a significant step towards reducing the rate of growth of CO_2 emissions in Uganda.

The Bujagali HEPP will produce an average of 1,397 GWh of electrical energy annually which represents the lower limit of the estimate. During construction

the project, energy is required to manufacture cement and steel and to and construct the project structures. The generation of this energy will result the release of CO_2 into the atmosphere. During operation of the project, the biomass submerged within the reservoir will slowly decompose also releasing CO_2 into the atmosphere. The upper limit estimate of the total quantity of CO_2 released into the atmosphere during construction and operation of Bujagali be some 240,000 tons.

Generating the same energy by burning fossil fuels (equal proportions of coal, oil and gas) would release into the atmosphere some 1 .18 million tons of CO_2 every year. Over a period of 50 years, the assumed commercial life of Bujagali, this annual CO_2 emission would result in a total of 59.2 million tons C02. Assuming that the annual energy would be generated by an "environmentally friendly" gas-fired combined cycle power plant only, the CO_2 emission over a period of 50 years would reduce from 59.2 to about 30 million tons.

Consequently the generation of hydro-electric energy at Bujagali will result in CO_2 emissions 125 to 250 times less than if the same energy were generated burning fossil fuels. The promotion of the Bujagali HEPP is thus in line with United Nations statement to control the rate of growth of CO_2 emissions into atmosphere and thereby reduce global warming.

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Appendix G.4
Terms of Reference for the Panel of Experts

Bujagali Hydropower and Interconnection Projects

Panel of Experts

Draft **Terms of Reference**

Introduction

1. World Bank Group (WBG) institutions are considering various financial instruments in support of the proposed Bujagali Hydropower and Interconnection Projects. The sponsors of these projects are Bujagali Energy Limited (BEL) and Uganda Electricity Transmission Company Limited (UETCL), respectively.

2. To proceed with such financing, WBG institutions have a number of policies and performance standards with which the project sponsor, or client, must comply. For social and environmental matters, these include so called "Safeguard Policies" (International Bank for Reconstruction and Development (IBRD) and International Development Association (IDA)); Policy on Social & Environmental Sustainability and associated Performance Standards (International Finance Corporation (IFC)); and Environmental Assessment Policy (Multilateral Investment Guarantee Agency (MIGA)). The policies also include by reference a number of related requirements and guidance documents such as technical guidelines, handbooks, guidance notes, and best practice guides. In addition, each institution has policies on the disclosure of information that apply directly to social, environmental and sustainability compliance on projects it finances.

3. Each WBG institution also has quality control and oversight bodies, such as an Ombuds office or Inspection Panel, that have various levels of internal and compliance oversight with respect to project documentation, processing, implementation and monitoring. These bodies' activities are guided by the individual institution's policy requirements as outlined above.

4. WBG institutions also have individual and collective responsibilities within their mandates to address developmental and poverty alleviation goals and objectives. For clarity here, it is recognized that such WBG goals and objectives are not passed on directly to project sponsors or clients of WBG institutions. Certain specific elements of such goals and objectives are considered by the WBG to be met through their project-sponsored activities, but the definition and implementation of those elements, as well as the larger responsibilities in these areas, remain with WBG institutions.

Panel of Experts Requirements

5. The World Bank's Operational Policy on Environmental Assessment (OP 4.01, January 1999) notes that "[f]or Category A projects that are highly risky or contentious or that involve serious and multidimensional environmental concerns, the borrower should normally also engage an advisory panel of independent, internationally recognized environmental specialists to advise on all aspects of the project relevant to EA. The role of the advisory panel depends on the degree to which project preparation has progressed, and on the extent and quality of any EA work completed, at the time the Bank begins to consider the project."
6. MIGA's Environmental Assessment Policy, which is Annex B to MIGA's Operational Regulations, has a similarly worded requirement.
7. IFC's Performance Standard 1 says with respect to Social and Environmental Assessment: "In projects with significant adverse impacts or where technically complex issues are involved, clients may be required to retain external experts to assist in the Assessment process." It also says with reference to Monitoring: "For projects with significant impacts that are diverse, irreversible, or unprecedented, the client will retain qualified and experienced external experts to verify the monitoring information."

8. IFC Performance Standards 6 (Biodiversity, paragraph 4); 7 (Indigenous Peoples, paragraph 11); and 8 (Cultural heritage, paragraph 4) also specify requirements for external experts in certain defined circumstances.
9. A footnote to World Bank OP 4.01 provides additional details on the panel's work: "The panel (which is different from the dam safety panel required under OP/ BP 4.37, Safety of Dams) advises the borrower specifically on the following aspects: (a) the terms of reference for the EA, (b) key issues and methods for preparing the EA, (c) recommendations and findings of the EA, (d) implementation of the EA's recommendations, and (e) development of environmental management capacity." Once again, MIGA's requirement is worded similarly, but with the addition of one point: "and (f) engineering matters, such as dam safety."

Bujagali Hydropower and Interconnection Projects

10. The project sponsors are to establish one single Panel of Experts (POE) to meet these multiple WBG POE requirements for both of these projects. The Panel's overall mandate is to advise the project sponsors on compliance with the WBG policy, guideline and other mandated social, environmental and sustainability requirements as summarized above.
11. Specifically, the Panel will address all of the policy issues noted in the above referenced documents in an integrated and comprehensive way based on the Social and Environmental Assessment (SEA)[1] work now under way by the sponsors' independent consultants to the agreed and approved Terms of Reference for the SEA work. (The one exception to this POE's work is the "engineering matters, such as dam safety," noted in MIGA's policy which will be addressed separately by the sponsors' Dam Safety Panel.) For certainty and specificity, the POE's mandate as presently envisaged is summarized in Annex A to this ToR.
12. The POE will carry out its work by reviewing relevant project documentation to be provided in advance by the project sponsors and making field (site) visits on a

[1] These Bujagali projects use the generic term "Social and Environmental Assessment" or SEA to refer to the environmental assessment-type documents required by lenders and regulators under various names and acronyms.

schedule to be agreed with the project sponsors, but no less frequently than once per calendar year during the pre-construction and construction phases of the projects.

13. The POE will submit an integrated draft report on its findings to the project sponsorsThe final draft of the POE's report will be publicly released by the project sponsors.

14. Present expectations are that the POE's work will continue through the construction stage of the projects. The Panel will review its mandate and activities regularly with the project sponsors to assure that its work reflects the sponsors' needs for POE advice and that the level of POE activities is appropriate to such agreed needs.

15. Specifically, the project sponsors reserve the right, in consultation with the POE, to adjust the POE's mandate to reduce any potential for duplication of effort, particularly during monitoring phases of the projects, and/or to integrate the Panel's activities with other monitoring activities the sponsors may develop or adopt in consultation with WBG institutions and other third parties.

ANNEX A

Specific Mandate for Panel of Experts, Bujagali Hydropower and Interconnection Projects

The WBG institutions' requirements for such a Panel's work are various and multiple, reflecting the changing timing and nature of their individual mandates. Certain historical requirements or precedents may need to be tempered with good professional judgement as to their current applicability and appropriateness. State-of-the-art EA practice is consultation driven and implementation oriented rather than primarily assessment focused, as in the past. Project Social and Environmental Action Plans, in particular, aim to accomplish project outcomes successfully in the social, environmental and sustainability areas, now. The roles of third parties, including lenders, are particularly relevant to managing project risks during the implementation of project Social and Environmental Action Plans. The developmental benefits of these projects must be integrated into SEA-type activities, including its own, and is encouraged to further the sponsors' objectives to consult in a free, prior and informed manner with all relevant stakeholders; to assure that the projects acquire and maintain Broad Community Support (BCS); and to assist in expediting the provision of project-delivered developmental benefits to affected stakeholders through its work, including its oversight of lenders' and other third parties' activities and actions.

Specifically, the POE will:

- Review the approved ToR's for the Social and Environmental Assessments (SEAs) for the projects
    - With respect to the whole suite of the projects' regulatory and lender requirements
- Review the projects' draft SEA documentation, including issues identification, recommendations and findings, implementation of SEA findings, and SEA management capacity

- Confirm through field and site visits as agreed with the project sponsors that SEA documentation reflects the projects' realities 'on the ground'
- Pay particular attention to the projects' outcomes and implementation activities as reflected in their Social and Environmental Action Plans
- Reflect and advise on the roles, responsibilities and activities of third parties, including civil society and lenders, as they impact on the projects' SEA requirements and activities
- Report regularly and to the agreed timelines on its conclusions based on its review of documentation and site visits
- Adopt a change management process for its own activities to be reviewed regularly with project sponsors going forward
    - Particularly with respect to avoiding duplication of effort around ongoing monitoring processes and activities for the projects.

*** *** ***

BURNSIDE

Appendix G.5
Correspondence with NEMA Regarding Fish Pass

14 September 2001

The Executive Director
National Environmental Management Authority
P.O. Box 222555
KAMPALA

Fax: 041 257521
Email: nema@imul.com

Subject: Fish Ladder for the Bujagali Hydro-power Scheme

You refer to the above-mentioned subject for an indicative position on the issue based on our opinion and information available. The Fisheries Resources Research Institute (FIRRI) did indeed carry out baseline surveys of the fisheries and aquatic ecosystem of the Upper Victoria Nile over four quarters during 2000. Up to ten Scientists and 15 support staff were involved in this study. There were quarterly reports and a Final Report submitted from which fishery aspects have been highlighted in the EIA for public comment. For a detailed understanding of the data, these reports may be consulted in addition to the following facts and opinion:

1. The Lake Victoria and Lake Kyoga basins are connected by the Upper Victoria Nile flowing out of Lake Victoria northwards to Lake Kyoga downstream, and, eventually through to Lake Albert, the Albert Nile and beyond;
2. The fish fauna of both lakes Victoria and Kyoga for the most part share a similar evolutionary origin. This means that many species of fish in Lake Victoria have also been recorded in Lake Kyoga;
3. It is also well known that many species of fish in the lakes undertake longitudinal upstream migrations on a seasonal basis for spawning. The species involved are: *Labeo victorianus* (Ningu), *Barbus altianalis* (Kisinja), *Clarias gariepinus* (Male), several small cyprinids and momyrids. These migrations have been well studied in fish from Lake Victoria migrating to inflowing rivers and streams. For example, *Labeo victorianus, Barbus altianalis, Clarias gariepinus* migrate up rivers Kagera, Nzoia, and the now vanishing inflowing streams such as the Bugungu near Jinja. The Victoria Nile with respect to Lake Victoria is an OUT-FLOWING river. It becomes IN-FLOWING with respect to Lake Kyoga. This means that it is the in-flowing influence at the Victoria Nile – Lake Kyoga mouth where we would expect upstream migration.

Our survey of the fisheries and aquatic ecosystem of the Victoria Nile reported the following observations:

- The investigated transects of Dumbbell Island had a fish fauna which was in many respects similar to the Lake Victoria fish fauna. There was a transition zone from the third transect downstream of Dumbbell Island merging into the more typically Lake Kyoga fish fauna. The transition also characterized aspects of hydrology (a decrease in velocity), channeled with (an increase) and the emergence of flood-plain like conditions associated with development of papyrus dominated wetland fringes.
- The most downstream transects also contained the highest density of anadromous (i.e. migrant species) including those cited above in addition to *Synodontis afro-fischeri, Schilbe intermedius* and typically Kyoga fishes (e.g. *Mormyrus macrocephalus*, a type of Kasulu) which do not occur in Lake Victoria. It was thus noted that from a fish migratory point of view, the Upper Victoria Nile behaved more as an IN-FLOWING river for fishes in Lake Kyoga.
- With respect to some of the elements of the fish fauna, their occurrence throughout the system proved that there were riverine fish populations that breed within the river irrespective of the natural physical barriers. Such populations especially upstream were unlikely to be affected by other barriers in terms of breeding.
- It was also observed that inspite of the present Owen Falls Dam barrier, the fishes known to be migrants occur in Lake Victoria (where they migrate UPSTREAM) and also occur in sections of the river where breeding specimens have been found.

Conclusions and Indicative Position:

There are resident riverine fish POPULATIONS in the Victoria Nile which include species that occur in both Lakes Victoria and Kyoga. Fishes in breeding stages V and VI (i.e. prior to spawning) have been found both upstream and downstream despite the presence of natural barriers. This indicates that these fishes breed within the river.

The present Owen Falls Dam is already a barrier to assumed migration towards Lake Victoria. Migrant fishes are found upstream and downstream of this barrier but the same species occur throughout the Upper Victoria Nile towards Lake Kyoga. It is not justifiable that a fish ladder or pass would improve the stocks of migrating fish in the Upper Victoria Nile. Were this to be so (which it is not), the present Owen Falls Dam would need a fish pass, as would Owen Falls Extension. This is not necessary and a Bujagali Fish ladder is not scientifically justifiable. A barrier in the Upper reaches up to Dumbell Island would not significantly affect the stability of fish populations in Lake Victoria and neither would a fish ladder be relevant. What has been proposed and should be considered in these proposed developments is habitat enhancement e.g. through quarry bio-manipulation (an aspect which is elaborated in the Final Report by FIRRI) and has been discussed with AES Nile power.

The anadromous fishes in Lake Kyoga (including species that are listed above and also occurring in Lake Victoria) migrate upstream into the lower Victoria Nile for breeding. This means that if a barrier were to be erected in the last c. 30km of the river, a fish pass would probably be required.

If it is considered that despite the occurrence of resident fish populations upstream of the Owen Falls Dam and just below it, a fish ladder is an absolute requirement for the next barrier, it would also suggest that a direct connection (fish pass / fish ladder) be constructed for the present Owen Falls Dam to allow a connection with lake Victoria. This scenario is thought to be unrealistic.

With respect to current developments, it has been suggested from our baseline studies that during the construction phase of the Bujagali Project, a comparable fishery monitoring regime be incorporated into the activities of that and the subsequent post-construction phases. In addition, it would also be desirable to develop a permanent mechanism of research and monitoring of the fisheries of the Victoria Nile because our studies revealed the increasing importance of the resource.

Similarly, the recommended Kalagara offset would require a study similar to the baseline survey carried out on the fisheries and aquatic ecosystem. The offset allows for in-depth investigations that may also guide mitigation measures elsewhere in the river.

I trust that this information will be of use to NEMA, and please, do not hesitate to contact me for further clarification on the subject.

Yours Sincerely,

Dr. R. Ogutu-Ohwayo
DIRECTOR

File 1) NEMA
2) AES

copy to Mr. Kamau
Dr. Balirwa
19/10/2001

(74)

NATIONAL ENVIRONMENT MANAGEMENT AUTHORITY (NEMA)

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NEMA/4.5

16 October 2001

The Project Manager,
AES Nile Power,
P.O Box 24401,
Kampala.

RE: FISH LADDER FOR THE PROPOSED BUJAGALI HYDRO-POWER DAM

Further to our discussions on the above referenced subject, this Authority has received a report from the Fisheries Resources Research Institute in which it is indicated that the omission of a fish ladder **MAY NOT** have significant negative impact to fishery dynamics upstream or downstream to the proposed dam and that a fish ladder is thus not scientifically justifiable. In view of this position, this Authority is issuing approval to your request to waive the requirement for installing a fish ladder as was previously contained in the approval conditions for EIA Certificate No. 179 for the project.

In executing the project, however, and in line with the Environment Monitoring Plan as contained in the Environmental Impact Statement for the project, you will be required to implement a fishery monitoring programme for the fisheries of the Victoria Nile during construction and post construction phases of the project. We urge you to liaise closely with the Fisheries Resources Research Institute (FIRRI), Jinja so that you can define the framework for the way forward on this matter.

Aryamanya- Mugisha, Henry
Ag. EXECUTIVE DIRECTOR

cc. The Permanent Secretary,
Ministry of Energy and Mineral Development,
Amber House, Kampala

" The Director,
Fisheries Resources Research Institute (FIRRI),
P.O Box 343,
Jinja.

18 OCT

18 OCT 2001