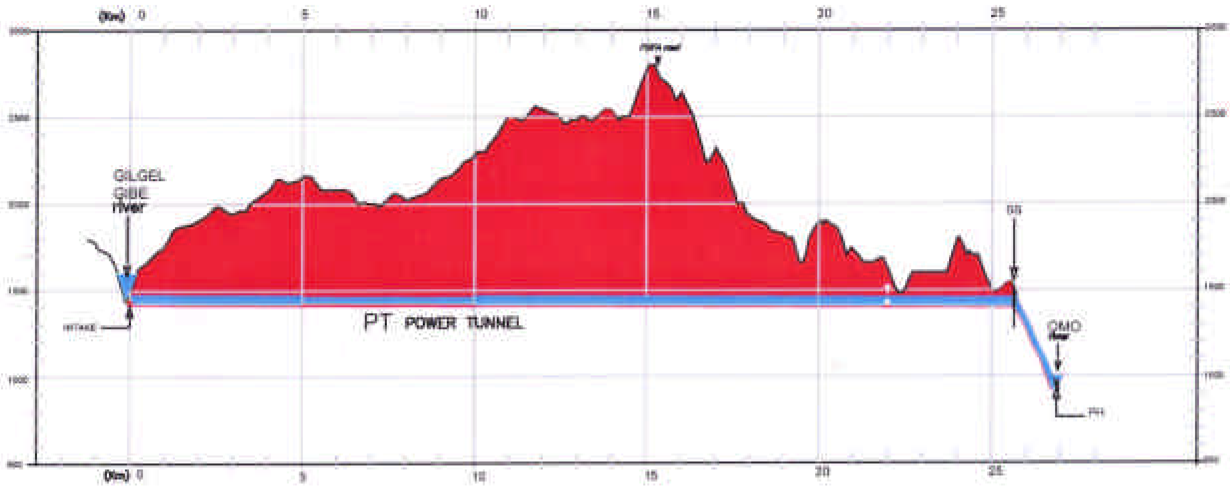
EEPCO
ETHIOPIAN ELECTRIC POWER CORPORATION

GILGEL GIBE II Hydro-electric Project



ENVIRONMENTAL IMPACT ASSESSMENT - September 2004

salini COSTRUTTORI S.p.A.

CESI

Client SALINI Costruttori S.p.A.

Subject Gilgel Gibe II hydroelectric project
Environmental Impact Assessment
Main Report

Order 0512/81/0001 E del 29/03/2004

Notes

N. of pages 135 **N. of pages annexed** 16

Issue date September 2004, 15th

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REVISIONS HISTORY

Revision number	Date	Protocol	Modifications and additions to take into account comments by EPA and EPPCO
1	15 September 2004	A4511403	Second emission
0	17 May 2004	A4501969	First emission

EXECUTIVE SUMMARY

Considering that the abundance of rivers can provide the country with the potential for large sustainable energy resources in the form of hydropower, only about one per cent of the available total Ethiopia's hydroelectric potential is being harnessed for generating hydroelectric power.

On the other hand Ethiopian Power System Expansion Plan – April 2004 envisages a peak load demand in the year 2013 of 2,547 MW with an electricity demand expected in 10,690 GWh/y against the present generating capacity of 676 MW producing an average energy of about 3,250 GWh/y.

The Gilgel Gibe project is one of the most attractive potential hydroelectric developments in the country. The Gilgel Gibe I hydroelectric power plant was inaugurated on 22nd February 2004.

In November 2002, Salini Costruttori S.p.A (Salini) developed a preliminary idea to exploit the very large geodetical head (i.e. 505 m) existing between the Gilgel Gibe river and the Omo river by constructing a 26 km long tunnel which makes use of the water regulated by the Gilgel Gibe I hydroelectric project.

Several meetings and project drafts lead the Ethiopian Electric Power Corporation (EEPCO) to the decision of constructing the second phase of the cascade of the hydropower plant, which uses the tailrace water of the existing Gilgel Gibe I hydropower plant. Water will be transferred to Fofa Gorge through 26 km tunnel and after generating the power the water will join Great Gibe (Omo river) at kebele in Yem special wereda.

On 17th November 2003, Salini submitted to EEPCO the Project Basic Design in accordance with the terms of reference of the Memorandum of Understanding signed on 21st October 2003.

On 3rd April 2004, Salini delivered to EEPCO five documents, identified as update of the Project Basic Design – Rev. March 04, which include all the clarifications, modifications and observations requested/made by the Employer/Consultant and agreed upon.

During the above meetings Salini was also requested to commission an Environmental Impact Assessment study to be prepared in accordance with the Ethiopian rules and in order to suit the needs of the financial institutions.

EIA is understood as an integral part of the planning process devoted to characterize environmental impacts due to the development of a project. It also seeks to define policies and strategies required to monitor and control such impacts. Hence, in order to understand the impact of the proposed access road and hydropower project on various environmental factors and to propose appropriate measures to overcome adverse impacts, EIA is taken as part of the project feasibility study.

This environmental impact assessment (EIA) report is intended therefore to identify positive and negative impacts of the second phase of Gilgel Gibe hydropower construction, and to suggest mitigation measures and monitoring plans to be implemented in order to avoid or minimise these negative impacts and to make the project construction environmentally friendly. No resettlement plan has been prepared considering that no resettlement is envisaged.

CESI was charged with the responsibility of preparing the EIA and to predict the expected environmental consequences of implementing project activities. World Bank guidelines for preparing environmental impact assessments were followed (Operational Directive 4.01). The EIA has also been based on the previous environmental studies including the Gilgel Gibe Hydroelectric Scheme - Feasibility Study (January 1994) and on the Gilgel Gibe Hydroelectric Project - Public and Environmental Health Implications (UNDPH/WHO, April 1986).

An Ethiopian and Italian expert team was assembled and given the responsibility for conducting the EIA and preparing the draft and final reports.

The scheme of the Gilgel Gibe second stage consists of a weir (alternative design, March 2004), an underground power tunnel connecting the Gilgel Gibe valley to the Omo valley, including a terminal surge shaft, underground and inclined penstocks, and an outdoor powerhouse equipped with four power generating units, with the following characteristics:

- Pelton N. 4 turbines, 105 MW, 470 m Hn, 25 m^3/s Q
- 0.44 plant factor (0.46 Gilgel Gibe I)
- 1625 GWh energy produced annually

The power house will be located at the right bank of Great Gibe river at Yem special woreda. The power house site is covered with woody grass land. The dominant tree species is Combertum mole and the major grass species is hyparrhenia. After generating the power, water will flow to the Great Gibe river (also known as Omo river).

The power house is a conventional surface outdoor type with vertical axis units located on the right bank of the Omo river, approximately 60 km downstream from the Gibe Bridge.

The access to the power house of Gilgel Gibe II has been envisaged by means of two roads: from Fofa village (the capital town of the Woreda) to Omo river (right bank) and from Kose village to Omo river (left bank).

The first one was chosen after the analysis of two possible paths. A South alternative was discarded because it was entirely new, no villages exist in the area and the time required for the construction was too long. A North alternative which follows the existing road up to Fofa village and links all the project sites by means of new roads (R 1 and R 2 from Fofa to power house, 30 km + R 3 to the tunnel outlet, 4.2 km from R2 + R 4 to surge shaft, 2.3 km from R3) was then chosen. About 1 km traverses Fofa town, 1.5 km is in Goromena hanger PA, and the rest is in Meleka PA. This access road, under construction, has affected few houses and farm land in Fofa town. Its impact on Meleka PA is mainly on grazing land and woody grass land.

The second one (from Kose village to Omo river) is a new 34 km long connection; together with the existing 58.9 km long road from Kose village to Wolkite (which needs a paving surface treatment) it represents a shorter connection to Addis Ababa with respect to the access via Saja-Fofa. By this access there will be no interference with the Wolkite-Jimma road construction works and the use of the precarious existing Bailey Bridge over the Omo river will be avoided.

A new bridge has been envisaged about 250 m upstream the power house in order to cross the Omo river.

The power produced by the plant will be delivered to the ICS (Inter Connected System) through a 230 kV transmission line which connects the Gilgel Gibe II Plant to a substation located in the area of Addis Ababa at a distance of about 250 km.

The Inter Connected System is a relatively small network, which serves the major towns and industrial centres in Ethiopia.

Site installations are envisaged at the weir, at the power tunnel inlet, at the surge shaft site, at the power tunnel outlet (also for penstocks). A permanent camp and offices are envisaged on the R6 new road from Kose to Omo river.

The characteristics of the foreseeable impacts have been identified considering:

- the actions that may produce impact, evaluated in the description of the Gilgel Gibe II Hydroelectric Project;
- basic environmental data obtained form direct field observations;
- information gathered from the available scientific publications and information derived by the study of similar projects.

A matrix that links project activities to the environmental components, considering the impacts (both positive and negative) generated by the project activities during all the different temporal phases of the project has been proposed.

In this matrix the effect on each environmental component, has been considered during the costruction phase and during operation activities. In more detail the impacts have been evaluated considering the five main activities which may have some effect on the environment:

- the weir erection and the relevant water storage capacity used as a daily regulation for the power plant;
- the tunnel excavation and the disposal material connected aspects;
- the temporary and the final roads built for construction activities and for standard operation activities;

- the powerhouse construction and related facilities such as camps, bridge on the Omo river, etc…
- the substation construction.

This matrix links environmental aspects to project activities in each project phase.

Environment Component	Construction Stage Activity Component					Operation Stage Activity Component				
	Weir	Tunnel	Roads	Powerhouse	Substation	Weir	Tunnel	Roads	Powerhouse	Substation
Physical										
- Seismology	0	0	0	0	0	5	5	0	0	0
- Hydrology	3	0	0	0	0	2	5	0	3	0
- Hydrogeology	0	2	0	4	0	0	4	0	4	0
- Storage sedimentation	3	0	0	0	0	5	0	0	0	0
- Water quality	0	0	0	0	0	0	0	5	4	3
- Climate	0	0	0	0	0	0	0	0	B	0
- Downstream effects	3	0	0	0	0	2	0	0	3	0
- Landscape	5	0	3	1	3	0	0	3	1	3
- Slope stability	4	0	3	3	5	2	0	3	C	D
- Disposal materials	0	2	3	5	0	0	0	0	0	0
Natural										
- Natural vegetation	3	3	2	4	3	2	0	4	0	0
- Fauna	3	4	2	2	3	5	0	5	0	0
Socio – economical										
- Dislocation of people	0	0	4	4	0	0	0	0	0	0
- Agricultural resources	0	4	3	5	5	0	0	0	0	0
- Infrastructures	0	0	0	0	0	0	0	A	A	C
- People's health	3	3	3	3	3	0	0	A	D	D
- Worker's health	3	2	3	2	3	0	0	0	5	5
- Employment opportunities	A	A	A	A	A	E	E	B	C	C
- Economic development	C	C	B	C	C	0	0	B	A	A
- Gender Issues	0	0	D	D	D	0	0	C	C	C

Positive Impact	**Negative Impact**	
A = Very Important	1 = Very important	O = No Impact
B = More Important	2 = More important	
C = Important	3 = Important	
D = Fair Important	4 = Fair important	
E = Less Important	5 = Less important	

Project benefits

A new hydroelectric plant along Gilgel Gibe - Omo River cascade represents a relevant step towards the country modernization. It will produce advantages for the country in terms of working opportunities, global economic growth, environment improvement, development in road construction and communications, growth of new social activities along the main new roads, better health conditions correlated to the social growth. Other benefits related to the power plant construction are represented by the satisfaction of regional water needs and the control of Gilgel Gibe river annual flows. This control will allow an agricultural development free from the water flow level variations during the rainy season.

In that area, the main economic benefit will be the temporary, but considerable, labour opportunities for the local population. Approximately 1,000 temporary jobs will be available for unskilled and semi-skilled workers. The benefit will last only during the power plant construction period, producing approximately 2,000 unskilled and semi-skilled employment per year. Since most of the wages derived by all the labour connected with the power plant construction will be spent and invested in that zone, the local economy will grow. Contractor will spend money to purchase food and services locally if the local entrepreneurs can be positioned to take advantage of the potential local economic windfall. Moreover, when contractors will spend their money for the services purchasing, the local entrepreneurs will take advantage from the potential local economic windfall.

In terms of roads and settlements, Gilgel Gibe II Project will require some efforts. In fact, new roads will be built to reach the powerhouse and the tunnel adits. Particularly, on the left side of Omo River, a road will be built for 34 km, from Kose to Omo River. Other roads will be built near the tunnel site camp, linking to adit camps and site installations.

A new bridge will cross the Omo River, few meters upstream the power house.

This new road net construction will boost the commerce growth. In the whole region, the project will have a positive impact on the local economy. Transportation companies, hotels, small factories and other outlets providing goods and services will take advantage by the project, the purchase of goods and services will generate income, and contribute to salaries and employment during power plant construction.

Some of the small entrepreneurs without aspirations of long-term economic growth probably will move in other zones after power plant construction, but a large portion of the commercial growth will remain.

Moreover, as it was the case for Gilgel Gibe I project, hydro plants contribute to the national grid and assist in meeting country’s demand for electrical energy that is an essential part of economic development. Similar projects, as Gilgel Gibe II, allow the country to mitigate the expenses (in foreign currency) for fuels and thermal power import and their transportation charges. Besides, some positive effects may be considered due to the fact that:

- hydroelectric power generation, on air quality point of view, is a totally clean way to generate electricity: there is no emission of dust, CO_2, NO_X, SO_X, etc…;
- the possibility to use electric power for cooking and for heating, may reduce the local consumption of forest wood. The deforestation is one of the main environmental assets of Ethiopian environment: cutting trees, spoiling soil, leads to soil erosion and, on a longer term, may produce desertification.

Hydro power plants, and particularly Gilgel Gibe II, offer a further benefit: they allow the regulation and the control of possible floods in the plain area of the Gilgel Gibe and Gibe River confluence. Moreover, thanks to the power plant building, some problems relevant to the stability of the lateritic colluvium covering the bedrock and the outcrops of tuffs (which offer a slight stress resistance and slight geotechnical parameters of equilibrium during rainy season) will be solved.

Impact assessment

In order to estimate the Environmental Impact of the proposed project and foresee which component of the environment will be subjected to some (positive and/or negative) impact by the project, a description of the "*Environmental receptors of impact*" has been carried out.

The following table summarizes the potential impact on each environmental component during the construction and the operation phases .

Receptor	**Description of the potential impact (positive and/or negative)**	
	Pre-during construction	*During normal working operations*
Air quality	dust production; transport pollution.	CO_2 emission reduction
Surface water	river flow alteration; pollution hazards; water resources availability	river flow alteration in the Gilgel Gibe; flood control; better use of water resources
Underground water	water disturbances	water disturbances
Soil	land occupation for allocating the excavated material	reduction of soil erosion due to the reduction of wood cutting for local energy production
Geomorphology	construction spoils	stability of the disposal area
Flora	destruction of natural forest	destruction of natural forest in the disposal areas
Ecosystems	local ecosystem disturbance	alteration of the local ecosystem
Socio-economy	employment opportunities	employment opportunities
	health risks	family income and structure
	customs of imported workers	opportunities due to the availability of power; infrastructure development
Health	sanitary conditions at camps; car accidents; diffusion of sexually transmitted diseases;	sanitary conditions inside the powerhouse and in the substation area; water quality, due to waste water production in the powerhouse;

Particurarly, the operations at the weir site will affect natural downstream flows, with the most significant effects felt from the tunnel intake to the confluence of Gilgel Gibe River in Gibe River. In fact, during dry seasons, when Gilgel Gibe I dam would not be spilling, the stretch downstream the dam is dry for 4- 6 months each year. The minimal flow to guarantee the biology life in the stretch downstream the weir should be at least equal to the low flow of the river. No human population would be affected in this first stretch of the river as it is uninhabited and will remain that way because of the buffer zone.

Comparison of the species list of the riverine and the surrounding vegetation with the list of endangered and endemic plant species of Ethiopia (Ensermu et al., 1992) does not indicate any endemic or endangered species in the area.

A compensation flow is part of the mitigation plan.

Considering the low water levels of the river during the dry season, an increased release of 2.0 m^3/s may be considered for maintaining the downstream ecosystem. The operators of the power station of Gilgel Gibe I and weir of the Gilgel Gibe II will be responsible for the maintenance of this compensatory flow.

In addition, another diversion weir project which planned a new structure just downstream the confluence of Bidru River in Gilgel Gibe River in order to use also its water to product hydro power, has been discarded because this river can guarantee a minimum runoff downstream the dam between the weir and the confluence of Gilgel Gibe River in Gibe River.

The effect of the reduced flow will be evaluated by the Environmental Management Unit with the technical assistance from EPA. Any change recommended in the compensation flow would be subjected to a cost/benefit analysis. EEPCO, as operator of the power plant will be responsible for the maintenance of this flow.

Environmental Comparison

In order to understand the Environmental Impact Assessment of the project in relationship with other hydroelectric projects in Ethiopia, a comparison was performed between Gilgel Gibe II Hydroelectric power project and the hydroelectric projects considered in the Ethiopian Power System Expansion Master Plan (EPSEMP) project signed in 1999 between the Ethiopian Electric Power Corporation (EEPCO) and BKS Acres.

In the EPSEMP seven criteria (land lost, people affected, access, cultural heritage, downstream effects, and aquatic ecosystems) were selected in order to rank the different schemes in terms of their environmental impact.

For each criterion, a scoring system was developed to give it a relative value. The score for each scheme was normalised by using a weighting system for the criteria. The following table shows the final results of the comparison.

The Impact Scores of the different schemes considered in the EPSEMP and of Gilgel Gibe II Hydroelectric power project

Scheme	Land lost	People affected	Access	Cultural	Downstream	Aquatic Systems	Score
Beles	0	0	0	0	2	1	12
Geba 1 and 2	8	2	1	0	1	1	41
Halele-Werabesa	10	1	1	0	2	2	49
Baro 1 and 2	6	2	3	0	1	2	50
Aleltu East	2	3	2	0	1	3	55
Aleltu West	2	3	2	0	1	3	55
Chemoga-Yeda	4	4	3	2	1	3	75
Genale 2 and 3	4	5	3	3	3	2	85
Gilgel Gibe II	**1**	**0**	**0**	**0**	**1**	**1**	**9**

Gilgel Gibe II Hydroelectric power project scheme, compared to all the hydroelectric schemes reported in the EPSEMP, has the lowest score due to the fact that only a small reservoir is envisaged and consequently no people are affected and almost no land is lost.

Besides, it has to be taken into account that a considerable amount of money has already been invested in the Gilgel Gibe Hydroelectric Project and it would be lost if another hydropower project were to be developed instead of the Gilgel Gibe Hydroelectric Project. In addition, any new hydropower site would be a "greenfields" site. In terms of environmental preference, it is clearly preferable to continue with construction at Gilgel Gibe Hydroelectric Project rather than substitute a new and undeveloped site. Other sites are being evaluated, not as a substitute for Gilgel Gibe Hydroelectric Project, but for future power generation.

Environmental Management Plan

A primary goal of EIA is to develop procedures to ensure that all mitigation measures and monitoring requirements specified in the approved EIA will actually be carried out in subsequent stages of project development. These mitigation measures and monitoring requirements are normally set out in an Environmental Management Plan (EMaP).

The EMaP prepared for the Gilgel Gibe II hydroelectric power project shows that the physical environment is low affected by the project while negative effects on downstream are mitigated by the release of a compensation flow together with the uncontrolled flow of the Bidru river.

As for the natural environment, the project impact is low because of the absence of rare, endangered or endemic fish species in the Gibe river system. Neverthless the implication of the change of flow regime in the downstream areas showed that compensation releases are required because effects on aquatic ecosystem are considered to be significant.

With reference to the socio-economic aspects, the implementation of the proposed Gilgel Gibe II hydropower project will bring about a number of both beneficial and adverse effects. The major and the most important benefit of the project is the generation of electric power that is expected to alleviate the energy shortage in the country and augment the development of the national economy.

Additional benefits can include development of job opportunities for the local communities and in-migrant population, improvement of the local social and physical infrastructure. The latter, with particular reference to roads, will allow easier links between the different area of the region. These and other benefits can support the Government objectives to enhance economic development and improve the living standard of the Ethiopian people.

As identified in the socio-economic environment impact assessment, the implementation of Gilgel Gibe II hydropower project will not bring any severe impacts on the social environment of the project area. In fact the agricultural practice in the Gilgel Gibe is very little and its role in the livelihood of the people living the area is minimal. The negative social impacts are limited to the establishment of constructions camps and other facilities, influx of labour force, loss of few residential houses (5 numbers) and of limited area of crops at homesteads.

This project will not cause population displacement because all the project components are located in areas where there is no settlement. The limited disturbance to human settlement is due to the construction of access road from Fofa town to the powerhouse and establishment of construction camps. With proper mitigation measures, these adverse effects will be manageable and can be reduced to acceptable levels. The important issue that should be given due attention is the social issue related to the influx of labour force during construction period. Particularly the potential spread of sexually transmitted diseases, especially HIV/AIDS could increase unless proper control measures are taken.

1 INTRODUCTION

1.1 Purpose

It is a universal thought that infrastructure development and environmental protection should go hand in hand. This is inline with the national policy that the development of Hydropower infrastructures as well as other development activities has to follow the principle of development without destruction and measures must be adopted to have a stress free environment.

Any environmental consequence has to be recognised early and taken into account in project design. By making project designers and implementing agencies attentive to environmental issues early, the EIA:

- enables them to take into account environmental issues
- helps to avoid unnecessary environmental costs and dalliance in implementation
- provides a formal mechanism for inter-agency coordination to deal with the concerns of affected groups
- can play a major role in building capability in the country for the solution of environmental problems

The main purpose of EIA can be stated as:

- to identify and forecast the possible positive and negative impacts to the environment resulting from the proposed project
- to provide mitigation measures which up on implementation will reduce or offset the negative impacts of a project resulting in a minimal level of environmental degradation
- to measure the level of plan implementation and the degree of effectiveness of the above environmental protection provisions.

1.2 Background

Ethiopia has an abundance of rivers that provide the country with the potential for large sustainable energy resources in the form of hydropower. Recent power planning studies have estimated that Ethiopia's hydroelectric potential is in the order of 30,000 MW, a potential greatly in excess of foreseeable domestic demand. Currently only about one per cent of the available total is being harnessed for generating hydroelectric power. Preliminary investigations have indicated that the most promising sites could be developed at lower costs than other power generation options.

Ethiopia's 10 year perspective plan for the period 1984 to 1993 recognised the importance of low cost energy as an incentive to industrial and economic development. At the same time, the plan realised that export sales could provide an attractive long term development opportunity. Neighbouring countries are poorly endowed with water resources that can be converted to inexpensive energy and they face the continuing prospect of increasing oil imports in order to meet their own domestic demand.

The Gilgel Gibe project is one of the most attractive potential hydroelectric developments in the country. The Gilgel Gibe I hydroelectric power plant was inaugurated on 22nd February 2004. The project involved 307 experts from 32 countries, at a cost of about 256 million Euros. The World Bank Group (IDA) covered 68% of the total cost and the European Investment Bank (EIB) and Ethiopian Electric Power Corporation (EEPCO) financed the rest. EEPCO covering 16%. 12 companies, from Italy, Spain, Germany, Austria, Bosnia, France and Ethiopia were involved in the construction of Gilgel Gibe I hydroelectric power plant.

In November 2002, Salini Costruttori S.p.A (Salini) developed a preliminary idea to exploit the very large geodetical head (i.e. 505 m) existing between the Gilgel Gibe river and the Omo river by constructing a 26 km long tunnel which makes use of the water regulated by the Gilgel Gibe I hydroelectric project and in this regard a first Report outlining the main features of the hydropower works was handed over to the Ethiopian Authorities.

In February 2003, Salini completed and delivered to the Ethiopian Authorities the Technical Report on the Project conceptual design which embodied the Ethiopian counterpart request to consider an alternative option of the hydropower scheme with a surface power house.

In March 2003, Salini carried out an Economical Analysis developed by using the DCFA method which was presented to the Ethiopian Authorities complete with sensitivity analyses performed considering different discount rates and energy selling prices as well as the positive effect brought to the Gilgel Gibe phase I by the construction of phase II.

A ground geological assessment and detailed topographical survey of the areas relevant to main components of the hydropower works were carried out during the months April-May 2003 which allowed the revision of the Project conceptual design.

In the period June-July 2003, Salini assessed the cost and the time required for the manufacture and erection of the Hydraulic Steel Structures and Electromechanical Equipment from information given by interested international suppliers.

On 31st July 2003, Salini finalised a proposal for the Project implementation committing itself in terms of construction cost and time for completion of the works.

On 21st October 2003, a Memorandum of Understanding was signed between EEPCO and Salini for the preparation of the Project Basic Design in order to include all the technical documents on which the offer presented by Salini was based (i.e. Topography, Hydrology, Sedimentation, Geology, Scheme Layout Optimisation, Design Criteria, Drawings, Calculations, Implementation Planning and Economical Analysis).

On 17th November 2003, Salini submitted to EEPCO the Project Basic Design dated October 2003 which was subsequently delivered, upon instruction from EEPCO, on 1st December 2003, to the Employer's Engineer (ELC- Electroconsult S.p.A) for their review and approval.

During the period January-March 2004, several meetings had been held in Addis Ababa, Rome and Milan in order to discuss the technical aspects related to the documents submitted by Salini.

On 3rd April 2004, Salini delivered to EEPCO five documents, identified as updating of the Project Basic Design – Rev. March 04, which include all the clarifications, modifications and observations requested/made by the Employer/Consultant and agreed upon.

During the above meetings Salini was also requested to commission an Environmental Impact Assessment study to be prepared in accordance with the Ethiopian rules and in order to suit the needs of the financial institutions.

1.3 Impact assessment responsibility and Assessment Team

CESI was charged with the responsibility of preparing the EIA and to predict the likely environmental consequences of implementing project activities. World Bank guidelines for preparing environmental impact assessments were followed (Operational Directive 4.01). The EIA has also been based on the previous environmental studies including the Gilgel Gibe Hydroelectric Scheme - Feasibility Study (January 1994) and on the Gilgel Gibe Hydroelectric Project - Public and Environmental Health Implications (UNDPH/WHO, April 1986).

A team was assembled and given the responsibility for conducting the EIA and preparing the draft and final reports. The team was comprised of the following members.

Mr. Carlo Bonfanti (Geologist, LITHOS)

Mr. Romeo Cironi (Biologist, CESI)

Mrs. Daniela Colombo (Environmental Hydraulics Engineer, CESI)

Mr. Maurizio Facchin (Geologist, LITHOS)

Mr. Stefano Maran (Physicist, CESI)

Dr. Seyoum Mengistu (Aquatic Ecologist, HAYWAS)

Mr. Paolo Stigliano (Geologist, EIA Team Leader, CESI)

Mr. Guido Testa (Environmental Hydraulics Engineer, CESI)

Mr. Temsgen Yimer (Sociologist, MDI)

Mr. Dejene Woldemariam (Environmentalist, MDI)

Prof. Zerihun Woldu (Terrestrial Ecologist, HAYWAS)

1.4 Revision – September 2004

The EIA first emission Report (edition May 2004) has been officially delivered to EEPCO on June 2004, 12th.

On July 2004, 13th EEPCO transmitted the comments of EPA (Environmental Protection Agency) subsequently integrating them with other comments on July 2004, 19th.

The present edition (September 2004) contains the answers and the integrations requested by EPA/EEPCO, as briefly summarized here below.

A) Introduction

The methodologies employed for assessment and evaluation of the impacts of the project at the feasibility level have been clarified on page 52.

B) Bounding and Scoping

Considering that Gilgel Gibe II Hydroelectric Project is strictly related to Gilgel Gibe I Hydroelectric Project, during the scoping phase, the EIA has been referred to the "Feasibility Report" prepared for Gilgel Gibe I project. (refer to page 53).

C) Table 4.2 synthesis of Environmental Matrix

Further explanation about the type and use of the matrix have been added on pages 53-54.

D) 5.1.3 Hydrology

As it is well known, data to complete the historical flood series relevant to Daneba station and Asendabo are not available, nevertheless, considering that the present weir site is close to the Deneba reservoir, the flows with return period of 100 years or more can be estimated as it was calculated and reported in Gilgel Gibe I Environmental Impact Assessment. The results of this computation have been shown on pages 61-62 and 64.

E) 5.1.5 Water quality

With the aim to complete and to enlarge the data on water quality, a new field campaign and the consequent chemical analysis has been performed on August 2004 by the Department of Chemistry of the Adis Abeba University. All explanation and results are reported on pages 64-70.

From the average of the chemical components analysed, it's possible to confirm that the measured values of the river characteristics are included in the normal range and indicate good water quality values.

F) 5.1.6 Soil

To determine soil thickness near the weir, a boreholes campaign has been organized, four boreholes have been done from which has been possible to determine geo – pedological characteristics and thickness of soils covering the bedrock (see Chapter 5.1.7 pages 70-71). The contractor, since data collected from this campaign, has decided to do some other seismic cross-hole analysis, particularly near the weir and at the intake.

G) 5.2.2.2.1 Fishery and Other Aquatic Resources

A baseline information with regard to microbiological community, including "plankton", "phytoplankton" and nutrients has been added to the report on pages 84-85.

H) Section 9 (Environmental Management Plan)

A deeper description of potential impact has been integrated in the present edition -September 2004- of the report, particularly related to slope stability (see pages 60-62), tunnel blasting operations (see pages 41-42) and pollution from different chemical substances during construction (see pages 46-49). With reference to those aspects in chapter 3.6 "Mitigative actions during construction activities" (pages 46-50) and 9.1.5 "Slope stability" (pages 123-124) some measures for preventing and/or minimizing such impacts have been introduced.

It is to be noted that the costs relevant to the mitigative measures relevant to construction activities (i.e 48 months) are to be borned by the main contractor under the EPC contract signed with EEPCO. While funding of an Environmental Monitoring Unit (EMU) to be formed as part of the Project Implementation Unit (PIU), established within EEPCO, is to be borned by the Employer's administration.

I) 9.1.5 Slope stability

A deeper description of the slope stability situation has been added to the chapter 5.1.3 "Slope stability" (pages 60-62) in which this item has been examined for upstream area and for downstream area (structures and disposal areas).

Furthermore, in chapter 9 "Environmental Management Plan" some different measures have been introduced relevant to Final slopes of the excavated areas, Slopes of disposal areas and protection of the Slopes during construction (see pages 123-124).

J) 9.1.8 Water Quality

Converting a flowing river system to a standing reservoir inevitably conducts to an eutrophication of the water, as the Gilgel Gibe I, and other experiences elsewhere, have shown. Nevertheless the present project is located just downstream of the Gilgel Gibe I dam and then it insists on a already impounded river. This situation allows to consider the eutrophication aspect which will take place whit the time quite insignificant if compared the limited storage area formed by the weir.

K) 9.2 Natural Environment

Very great care shall be taken to ensure that no alien aquatic species, especially fish, should be introduced into the Gilgel Gibe II lagoon and river. The monitoring phases shall include regular check of the ichthyofaunal composition (see pages 127-128).

L) 7.3.4 Impacts Related to the Workforce

Due consideration about potential spillage of hazardous substances and risk of explosions and fires, have been added to the report (see pages 41-42 and 46-50).

Further, mitigative actions and procedures, that shall be used, have been explained (see Chapter 3.6 "Mitigative actions during construction activities").

All this measures, which have been considered by the EPC contractor in his method of statement for the works, allow to consider very low the risk for the workforce.

M) Mitigative measures to minimizing release of chemical and used oils pollutants from tunnel excavation

Mitigative actions and procedures, that shall be used and relevant to all kind of possible pollutant substances employed during excavation phase, have been considered and explained. All this measures, included in the method of statement of the works proposed by the EPC contractor, allow to consider very low the residual impacts of the construction phase (see pages 46-50).

N) Archaeological issues

During the field investigation the importance of the project area and the immediate surrounding were assessed for their potential archaeological and religious importance by interviewing the local residents and authorities. According to these officials and local residents, the Gilgel Gibe II site has no signs of archaeological artefacts or cultural sites which could be given such importance as to hinder the execution of the project. (see page 111).

O) Self-monitoring procedures

Mitigative actions and procedures, that shall be used and relevant to all kind of possible pollutant substances employed during excavation phase, have been considered and explained. (see pages 46-50).

2 POLICY, LEGAL, AND INSTITUTIONAL FRAMEWORK

2.1 Institutional and administrative framework

The following paragraphs discuss the institutional and administrative framework at the Federal and Regional level and organisations responsible for the preparation of environmental policy and technical guidelines.

2.1.1 Federal Democratic Republic of Ethiopia

The Federal Democratic Republic of Ethiopia (FDRE) comprises the Federal State and nine Regional State members. The power and duties of the Federal, Regional and Local governments have been defined by Proclamations 33 of 1992 and 41 of 1993, and 4 of 1995. Under these proclamations, duties and responsibilities of Regional States include planning, directing and developing social and economic development programmes, as well as the protection of natural resources of their respective regions.

2.1.2 Regional Government

The Gilgel Gibe II Hydropower Project lies within the Jima Zone of the Oromiya Administration Region and the Yem Special Wereda of the Southern Nations and Nationalities Peoples Region (SNNPR).

The Oromiya and SNNPR Regional Governments are two of the regional states established by the Federal Government. The regions have Zones and Weredas. The basic administration unit is the Wereda and each Wereda is sub-divided into Kebele and peasant/farmers associations. Each administrative unit has their own local government elected by the people.

Based on the powers and responsibilities of the regional governments, the two Regional Governments have established Sectoral Bureaus, Commissions and Authorities.

2.1.3 Environmental Protection Authority

The Environmental Protection Authority (EPA) was re-established in October 2002, under Proclamation 295/2002, and is an autonomous government body reporting directly to the Prime Minister. It has a broad mandate covering environmental matters at federal level. The Proclamation sets out the main responsibilities and broad organisational structure of EPA and these may be summarised as follows:

- preparation of environmental protection policies and laws and to ensure that these are implemented
- preparation of directives and implementation of systems necessary for the evaluation of the impact of projects on the environment
- preparation of environmental protection standards and implementation of directives concerning soil, water and air
- the conduct of studies on desertification and the co-ordination of efforts to combat it
- to establish a system for EIA of projects, policies, strategies, laws and programmes

- to enforce implementation of this EIA process (i.e. review EIA reports) and the recommendations which result from it for projects that are subject to Federal licensing, execution or supervision
- to enter any land, premises or any other places that falls under the Federal jurisdiction, inspect anything and take samples as deemed necessary with a view to ascertaining compliance with environmental protection requirements
- to ensure implementation of environmental protection laws
- preparation of recommendations regarding measures needed to protect the environment
- enhancement of environmental awareness programmes
- implementation of international treaties concerning the environment to which Ethiopia is a signatory
- provision of advice and technical support to the regions on environmental matters

With these powers, EPA has the mandate to involve itself with all environmental issues and projects that have a federal, inter-regional (involving more than one Region) and international scope.

In view of the multi-sectoral nature of the EPA and the number of government agencies involved in various aspects of environmental management, overall co-ordination and policy review and direction is the responsibility of an Environmental Protection Council (EPC) within EPA.

The responsibilities of the council shall include:

- to review proposed environmental policies, strategies and laws, and issue recommendations to the Government,
- based on report submitted to it by the Authority, evaluate and provide appropriate advise on the implementation of the environmental policy of Ethiopia; and
- review and approve directives, guidelines and environmental standards prepared by the Authority.

2.2 National policies and strategies

The following sections discuss the national policies and sectoral strategy background regarding environmental protection and EIA in Ethiopia.

2.2.1 The Constitution

The FDRE Constitution contains a number of articles that are relevant to environmental matters in connection with development projects, as well as to the environment in general. Article 43 gives the right to people to improved living standards and to sustainable development. Article 92 of Chapter 10 (which sets out national policy principles and objectives), includes the following significant environmental objectives:

- Government shall endeavour to ensure that all Ethiopians live in a clean and healthy environment,

- the design and implementation of programmes and projects of development shall not damage or destroy the environment,
- people have the right to full consultation and to the expression of their views in the planning and implementation of environmental policies and projects that affect them directly,
- Government and citizens shall have the duty to protect the environment.

2.2.2 Conservation Strategy of Ethiopia

Since the early 1990s, the Federal Government has undertaken a number of initiatives to develop regional, national and sectoral strategies for environmental conservation and protection. Paramount amongst these was CSE, approved by the council of ministers, which provided a strategic framework for integrating environmental planning into new and existing policies, programs and projects. Although yet to be approved by the Federal Government, the CSE is an important strategy document which views environmental management from several perspectives. The CSE itself provides a comprehensive and rational approach to environmental management in a very broad sense, covering national and regional strategies, sectoral and cross-sectoral strategy, action plans and programmes, as well as providing the basis for development of appropriate institutional and legal frameworks for implementation.

The plan comprehensively presented the exiting situation within the country and gave a plan of priority actions on the short and medium term. In particular, it recognises the importance of incorporating environmental factors into development activities from the outset, so that planners may take into account environmental protection as an essential component of economic, social and cultural development.

Following CSE, the Oromiya and SNNP Regional Governments have prepared Conservation Strategy document for their respective Regions. This Regional conservation strategy documents give details about environmental issues prevalent in the territory, and outlining the ways in which environmental problems were to be addressed.

2.2.3 Environmental Policy of Ethiopia

The Environmental Policy of Ethiopia (EPE) was approved by the Council of Ministers in April 1997 (EPA/MEDAC 1997). It is based on the CSE which was developed through a consultative process over the period 1989-1995.

The policy has the broad aim of rectifying previous policy failures and deficiencies which, in the past, have led to serious environmental degradation. It is fully integrated and compatible with the overall long-term economic development strategy of the country, known as Agricultural Development-Led Industrialisation (ADLI), and other key national policies.

The EPE's overall policy goal may be summarised in terms of the improvement and enhancement of the health and quality of life of all Ethiopians, and the promotion of sustainable social and economic development through the adoption of sound environmental management principles. Specific policy objectives and key guiding principles are set out clearly in the EPE, and expand on various aspects of the overall goal. The policy contains sectoral and cross-sectoral policies and also has provisions required for the appropriate implementation of the policy itself.

The section of the EPE concerning EIA sets out a number of policies, key elements of which may be summarised as follows:

- recognition of the need for EIA to address social, socio-economic, political and cultural impacts, in addition to physical and biological impacts, and for public consultation to be integrated within EIA procedures
- incorporation of impact containment measures within the design process for both public and private sector development projects, and for mitigation measures and accident contingency plans to be incorporated within environmental impact statements (EISs)
- creation of a legal framework for the EIA process, together with a suitable and co-ordinated institutional framework for the execution and approval of EIAs and environmental audits
- development of detailed technical sectoral guidelines for EIA and environmental auditing
- development of EIA and environmental auditing capacity and capabilities within the Environmental Protection Authority, sectoral ministries and agencies, as well as in the regions

The thorough and holistic approach taken to development of the policy and, in particular, recognition of the importance of addressing cross-sectoral environmental issues, has led to a national approach to environmental management, which is not only comprehensive, but also provides a sound and rational basis for addressing the environmental problems faced by the country now and those which are anticipated over the next decade.

Implementation of the EPE is still very much in its early stages, but a number of key elements either has been or are in the process of realisation. Some of these are referred to in the following sections.

2.2.4 Water Resource Policy

The Ministry of Water Resources has formulated the Federal Water Resource Policy for a comprehensive and integrated water resource management. The overall goal of the water resources policy is to enhance and promote all national efforts towards the efficient and optimum utilisation of the available water resources for socio-economic development on sustainable bases. The policy is to establish and institutionalise environment conservation and protection requirements as integral parts of water resources planning and project development.

2.2.5 The National Policy on Women

This Policy was issued in March 1993 and stresses that all economic and social programs and activities should ensure equal access of men and women to the country's resources and in the decision making process so that they can benefit equally from all activities carried out by the central and regional institutions.

2.2.6 Environmental Framework Legislation

The following three Proclamations have been issued by EPA and they represent a framework building on the policies and strategies set out in the CSE and the EPE, which sets out basic and general provisions for the regulation of environmental matters in a coherent and holistic manner, and will be supplemented in due course by more sector-specific legislation.

2.2.6.1 Proclamation on Institutional Arrangement for Environmental Protection

The Proclamation for the Establishment of Environmental Protection Organs, No. 295/2002, was issued to establish a system that fosters coordinated but differentiated responsibilities among environmental protection agencies at Federal and Regional Levels. The proclamation recognizes assigning responsibilities to separate organisations for environmental development and management activities on the one hand, and environmental protection, regulations and monitoring on the other is instrumental for the sustainable use of environmental resources, thereby avoiding possible conflicts of interests and duplication of efforts. A series of institutional mandates that would extend the powers and duties of the Environmental Protection Authority (EPA) and the Environmental Protection Council (EPC) beyond those defined in the enabling legislation, which established these bodies are also included. Powers and duties are also proposed in relation to Zonal, Wereda and Community Environmental Coordinating Committees, which will also be established.

2.2.6.2 Proclamation on Environmental Impact Assessment

The primary aim of the Proclamation on Environmental Impact Assessment (No. 299/2002) is to make EIA mandatory for specified categories of activities undertaken either by the public or private sectors, and possibly, the extension of EIA to policies, plans and programmes in addition to projects.

The provision of the proclamation include:

- Projects will be subject to EIA and execution is subject to an environmental clearance from the EPA or Regional Government Environmental Agency, as applies;
- EPA or the Regional Agency, depending on the magnitude of expected impacts, may waive the requirement of an EIA;
- All other licensing agencies shall, prior to issuing of a license, ensure that either EPA or the regional Environmental Agency has authorised implementation of project; and
- A licensing agency shall either suspend or cancel a license that has already been issued, in the case that EPA or the Regional environmental agency suspends or cancels the environmental authorisation.

Procedures that must be followed in the EIA process are described in the proclamation:

- A Proponent shall ensure that an environmental impact assessment is conducted and an environmental impact study report prepared by experts that meet the requirements specified under a directive issued by the Authority.

- The Authority or Regional environmental agency shall, after evaluating an environmental impact study report by taking into account any public comment and expert opinions:
- approve the project without conditions and issue authorisation if it is convinced that the project may not cause negative impacts;
- approve the project and issue authorisation with conditions that must be fulfilled in order to reduce adverse impacts to insignificance; or
- refuse implementation of the project if the negative impact cannot be satisfactorily avoided by setting conditionality of implementation.

The Authority or the relevant Regional environmental agency shall audit the implementation of an authorised project in order to ensure compliance with all commitments made by, or obligations imposed on, the proponent during the approval of an environmental impact study report.

For the support of EIA studies, existence of standards is a prerequisite. In the FDRE at the moment ambient quality objectives do not exist. However, now proclamation on Environmental Pollution Control and Environmental Impact Assessment are issued and other relevant legal documentation is in the process. When this Law is adopted and comes into force, it will become an invaluable legal tool for environmental planning, management and monitoring.

2.2.6.3 Proclamation on Environmental Impact Assessment

The Proclamation on Environmental Pollution Control (No. 300/2002) is mainly based on the right of each citizen to a healthy environment, as well as on the obligation to protect the environment of the Country. The primary objective of the Proclamation on Environmental Pollution Control is to provide the basis from which the relevant ambient environmental standards applicable to Ethiopia can be developed, and to make the violation of these standards a punishable act. The Proclamation states that the "polluter pays" principle will be applied to all persons. Under this Proclamation, the EPA is given the mandate for the creation of the function of Environmental Inspectors. Article 7(1) of this proclamation gives the authority to ensure implementation and enforcement of environmental standards and related requirements to Inspectors (to be assigned by EPA or regional environmental agencies).

2.2.6.4 Environmental Protection Authority's EIA Guideline

In May 2000, as part of the ongoing effort to develop environmental legislation and guidelines in Ethiopia, the EPA released the final draft of its EIA Guidelines document. This guideline follows the conventional pattern adopted in many other parts of the world.

The guideline requires all projects to be submitted to an Environmental Screening to enable a decision to be taken as to whether the project is to be submitted to full EIA (in the case of projects which may have significant impacts) and are defined as falling under Schedule 1, or are of projects such a type or scale which does not justify full EIA, and therefore fall into Schedule 2. Schedule 3 projects are the ones who have no impact on the environment and do not require EIA. The proposed Gilgel Gibe II hydropower project is a category 1 and requires full EIA.

According to the Guideline, approval of an Environmental Impact Statement (EIS) is conditional and it is on compliance with environmental quality criteria, or other provisions stated in the EIS, and the approving authority may conduct audit and surveillance to ensure compliance during and after project implementation.

2.2.7 Legal framework for expropriation and compensation

2.2.7.1 Land Tenure

Land in Ethiopia is state owned by proclamation 31/1975 issued to deal with Government ownership of rural land and proclamation 47/1975 issued to cover Government ownership of urban land. Under Article 3(1) of the first proclamation, all rural land shall be the collective property of the Ethiopian people.

In December 1994 the new constitution was approved. It retains land under the control of the people and Government of Ethiopia. Article 40 states that ownership of both urban and rural land is vested in the State and the people, and is common property which is not subject to sale or other means of exchange. Peasants have the right to obtain land without payment, and are protected against eviction from land in their possession.

2.2.7.2 Expropriation

The 1960 Civil Code of Ethiopia contains relevant provisions regarding expropriation of property for public purposes (Arts.1444-1488). Under this code the owner may be compelled to surrender the ownership of land for public purpose.

According to the constitution of the FDRE, full right to immovable property and permanent improvements to land is vested in individuals who have built the property or made the improvements, but government may expropriate such property for public purposes, subject to the payment in advance of compensation commensurate to the value of the property or alternative means of compensation, including relocation with adequate State assistance.

2.2.7.3 Compensation

With regards to compensation, Article 7(2) of proclamation 4/1975 states that the government shall pay fair compensation for property found on the land but that the amount of compensation shall not take the value of the land into account because land continues to be state owned.

As discussed in Section 1.2.1, the Constitution lays down the basis for the property to be compensated in case of expropriation as a result of State programs or projects in both rural and urban areas. Art. 44.2 clearly states that “ All persons who have been affected or whose livelihoods have been adversely affected as a result of state programs have the right to a commensurate monetary or alternative means of compensation, including relocation with adequate state assistance.” Thus, persons who have lost their land as a result of acquisition of such land for the purpose of constructing dam and creating reservoir are entitled to be compensated to a similar land plus the related costs arising from relocation; assets such as buildings, crops or fruit trees that are part of the land etc.

Hence, project plans must include an “attractive” and sustainable resettlement strategy, offering adequate compensation and incentives to the loss of livelihood.

2.2.8 Multilateral agreement

The Federal Democratic Republic of Ethiopia has ratified several international conventions and protocols and these include:

- Vienna Convention on Ozone Layer Protection (1990);
- Montreal Protocol for Substances Depleting the Ozone Layer (1990);
- Convention on Biodiversity (Rio convention) (1997);
- Framework Convention of United Nations on Climate Change (1997);
- Convention on the Control of Transboundary Movement of Hazardous Substance (1987).
- African Convention on the Conservation of Nature and Natural Resources
- Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar)
- Convention to Combat Desertification (CCD)
- Convention concerning the Protection of World Cultural and Natural Heritage.
- Convention on International Trade in Endangered Species (CITES).

3 PROJECT DESCRIPTION

3.1 Project location

The present project is a second stage of the Gilgel Gibe hydroelectric cascade which includes Gilgel Gige I (inaugurated on 22nd February 2004) and Gilgel Gibe II (proposed).

The cascade is located in the Jimma Zone Administration between the Gilgel Gibe and Omo rivers, some 250 km South-West of Addis Ababa and about 80 km North-East of Jima. The Gilgel Gibe is a tributary of the Great Gibe River, also known as Omo River downstream of the bridge of the highway Addis Ababa – Jimma.

Most of the project component sites are in Yem Special Woreda of the Southern region. The powerhouse, access road, project camps and construction of other facilities are located in this Woreda. The access road to the powerhouse is about 30 km from Fofa the capital town of the Woreda. The access road passes through Gormihangere, Meleka Kerzidoyo, Shosherna, Alman and Shosho rural kebeles of the Woreda. Bordering Yem are Gurage Zone on the North-East and Hadya Zone on the East, and South and Jimma (Oromiya) from North-West to South-West. Fofa town is situated in the central part of the Woreda. The road to Fofa branches off at Saja from the Main Addis-Jima asphalt highway.

The project area is shown in Map 1.

Map 1: The project area

The area of Gilgel Gibe I reservoir is a fairly flat plateau about 1,650 m a.s.l.. The Gilgel Gibe (Little Gibe) River, which flows through Jimma Zone Administration from South-West to North-East, and is extremely variable in course and gradient.

In the Gilgel Gibe I reservoir area, the stretch of river between Asendabo and the Deneba waterfall has a winding and relatively flat course. The river banks near the Deneba waterfalls become steeper and this section of the valley was suitable for the construction of water retaining structures of the first power plant. A 40 m high dam was sufficient to obtain a reservoir with the required storage capacity. Downstream of the 20 m high Deneba waterfall, which is immediately downstream of the dam site, the river narrows and the gradient increases to about 1.4-1.5 per cent. Within a few kilometers below the waterfall, the river drops considerably in elevation, which in conjunction with the drop at Deneba Falls represents the sizable hydroelectric potential of the first Gilgel Gibe project.

The first power plant of the cascade regulates the Gilgel Gibe river with a reservoir of 839 Mm^3 total storage and has a gross head of 240 m. The second power plant uses the water discharged by the first one and has a gross head of 505 m. This new head is created by a waterway that bypasses about 110 km of the two rivers (Gilgel Gibe and Omo).

The intake of the proposed second power plant is located on the Gilgel Gibe river downstream of the Gilgel Gibe I outlet.

Highway #7 is located within a few kilometres of the right bank of the Gilgel Gibe river and links Addis Ababa to Jimma, but the area of the proposed alternative diversion weir design (March 2004, see description below) is quite far from the facilities existing near the Gilgel Gibe I. Consequently a new access road and a new site installation are required for the construction activities.

The waterway crosses the ridge between the Gilgel Gibe valley and the Omo valley by means of a 26 km long tunnel and some 1.2 km long penstocks. The surface powerhouse is located along the Omo river bank approximately 60 km downstream of the Gibe bridge.

The access to the power house of Gilgel Gibe II has been envisaged by means of two roads: from Fofa village to Omo river (right bank) and from Kose village to Omo river (left bank).

3.2 General project description

The scheme of the Gilgel Gibe second stage consists of a weir (alternative design, March 2004), an underground power tunnel connecting the Gilgel Gibe valley to the Omo valley, including a terminal surge shaft, underground and inclined penstocks, and an outdoor powerhouse equipped with four power generating units.

The proposed plant has the following basic features:

- Intake reservoir, 1.2 Mm^3 useful capacity (alternative design, March 2004)
- 26 km power tunnel length (D = 6.3 m, 0.25 m lining) of which
    - 0.8 km constructed with Drill and Blast technology
    - 25.2 km constructed with TBM technology

- 1.2 km length of N. 2 penstocks, average diameter 3.2 m (alternative design, March 2004)
- power house outdoor
- Pelton N. 4 turbines, 105 MW, 470 m Hn, 25 m^3/s Q
- 0.44 plant factor (0.46 Gilgel Gibe I)
- 1,625 GWh energy produced annually

and, with reference to,

- hydrology:
  - about 4,300 km^2 catchment area (about 4,200 km^2 Gilgel Gibe I)
- weir (alternative design, March 2004):
  - 33 m height above ground
  - 170 m width, approx 38 m of total height
- spillway (alternative design, March 2004):
  - 2,350 m^3/s max discharge flow (sill)
- intake (alternative March 2004):
  - 1,437.0 m a.s.l. flood level (Q=2350 m^3/s)
  - 1,431.5 m a.s.l. normal operating level
  - 1,424.0 m a.s.l. min operating level
  - 1,422.0 m a.s.l. intake crest elevation
- surge shaft:
  - 88.0 m height
  - 18.0 m diameter
- power house (basic design, Oct 2003, layout under revision due to the new solution selected for the branches at the turbine inlet):
  - 120x25x36 maximum size
  - 505.0 m max gross head
  - 470.0 m design head (net head at average resevoir level)
  - 101.5 m^3/s design flow
  - 420 MW installed power
  - 1,430 GWh/y annual energy available to earn revenue

Map 3-2 (01 LAYOUT 50K,26may04.dwg) and Map 3-3 (02 Tunnel PLAN and PROFILE, 26may04.dwg) illustrate the general layout of Gilgel Gibe I and II.

3.3 Description of project components

3.3.1 River diversion

The river diversion is not an easy task due to the following conditions:

- the river bed is only 40 m wide
- the presence of the Gilgel Gibe I plant in operation provides flows of 100 m^3/sec also during the dry season.

Two alternatives have been taken into consideration:

- traditional solution with two cofferdams and a diversion tunnel. In this case the tunnel will incorporate the bottom outlet structure
- special solution (concrete wall) without tunnel.

The investigation (presently in progress) will make available the basic data required to decide which of the two alternatives is the most suitable.

3.3.2 Access Roads

The access to the power house of Gilgel Gibe II has been envisaged by means of two roads: from Fofa village (the capital town of the Woreda) to Omo river (right bank) and from Kose village to Omo river (left bank).

The first one was chosen after the analysis of two alternatives. A South alternative was discarded because it was entirely new, no villages exist in the area and the time required for the construction was too long. A North alternative which follows the existing road up to Fofa village and links all the project sites by means of new roads (R 1 and R 2 from Fofa to power house, 30 km + R 3 to the tunnel outlet, 4.2 km from R2 + R 4 to the surge shaft, 2.3 km from R3) was then chosen. About 1 km traverses in Fofa town, 1.5 km is in Goromena hanger PA and the rest is in Meleka PA. This access road, under construction, has affected few houses and farm land in Fofa town. Its impact on Meleka PA is mainly on grazing land and woody grass land.

The second one (from Kose village to Omo river) is a new 34 km long connection; together with the existing 58.9 km long road from Kose village to Wolkite (which needs a paving surface treatment) it represents a shorter connection to Addis Ababa with respect to the access via Saja-Fofa. By this access there will be no interference with the Wolkite - Jimma road construction works and the use of the precarious existing Bailey Bridge over the Omo river will be avoided.

To cross the Omo river, a bridge has been envisaged about 250 m upstream the power house.

The above description refers to the basic design (October 2003). The area of the proposed alternative diversion weir design (March 2004, see description below) is quite far from the facilities existing near the Gilgel Gibe I. Consequently a new access road and a new site installation are required for the construction activities. The new route starts from the existing Deneba – Sekoru main asphalt road at Bidiru PA, travels towards to Gilgel Gibe valley through existing foot path for few km, then goes through the farm and grazing land, and finally enter into a very steep slope where it approaches the proposed weir site. It reaches the weir site (on the right bank) with a total length of about 5,0 km and 7,5 % of average slope.

After the design of the alternative diversion weir the new tunnel levels are about 8 m lower in respect to the basic design.

3.3.3 Inlet works

The following description refers also to the alternative diversion weir presented in March 2004 in order to adhere to the Client request of having a regulating capacity sufficient to '*increase the* *flexibility*" of the cascade power plant. The present version of the design envisages a daily regulation.

The desilting weir is located on the Gilgel Gibe river 1 km upstream from the Gilgel Gibe I "Korean bridge" and just downstream of the last creek in the valley. Its purpose is to increase both the storage of silting from the small (about 80 km^2) catchment area existing between the reservoir and the first power plant outlet and the disposal area for the material excavated in the inlet works.

This structure receives the outflow of the Gilgel Gibe I dam spillway as well as the runoff (and sediments) of the mentioned above small catchment area. The upstream water elevation depends on the spillway outflow, while the downstream water level is nearly constant and controlled by the weir and the outflow of the second power plant.

The solution adopted includes a small embankment about 12 m high (basic design October 2003), designed permeable and capable of being overtopped during the spillway overflow. The embankment height was chosen according to the criterion of minimising the overall cost of construction and desilting operation. Every 4 years a volume of about 150,000 m^3 of silt has to be removed from the reservoir in order to increase up to 50 years the life span of the present plant making it identical to that adopted for the main upstream dam of the first power plant.

During the dry season the small reservoir will be nearly dry. During the rainy season, this permeable structure acts as a filter, improving the quality of the runoff due to this small catchment area.

The downstream slope is designed to counteract the hydraulic traction forces by means of a typical rock grading and steel reinforcement.

The crest is shaped as required to contain the exceptional design flow (2,350 m^3/s).

All the weathered rock and debris must be removed from the construction area.

Potentially unstable areas along the sides of the spillway chute have to be protected (anchored Reno mattresses).

The proposed alternative diversion weir is located about 2.3 km downstream of the weir proposed in the basic design (October 2003), which was 300 m downstream of the Gilgel Gibe Tail Race Tunnel (TRT) outlet shaft. Investigations (geophysical and boreholes) in order to select the most suitable location are presently in progress.

The proposed alternative is 33 m above ground, 170 m wide and 38 m high (total height). The spillway crest is 90 m. The design flood is 2,350 m^3/s.

The proposed reservoir has 1,2 Mm^3 of useful capacity for power plant daily regulation.

The max outflow of the Gilgel Gibe I power plant is 102 m^3/s. This means that the reservoir, forward by the diversion weir, can guarantee a daily regulation of 3.3 hours (with Gilgel Gibe I fully closed) or more (with Gilgel Gibe I partialised).

The most important elevations and capacities of the alternative are as follows:

- 1,437.0 m asl Flood level (Q=2,350 m^3/s)
- 1,431.5 m asl Normal Operating Level
- 1,424.0 m asl Min Operating Level.
- 1.2 Mm^3 Useful Reservoir Capacity (min daily regulation of 3.3 h with Gilgel Gibe I fully closed)
- 1.0 Mm^3 Dead capacity
- 7.5 m Reservoir drawdown in daily operation
- 1,422.0 m asl intake tower, sill elevation
- 7.0 m min submergence assumed (> 5,7 m)
- 5.7 m min submergence required to avoid vortex formation (Froude number = 0,4 < 0,6)
- 1,403.0 m asl max IL (intake level) of the 6,3 m diameter tunnel
- 1,410.0 m asl approx river thalweg elevation in the assumed intake location

The large floods of the Gilgel Gibe river (2,350 m^3/s) control the type of structure that is necessarily a concrete weir with a spillway crest 90 m wide, i.e much wider than the river bed (about 40 m). To solve this problem the design includes:

- curved dam axis
- spillway
- sky jump energy dissipator
- river bed reshaping and erosion protection

No footbridge have been incorporated on the ungated spillway. The personnel will have access to the left bank only using the upper inspection gallery.

A bottom outlet structure enables the reservoir emptying. To take into account the silting of the reservoir, the intake of the bottom outlet includes a sill than can be easily rised .

The Omo basalt formation is in itself practically impermeable. The presence of fissured basalt zones does not affect the reservoir permeability because there are not present lateral valleys at lower elevation. Regarding the weir foundation, the basalt formation is generally fractured and requires a grouting screen and a drainage system adequate to guarantee uplift of acceptable value.

With reference to the hill slopes (covered by a “Colluvium” non plastic sandy silt including basalt fragments), during the January 2004 survey a landslide was found at chainage 3+150 on both sides of the valley. Other minor instabilities have been detected on the right bank at Ch 2+750 and in various sites downstream of the proposed reservoir. This indicates that the geotechnical parameters controlling the stability of the detrital cover are so low that locally (where the slopes of the valley are steep) the equilibrium during the rainy season is not guaranteed.

The very rapid drawdown (max 8 meters in about 3.3 hours) of the reservoir will create stability problems much more critical. The remedial works presently envisaged for the critical areas include slope reshaping (earth works), slope toe stabilisation (gabions), and slope surface stabilisation (filter, flat gabions, dowels, drainage holes). The stabilisation of the toe of the slopes on both side of the valley downstream the dam energy dissipator will be obtained by protection gabions or/and a small weir.

The alternative diversion weir is located upstream of the Bidru river which is of major importance due to the large catchment area (about 46 km^2).

In the intake inlet area it is envisaged to construct a yard protected by an embankment which will permit the assembling of the TBM and the construction of the intake tower without any interference with the normal operation of the first power plant.

Once the plant is made ready for normal operation, the power tunnel intake will divert the water released by the first plant of the cascade into the second one without air (large water head is required at the tunnel entrance) and with negligible head losses. It will also allow the screen cleaning for normal maintenance and permit to close the tunnel for extraordinary maintenance.

The location for the structure adopted with the basic design was selected on the basis of the geological conditions in order to minimise the presence of weak tuff layers in the critical zones.

The new location of the intake (alternative diversion weir March 2004) is just 200 m upstream of the dam, at chainage 2 + 340 km.

The minutes of Meeting dated 10th Feb 2004 (page 13) mention that :

"*The possibility of reducing the silting by flushing devices and of introducing gravel / sand traps or adequately design the water intake to avoid entrance of materials to the tunnel will be considered while studying the new solution*"

In the new position the sill is 12 meters above the invert level of the river and consequently no sand trap is required.

The investigations presently in progress will provide the basic data required to update the design.

3.3.4 Adits

The term refers to all the temporary works required to start the tunnel (yard for site installation) to the tunnel portals excavation and support, to the access tunnel (if any) and also to the plug (if any).

Following the Client's request, made in April 2004, it was agreed to construct the tunnel using No. 2 TBM machines.

As a consequence of this decision

- The design of the Adits to the tunnel was entirely revised
- The tunnel profile was modified accordingly
- The DB section of the tunnel has been reduced

The adits originally foreseen at chainages 22 and 23 have been cancelled and substituted with Adit 0 and Adit 26.

ADIT 0 (Tunnel inlet)

A new Adit at chainage 0+ 000 km is required for the site installation of the TBM No. 1.

It includes: Quarry, Concrete Factory, Storage and loading area, TBM No.1 site installations, 500 m of the power tunnel and the Disposal area.

Along the narrow valley of the Gilgel Gibe, just upstream of the alternative weir (rev. March 2004) a suitable area has been selected for the site installation of all the inlet works, id est

- Adit 0 (yard, quarry, tunnel portal, adit tunnel)
- TBM no.1 site installations (concrete factory, storage and loading area, TBM site installations)
- Intake structure
- Weir
- Disposal area

Yard

The yard required to accommodate the site installation of the temporary and permanent works has the length of about 200 m and a width variable between 20 and 60 m. The local enlargement (about 60 m) is located in a small valley.

The area is covered by vegetation. The geophysical investigation carried out in this area indicates that the depth of the highly fractured Omo basalt can reach up to 20 m in depth.

The tunnel portal is located at the downstream end of the yard, in a Basalt class III.

ADIT TUNNEL (power tunnel)

This section of the power tunnel, constructed with the traditional Drill and Blast technique, has a length of about 500 m and a diameter enlarged to 8,0 m in order to permit the entrance of the TBM.

Disposal area

Both the fissured rock excavated to create the yard and the muck of the tunnel, will be loaded on belts and disposed in an embankment filling the small gulley located about 500 m downstream.

In such a way the environmental impact of the excavation and of the fill will be minimal.

The construction sequence of this section of work will be as follows:

- Construct a culvert along all the thalweg of the gulley. The size will be adequate to guarantee the free drainage of the embankment
- Start excavation of the yard and adit
- Transport the spoiled material from the excavations to the disposal area over the culvert
- Complete the site installations of the TBM
- When the TBM no.1 will start to excavate the upstream section of the Tunnel, the excavated material will be discharged by lateral movements of the train wagons and transported (by belts) in to the disposal area enlarging the embankment.

ADIT 26.0 (Tunnel outlet)

This adit is required for:

- the DB site installations
- the construction of the portal of the tunnel outlet

- the construction of the last section of the power tunnel (200 m)
  a) from the outlet portal (ch 26+000)
  b) to the TBM no.2 starting point (ch 25+800)
- the site installation concerning the penstocks

The tunnel outlet has been located in a sound geological structure (Rhyolite) in order to minimize the construction problems.

3.3.5 Tunnel (power waterways)

The tunnel intake is located at Bidru rural area of Sekoru Woreda in Jimma zone of Oromyia region and the outlet at the Fofa Gorge in Yem special Woreda.

The power tunnel has a total length of 26 km (of which 25.2 excavated with the two TBM and 0.8 km with the DB technique).

The power tunnel has an internal diameter of 6.3 m, and an excavation diameter of 7.0 m.

In the inlet section (500 m) and the outlet section (300 m) the internal diameter is enlarged to 8.0 in order to permit the installation of the TBM No. 1 and TBM No. 2 respectively.

As shown in the enclosed drawings (plan and profile)

- The alignment of the power tunnel is nearly straight
- In order to minimise the length of the section where the drainage requires pumping, the longitudinal profile has no. 3 slopes:
  a) From ch 0+000 to ch 2+000 the tunnel will be excavated working down slope and the drainage of the waters will be provided by pumps
  b) From ch 2+000 to ch 13+900 the tunnel will be excavated working up slope (0.53 m/km), facilitating the drainage of the waters. In the central point a dismantling chamber provides the facilities required for the dismantling of both the TBM
  c) From chainage 26+000 (end of tunnel) to chainage 13+900 (central point) the tunnel will be excavated working up slope (0.81 m/km) facilitating the drainage of the waters

Two working fronts will be available (one for each TBM machine).

The first working front proceeds from upstream to downstream of the tunnel, id est from the inlet (chainage 0+000) to the central point (chainage 13+900).

In this location (adit 0) all the site installations concerning the TBM No. 1 must to be completed before construction can start. They include:

- Access road
- Camp
- Yard
- Quarry
- Concrete plant
- Production of 1,5 months stock of segmental lining

- Loading and unloading facilities

The second working front proceeds from downstream (Tunnel Oulet at chainage 26+000) to upstream up to the central point (chainage 13 + 900).

In this front (adit 26) all the site installations for the TBM No. 2 must be completed before construction can start. The installations are identical to that concerning TBM No. 1.

The two TBM will meet in the “central point” where a dismantling chamber of about 20 m in length will be constructed (using the DB technique).

In order to avoid any interference between the construction of the Tunnel and of the Surge Shaft, the design of the shaft has been modified, locating the centreline on the side of the tunnel.

3.3.5.1 Tunnelling and blasting operations

In the case of potentially unstable ground, this shall be inspected by experienced personnel to lay down any special safety measures that might be required.

- Prior to their use, all excavation equipment shall be inspected, both with regard to their operation and to the different protections required. If any major defect is detected, the use of the equipment shall not be allowed. Where thought convenient, certificates shall be required from the manufacturer or owner of the item of equipment, issued by a reputable and recognised agency.
- The power supply systems, both the system that supplies the excavation equipment and the system that feeds the lighting and auxiliary equipment, shall be water-resistant and shall be protected by differential breakers with the required sensibility.
- Provision shall be made for emergency lighting, to allow personnel find their way out of the tunnel in the case of a power failure.
- Provision shall be made for suitable ventilation means, based upon the calculations made in accordance with the type of equipment and/or excavation procedures, so that the oxygen content and the planned toxic vapour limits are guaranteed.
- All excavation work supervisors shall be conversant with the risks posed by this activity and shall advise their staff accordingly.
- Prior to the commencement of the work, all personnel shall be informed about the work methods, about the excavation system, about the safety measures to be put in place and on the course of action to be taken in case of an accident.
- The quality of the oxygen shall be checked at all times, as well as the presence of toxic vapours or other gases, the build up of which could give rise to harmful or explosive mixtures.
- Environmental recordings (noise levels, dust content, etc.) shall be taken periodically.
- Personnel shall be provided with reflective stickers glued to the helmet, so that they can be readily seen inside the tunnel.
- Details of the steps to be taken to prevent the risk of being run over shall be given in the final method statement.

- The risk of landslides shall be permanently monitored.
- As a general rule, driving at a speed of more than 30 Km/hour in the vicinity of the current heading and at the entrance and exit of the tunnels shall be prohibited.
- The place of the firing shall be properly protected.
- Prior to the firing, sufficient notice shall be given to all the personnel in the vicinity by sounding the compulsory hoots and sirens. The same procedure shall be followed, once the blasting is over.
- The following notices "NO ENTRY – BLASTING IN PROGRESS" should be displayed at all entrances.
- The explosives shall be stored in buildings complying with Ethiopian law and regulations. The building shall be provided with a cavity ceiling to prevent, to the extent possible, a very high temperature inside the building and shall be surrounded by an earth/rock fill embankment.
- Once inside the magazine, strict compliance with the safety regulations, usually laid down for this type of facility, shall be adopted.
- The removal of debris from the heading shall be supervised by the individual responsible for the heading, at that time. He/she shall properly distribute the personnel at the heading, which shall be as little as possible.
- To minimise the raising of dust, the debris shall be sprayed with water.
- Attempts shall be made to set up the lighting of the heading before the debris is removed, so that both the equipment and ancillary personnel can have an adequate level of lighting.

3.3.6 Surge shaft

The surge shaft is necessary to isolate the power tunnel from the water hammer created by the turbine closures and to feed the required flows at the starting of the turbines.

The surge shaft is located at chainage 25+910 (70 m upstream of the Tunnel outlet).

The optimum diameter has been identified in D = 18 m with a maximum surge level of 1,465 m a.s.l. and a minimum (maximum draw down level) of 1,391 m a.s.l..

The modifications made to the Basic Design surge shaft structure are a direct consequence of the review of the hydraulic transient analyses carried out to take into account the maximum and minimum operating levels of the alternative weir impounding (rev. March 2004).

3.3.7 Penstocks

The layout selection has been performed using the following procedure:

- penstock route and profile have been preliminarily selected in order to minimise conduit length, the excavation works, number and size of thrust and bearing blocks (overall construction costs),
- two different alternatives have therefore been analysed regarding the number of penstocks (two and four penstocks),
- optimum average equivalent diameter has been obtained for each of the above two alternatives carrying out statical and economical analyses.

For the purposes of the evaluation of the optimum average equivalent diameter the following assumptions have been adopted for both alternatives:

- the total real length of the penstocks considered is 1.2 km
- a geodetic head of 457 m is assumed (el. pstk_start = 1,383 m a.s.l., el. pstk_end = 926 m a.s.l.)
- a maximum head of 555 m (at the penstock end section) is considered
- an average design head of 300 m is therefore adopted.

The “four penstocks” solution (one conduit for each unit), more conservative, particularly for the construction schedule of the power plant and maintenance activities, has been adopted for the basic design stage.

According to the Client request *“to reconsider the current layout that foresees four separate penstocks, each equipped with an upstream butterfly valve, evaluating the possibility to adopt a layout with two penstocks, each equipped with two butterfly valves, one main and one maintenance, thus increasing overall reliability and allowing maintenance to the main butterfly valves without emptying the whole power tunnel.”* (meetings 10 and 11 Feb. 2004), the 2 penstock alternative has been reconsidered and also updated taking under consideration:

- steel lining of the tunnel downstream at the surge tank
- alternative diversion weir (tunnel elevation lowered of about 8 m)
- two butterfly valves for each penstock (one main and one for maintenance).

The hydraulic and stability calculations indicate that the new basic parameters are: 3.60 to 2.80 m of internal diameter, 15 to 55 mm thickness, and n. 16 thrust blocks for each conduits.

The new solution selected for the branches at the turbines inlet, will require a revision of the power house layout.

3.3.8 Power house

The power house will be located at the right bank of Great Gibe river at Yem special woreda. The power house site is covered with woody grass land. The dominant tree species is Combertum mole and the major grass species is hyparrhenia. After generating the power, water will flow to the Great Gibe river (also known as Omo river).

The power house is a conventional surface outdoor type with vertical axis units located on the right bank of the Omo river, approximately 60 km downstream from the Gibe Bridge.

Since time was a critical factor, the surface power house was preferred to the underground power house alternative as it simplified the execution of works and allowed considerable time saving due to the flexibility of the construction program.

The geological situation is favourable for the construction of the surface powerhouse.

The main powerhouse structure is approximately 120 m wide (upstream-downstream direction) and 23 m long. This solution minimises the required excavation following the narrow Omo river valley.

Yards (total area is approximately 6600 m^2) are located all around the main power house structure.

A conservative layout of the power house substructures has been selected in order to guarantee the shortest construction period and to facilitate maintenance operations. The construction of the power house requires minimal (or nil) river diversion and dewatering works. The maintenance of the turbine, having access to the turbine shaft, is possible most of the time and requires the closure of the stoplogs only during flood period.

With reference to the alternative design (March 2004), the new solution selected for the branches at the turbine inlet, will require a revision of the power house layout.

3.3.9 Transmission Line

The power produced by the plant will be delivered to the ICS (Inter Connected System) through a 230 kV transmission line which connects the Gilgel Gibe II Plant to a substation located in the area of Addis Ababa at a distance of about 250 km.

The Inter Connected System is a relatively small network, which serves the major towns and industrial centres in Ethiopia.

The generating capacity of the plants that currently supply the ICS (8 hydroelectric and 2 thermal plants), including also the Gilgel Gibe I, is about 767 MW with an average energy capability of about 3,250 GWh/y. However, the dependable capacity is reduced to less than 676 MW due to derating and unit unavailability due to forced outages.

According to demand forecast studies, envisaged in the Ethiopian Power System Expansion Plan – April 2004, the peak load demand expected in years 2013 is 2,547 MW, while the electricity demand expected for the same year is 10,690 GWh/y.

The ratio between the highest unit capacity (61 MW, Gilgel Gibe I) and the total network capacity (676 MW) is already high (about 9%) and should not be increased in order to limit network disturbances in case of sudden shut-down of one of the major units.

Since the new capacity brought by Gilgel Gibe II will increase the total network capacity to about 1,080 MW, the maximum unit size should not exceed 100 MW. The above mentioned ratio will decrease in the future since more capacity is expected to be added to the Ethiopian Grid in the next decades.

3.4 Camps and construction facilities

3.4.1 Camps and site installations

Site installations are envisaged at the weir, at the power tunnel inlet, at the surge shaft site, at the power tunnel outlet (also for penstocks) and a camp site at Fofa.

To guarantee the start of the TBM activities, a camp and site installation is envisaged at the weir/power tunnel inlet. Site installation envisages the storage, loading and factory precast segments.

The Site Installations Areas relevant to the power tunnel inlet/outlet include the entire system required to produce the concrete lining, to load and unload the TBM trains and to stockpile the Rhyolites and the Basalts resulting from the tunnel excavation.

A permanent camp and offices are envisaged on the R6 new road from Kose to Omo river.

3.4.2 Construction facilities

There are numerous good sources of Basalt and Ryolite available for concrete aggregates and road construction materials.

As far as the Intake works are concerned, the main quarry of Gilgel Gibe I Power plant (Basalt) will be used.

For the Tunnel lining and the Power House the investigations indicate that the most suitable source of aggregate are near the Adits where very good quality rhyolite is available in unlimited quantities. The final locations will be selected to minimise transportation distances.

Very steep slopes and very narrow valleys exist in the entire area of the project. The problem of the spoil material is consequently quite unusual. It has been decided with reference to:

- intake: to use the material from the excavation areas (weir, intake) to expand the size of the small desilting weir;
- tunnel: use the narrow valley existing in the Adit to create a large embankment (and a yard);
- penstock and power house: the excavation materials will be used to create no. 2 large yards, upstream and downstream of the power house.

3.5 Analysis of alternatives

Aside from demand management options, the alternatives to be considered would be fundamentally to choose to proceed with the Gilgel Gibe Hydroelectric Project or to abandon the works and to select another power generation option. With reference to Gilgel Gibe I project, EEPCO (Ethiopian Electric Power Corporation) has completed demand side management studies and have instituted tariff increases as a result of those studies. The demand forecasts still call for a significant increase in generation capabilities to maintain economic growth and development (see Ethiopian Power System Expansion Plan – April 2004).

The high costs of importing fossil fuels to land-locked Ethiopia preclude thermal power options that would depend on foreign fuels. Currently, fossil fuel resources in Ethiopia have not been developed or proven to the extent that a thermal station would be feasible. Studies have shown that the potential for relatively low cost hydropower is the least cost option for Ethiopia at this time.

A considerable amount of money has already been invested in the Gilgel Gibe Hydroelectric Project and it would be lost if another hydropower project were to be developed instead of the Gilgel Gibe Hydroelectric Project. In addition, any new hydropower site would be a “greenfields” site. In terms of environmental preference, it is clearly preferable to continue with construction at Gilgel Gibe Hydroelectric Project rather than substitute a new and undeveloped site. Other sites are being evaluated, not as a substitute for Gilgel Gibe Hydroelectric Project, but for future power generation.

Wind and solar power generation potential is good in Ethiopia, but costs for these systems are not competitive for contributions to the national grid.

Four different alternatives have been analysed to select the waterway layout from Gilgel Gibe river to Omo river. All the alternatives have the same inlet, downstream the Tail Race Tunnel outlet of the Gilgel Gibe I, while the outlets in the Omo river are spread over about 11 km.

After checking the geodetic head, the official 1:50,000 maps have been used for the purposes of this analysis.

The same design criteria have been adopted for all the alternatives.

A classical cost-benefit analysis has been used to compare the different layouts and to select the most promising alternatives. The economical analysis leaded to the area where to perform the geological survey which identified the hill where the rock conditions appear most promising both for the outlet works (surge tank, penstocks, power house) and access roads.

Considering the economic analysis, the site reconnaissance and investigations performed the so called Alternative C has been selected (basic design October 2003).

Afterwards the selected layout has been partially modified following the Client requests expressed during the meeting dated 10th feb 2004. The proposed alternative diversion weir was then located about 2,6 km downstream of the weir proposed in the basic design (October 2003), which was 300 m downstream of the Gilgel Gibe Tail Race Tunnel outlet shaft. Consequently the inlet position of the waterway from Gilgel Gibe river to Omo river has been changed.

3.6 Mitigative actions during construction activities

3.6.1 Pollution from used oils, chemicals and other pollutants

In principle the pollutants largely used for or generated by the construction activities are:

- Oils and lubricants from the equipment engines leakages, equipment washing, used oils from the regular maintenance of the equipment.
- Wastage and leakages of fuels.
- Dusts from the treatment plants such as crushing and screening plant.
- Cement dust from cement bags storage and handling
- Water from the tunnel excavation drainage contaminated by chemicals such as additives for the grout mixes and shotcrete, explosives dust, leakages of oils and lubricants from the equipment travelling inside the tunnel.
- Solid wastage such as empty barrels, empty drums containing toxic chemicals such as additives, empty cement paper bags.

3.6.1.1 The pollutants such as oils and lubricants

They are mainly generated in specific areas as Workshops, Maintenance areas and Washing stations. In principle the contractor shall concentrate these areas in very well defined limited areas of the workshops as follows:

a) Main workshop at the installations area for the intake structures (upstream)
b) Main workshop at the installations area for the outlet structures (downstream)
c) Small workshop (mainly for maintenance) at the Surge Shaft collar area.
d) Workshop for the tunnel trains maintenance at the intake portal area.
e) Workshop for the tunnel trains maintenance at the outlet portal area.
f) All these areas will be provided with a suitable concrete floor duly sloped to allow the flowing of the oils and the contaminated water towards the oil trap.
g) The oils from the regular maintenance of the equipment will be collected from the bottom of the engines by appropriated drums. The oil will be discharged in a 6,000 litres tank to be regularly collected by a local company for the proper wastage (according to the national rules and regulations).
h) The contaminated water from the washing section of the workshop duly conveyed to the oil trap, will than be left in the pit of the oil trap for the separation.
i) The oils, ones separated from the water, will be than collected from the oil trap and kept in a 6,000 litres tank to be regularly removed from the site by a local company for the proper wastage (according to the national rules and regulations).

3.6.1.2 The pollutants such as fuels

All the fuels used to clean the mechanical parts of the engines in the workshop, the fuel to be wasted because contaminated by any reason or any means, and any other fuel to be wasted for any reason, shall be collected by suitable drums and kept in a 6,000 litres tank to be regularly removed from the site by a local company for the proper wastage (according to the national rules and regulations).

3.6.1.3 The pollutants such as dusts from the treatment plants

To avoid the river water pollution by the fine dust produced by the crushing plants both upstream and downstream, all the water from the washing plant of the sands shall be conveyed through a concrete lined ditch to a sediment pool closed to the treatment plant.

The sediment pool shall be dimensioned to receive at least the volume of dust produced by the plant in one month time (approximately) 15,000 tonnes/mois of aggregates x 2.5% of dusts = 375 tonnes equivalent to 250m^3 approximately. The pool will be therefore of about 25m long x 6m wide x 2m deep.

The sediment pool shall be provided with ditches specially shaped and positioned to convey the clean water, after sedimentation, to the discharge canal to the river.

The sediment shall be regularly (ones a week) cleaned by a backhoe excavator, left for few days to dray and later taken to controlled disposal areas.

3.6.1.4 The pollutants such as cement dust from cement handling.

This pollutant will be mainly generated at the concrete batching plant where the bulk cement will be transferred from the tracks to the silos and in the storage areas of the cement bags where the bags cutting machine is located.

All the cement not contaminated shall be regularly collected by assigned personnel and placed in appropriated drums. The cement will be than conveyed to the cement silos.

The contaminated cement shall be given the local company for the proper wastage (according to the national rules and regulations).

Cement silos shall be provided with filters susceptible of being maintained.

3.6.1.5 The pollutants such as water from the tunnel excavation drainage.

It is obvious that the water flow from the drainage of the excavated tunnel is heavily contaminated by different pollutants from the use of the equipment, chemicals used for the grouting, shotcrete explosives and whatsoever.

In this project the points of arrival of the tunnel drainage system are the intake pump sump and the outlet portal.

At the Intake portal it is required a considerable pump sump because the drainage water flow is to be raised to the river level from the trench at the Intake structure area (quite below the river bed level). Before the pump sump is therefore compulsory to provide a sediment pool and an oil trap to retain all the solid sediments and oils from the water before the eventual restitution to the river.

Sediments and oils will be regularly (ones a day) taken away from the pool and the oil trap and duly sent to wastage (as for the other similar pollutants).

Same operations are foreseen for the downstream drainage system at the outlet portal. The decontaminated water in this case will go back to the river by gravity.

3.6.1.6 The pollutants such as any kind of solid wastage (barrels, wasted concrete, steel scrap, empty drums and cement bags).

In principle, the solid wastage shall be buried in identified and defined pits at a depth of not less than 5m. The pit will be at the end of the works backfilled up to the natural ground level with selected materials and the surface duly grassed. The minimum thickness of the backfill materials above the pollutants must be not less than 5m.

In details all the different pollutants shall be duly treated before the final waste as follows:

The barrels, if used for toxic compounds will be left at the air to dry and than squashed to reduce the volume to the possible minimum.

The empty drums (mainly plastic used for the additives) will be duly washed by water and given to the local institutions for the best social use.

The cement empty bags, ones cleaned for the remaining cement will be folded and packed given to the local institutions for the best social use.

The steel reinforcement wastage and the wooden wastage from the carpentry yard will be also given to the local institution for social use.

The concrete wastage and all the scrap from the different origin such as workshop, laboratory, concrete plant, and all the materials not to be re-exported (tyres) shall be buried in the assigned pits.

3.6.2 Waste Dumping

Solid and Liquid

It is strictly forbidden to dump solid and liquid waste into rivers and tributary streams. These include, among others, the following:

- Products from excavations and demolitions, rocks, steel sections, scrap, rebar cuttings, rubber and plastic materials, aggregate, natural or synthetic substances and prefabricated products and glass.
- Remains and washings from plants or vehicles used for the transportation of concrete and asphalt or bituminous products and their potential additives.
- Detergents and other chemical products used during construction.
- Paint, solvents and oil.
- Rubbish.
- Before removing this waste from the site, it shall be classified in accordance with the type of spoil areas agreed with client.

Stacking up

The stacking up of materials, aggregate, earth, etc., as well as the parking of vehicles and equipment on the natural beds of streams shall not be allowed.

Dust

Plans shall be in place to systematically water the service roads to minimise the raising of dust.

Fumes

The uncontrolled burning of construction materials on site shall be prohibited.

Noise

Care shall be exercised to ensure that any noise-producing item such as compressors, generating sets, tractors, etc., keep their noise-suppression covers on. Their use at night in areas where they can become a nuisance shall be avoided.

Garbage

In order to keep the site clean, provision has been made for plastic containers, provided with covers, that shall be located in the camps near dining-rooms and also near long duration jobs, such as tunnel adits where people usually enjoy a meal in the open air. Garbage shall be daily removed from the containers by a special team provided with a special truck.

The garbage shall be duly offloaded in the assigned area and treated to avoid any pollution. In principle the garbage will be dumped and distributed in layers over an impervious area and covered with a 30 cm thick layer of impervious material.

Mud

Care shall be exercised so that when a site vehicle joins a local road after driving along site roads, the mud carried on the wheels of said vehicle, in rainy spells, is minimised.

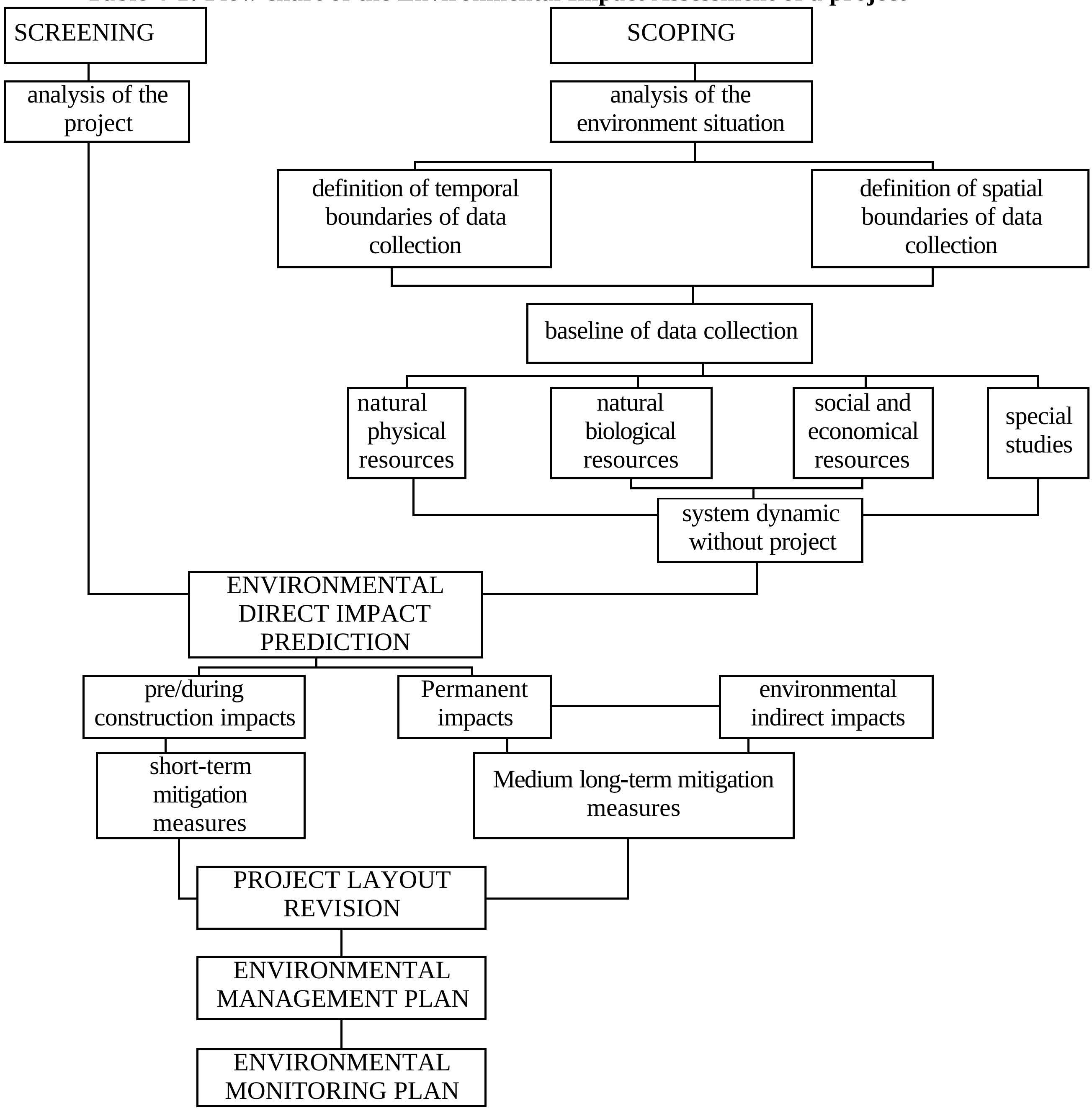
4 IMPACT ASSESSMENT METHODOLOGY

4.1 Introduction

The scope of the Environmental Impact Assessment activity is to evaluate the temporary and permanent impact of a project on the natural and human environment.

In general terms the methodology of an Environmental Impact Assessment may be well described by the following flow chart (Table 4-1).

Table 4-1: Flow chart of the Environmental Impact Assessment of a project



In particular, the methodologies employed for assessment and evaluation of the impacts of the project at the feasibility technical level have been:

- personal experience of CESI consultant: they have been in Ethiopia also to prepare the Gilgel Gibe I project's feasibility report. They gave informations about geology, geomorphology and description of the impact area
- consultation with people affected by the Project and local authorities to obtain supplementary information on social, socioeconomic and socio-cultural conditions, to identificate valid mitigation measures
- GIS Computer Based modeling: the slope stability of the riverine areas has been simulated, by 3d simulation programs, based on topographic data
- hydraulic data collections of rivers, considering that the physical limits if the EIA are the discharging channel of the Gilgel Gibe I Hydroelectric Project upstream and the discharging channel channel of Gilgel Gibe II Hydroelectric Project downstream.

4.2 Bounding and Scoping

The sense of scoping procedure is to analyse the environmental situation prior to project construction, in order to define the temporal and spatial boundaries of the baseline data.

The physical limits of the EIA are the discharging channel of Gilgel Gibe I Hydroelectric Project upstream, and the discharging channel of Gilgel Gibe II Hydroelectric Project downstream. A bigger extension of EIA boundaries is not necessary, considering that no environmental impacts due to the project may be expected upstream; in addition after the discharging of the original amount of water in the Omo river there is no more impact due to water diversion.

Scoping has included the most important and major environmental issues, namely:

- water quantity and quality of the Gilgel Gibe River downstream the diversion weir;
- riverine vegetation and other vegetation that might be affected by construction activities (in particular the disposal areas of the excavated material);
- underground water disturbances;
- terrestrial and aquatic fauna;
- people living in the area
- health aspect of the project
- dislocation of people
- employment opportunities
- agricultural resources
- economic development
- gender issues

The temporal boundaries may be strictly related to construction activity for some environmental aspects of the project, but for some others aspects may be extended to the project operation activities.

Considering that Gilgel Gibe II Hydroelectric Project is strictly related to Gilgel Gibe I Hydroelectric Project, during the scoping phase, before producing this EIA reference has been made to the "Feasibility Report" prepared for Gilgel Gibe I project. In particular the data collected for that study have been compared with the new data received from the local consultants. In the second phase, after data comparisons (hydraulic, topographic, socio-economic and socio-cultural informations) the detailed EIA study and the final report has been produced.

4.3 Public participation

The field investigation included consultation with various Project Affected Person (PAP), local authorities and various stakeholders at all the project sites. This was carried out in order to obtain supplementary information on social, socioeconomic and socio-cultural conditions. The consultation was also carried out to obtain the views of the PAPs on various aspects of the project including background information relevant to impact assessment (in particular, to identify any areas of specific concern which needed to be addressed in this assessment) and identification of mitigation measures.

4.4 Assessment

The characteristics of the foreseeable impacts have been identified considering:

- the actions that may produce impact, evaluated in the description of the Gilgel Gibe II Hydroelectric Project;
- basic environmental data obtained form direct field observations;
- information gathered from the available scientific publications and information derived by the study of similar projects.

A matrix that links project activities to the environmental components, considering the impacts (both positive and negative) generated by the project activities during all the different temporal phases of the project has been proposed. In particular, in tab 4-2 a blank matrix is proposed that contains the aspect whose impact will be treated in this report, giving for each aspect considered, a different weight in terms of impact. Weights for each aspect in the different phases are the results of comparisons between the technicians that have taken part to the EIA project.

For each phase (during construction activities, and during operation stage activities), as per studies made on other project cases, the impacts are defined considering the main five activities which may have some effect on the environment:

- the weir erection and the relevant reservoir creation;
- the tunnel excavation and the disposal material connected aspects;
- the temporary and the final roads built for the construction activities and for standard operation activities;
- the powerhouse construction and related facilities such as camps, bridge on the Omo river, etc…
- the substation construction.

This matrix links environmental aspects to project activities in each project phase.

Each cell of the matrix will contain the relevant value, according to the legenda, as determined during the Study. See page 116 of the report.

Table 4-2: Synthesis of Environment Impact Matrix

Environment Component	**Construction Stage Activity Component**					**Operation Stage Activity Component**				
	Weir	Tunnel	Roads	Powerhouse	Substation	Weir	Tunnel	Roads	Powerhouse	Substation
Physical										
- Seismology										
- Hydrology										
- Hydrogeology										
- Storage sedimentation										
- Water quality										
- Climate										
- Downstream effects										
- Landscape										
- Slope stability										
- Disposal materials										
Natural										
- Natural vegetation										
- Fauna										
Socio – economical										
- Dislocation of people										
- Agricultural resources										
- Infrastructures										
- People's health										
- Worker's health										
- Employment opportunities										
- Economic development										
- Gender Issues										

Positive Impact	**Negative Impact**	
A = Very Importan	1 = Very important	O = No Impact
B = More Importan	2 = More important	
C = Important	3 = Important	
D = Fair Important	4 = Fair important	
E = Less Important	5 = Less important	

5 DESCRIPTION OF THE ENVIRONMENT

5.1 Physical Environment

5.1.1 Geology

5.1.1.1 Regional Geology

The Gilgel Gibe II project area is located on the South Western Ethiopian plateau. The area is characterized by basic and subsilicic effusive volcanic rocks, frequently inter-layered with reddish paleosols of Tertiary age.

During the Oligocene Period thick traps of basalt accreted on the old pediplain as a consequence of North - South striking; the first result of this accretion was an extensive faulting related to the mid Africa rifting.

Bedrock is characterized by rhyolites, as large dome and sheets, intercepts of andesite and trachyte, columnar basalts lava with layers of tuff and lacustrine elements, syenites, rhyolites, porphyry, from youngest to oldest.

This types of rocks are grouped in different formations as:

Recent Volcanics – Rhyolites as large domes and sheets, with intercepts of andesite and trachyte. Volcanic plugs of trachyte are also founded (Pliocene – Early Quaternary)

Wollega Basalts – columnar basalts interbedded with acidic tuffs and loose fluvio lacustrine sediments (Miocene – Pliocene)

Jimma Volcanics – rhyolites alternated with tuff and basalts (Oligocene – Miocene)

Omo Basalts – tuff and red paleosols (Oligocene – Miocene).

Most of the characteristics of the formations described, are well known and were investigated during the Gilgel Gibe I Project, encountered during excavation of the power tunnel.

In details the encountered formations were:

- Omo Basalt Formation, (the most representative formation in this area), commonly fine grained with flows up to 10 m thick alternated with minor tuff and red paleosols
- Jima Volcanic sequence, partially constituted by trachytes, mainly composed of massive white, pinkish and gray rhyolites in thick flows alternating tuff and subordinate basalts, within certain down faults blocks.

Geological models by Canuti and Merla, allow to foresee some other formations to be encountered along the tunnel, particularly:

Jima Volcanic Formation, intersected by the Gilgel Gibe II Power Tunnel, characterized by dolerite dykes.

The entire volcanic sequence is frequently coverd by thin, residual, subtropical lateritic soils, which have been formed on hill and ridge foot slopes.

The hills on the right side of the Gilgel Gibe River, near the first adit of the tunnel, are mostly covered, to an elevation of about 1,800 m a.s.l., by thick colluvium's deposits together with deeply weathered landslide and rockslide material.

5.1.1.2 Regional Structures

The volcanic layers of the inlet area generally dip few degrees towards South-West and are crossed by North-East to South-West and North-West to South-East fractures and faults, related to the Ethiopian Rift, the main regional alignment .

The tectonic alignments of the region trend roughly North-East to South-West of the area interested by the new plant, at a distance of about 150 km from the middle of the rift system.

Since Merla, Canuti and Mohr, the Gilgel Gibe II Power Tunnel crosses a dome like structure. At the inlet the Omo rock formation is flexed slightly westwards towards the Jima graben. Moving along the tunnel the rock formations become horizontal, before flexing quite steeply South East towards the Omo gorge. The Wollega (or Pliocene) formation of soft tuff and lacustrine sediment lies horizontal and unconformable above the Omo/Jima Formations. The upper Jima rhyolites occupy the lower leveld between the main watershed and the Omo river; here the South - East flexure is not so clear due to the many dykes, that have broken the rock mass into thin vertical slides. Their dimensions are usually more than 5 meters thick, while their length is not foreseeable.

The strike of all these fault systems is around 20°/200°, parallel to the main rift valley as mapped in the geological map for the Gilgel Gibe I Project and according to Merla et al. (1978). The Omo fault is shown with a 200 km continuity and runs through the Omo gorge where the Gilgel Gibe II outlet is located.

Most of the dykes and faults mapped have the same North - South trend as the Omo gorge.

5.1.1.3 Geognostic and geophysic investigations

In order to complete field information about bedrock along Gilgel Gibe II Project, the contractor made some geognostic and geophysic investigations.

Geognostic and geophysic investigations have been done during the time October 2003 – August 2004, as shown in the following table:

Table 5-1: Geological in-situ measures

Location	Seismology	Boreholes
Intake	2x500 mt. line	n.2: bh1=100 mt.; bh13= 44 mt
Weir	4x1.200 mt. line	n.3: bh7= 41 mt.; bh8= 40 mt.; bh11= 90 mt.
Tunnel		n. 1 bh14= 140 mt. n. 3 Proiected on tunnel axis: bh 2= 121 mt bh 2b= 141 mt. bh5= 155 mt
Adit 22 e 23	6x2.900 mt. line (Adit 22); 3x1.150 mt. line (Adit 23)	n. 3: bh2; bh 2b; bh5
Outlet works	6x1.380 mt. line (Surge shaft); 10x1.265 mt. line (Penstocks); 10x1.265 mt. line (Power haouse)	n. 1: bh4=100 mt.

Inlet area: boreholes in this area show that the colluvium thickness is higher than the first assumptions made since field geological works.

In fact the thickness of these deposits is as follows (see Map 8 and MAP 9 for details):

Area of investigation	Colluvium thickness
Intake	5 meters
Weir	12 to 20 meters

Tunnel: boreholes show that the bedrock is primarily made by massive or fractured basalt (see bh 14) and rhyolite (see bh 2, 2b, 5).

In the borehole no.14 the geotechnical data shows that there are intervals of massive and fractured basalt in deep. Width range of the fractures is between 5 centimeters and 80 centimeters with an UCS value of 100 or more.

In the boreholes no. 2, 2b and 5 the geothecnical data shows, at the tunnel elevation, a rhyolite generally fractured.

Adit 22–23: At the instance of EEPCO on April 2004 we decided to mine 26 km of the tunnel by no. 2 TBM, instead of using one as scheduled before. This choice has caused substantial variations of the project, as the pullout of the audits 22 and 23 and their displacement at tunnel inlet (Adit 0 + 00) and outlet (Adit 26 + 00).

Therefore part of data acquired in this area were been used to feature the geology and geostructure of the rock mass.

Outlet works: The 6 seismic lines located in correspondence of SURGE SHAFT show a width covering up to 4 m, and a width fractured rock (with 1800m/s speeds) up to 30m.

This situation is generally confirmed by bh 4, where was substantially found rhyolite and doleritic intrusion.

Seismic lines, in the PENSTOCKS area, show that the weathered bedrock deep under the penstocks varies in the range between 1 to 4 m (a little higher compared with first superficial investigations).

Data collected could be considered enough to better define the geological framework of the investigated area. Moreover on the base of the results, the contractor decided to organize another boreholes and seismic campaign to better define the geological situation at the inlet and outlet works and to define the impact mitigations since the geo-pedological framework near the inlet.

5.1.2 Seismology

Most of the major earthquakes in Ethiopia are related to the main rift valley structures.

The site of the new plant, particularly the tunnel intake downstream Gilgel Gibe Dam, is about 100 km far from the rift structures. Thanks to this distance, any seismic event in the rift valley will have attenuated effects in the project area.

The most relevant seismic event recorded is an earthquake 5.2 Richter intensity. Since available seismic data, the horizontal ground acceleration value must be considered greater than 0.1g, for this reason, during the project desing a value of 0.2g should be adopted. The information relevant to the regional seismicity was obtained from P. Gouin's study "Earthquake History of Ethiopia and the Horn of Africa", published in 1979. The study lists and describes all the known earthquakes occurred in Ethiopia from 1400 to 1975, partly identified through written or direct historical information, and partly through the interpretation of recordings made in recent years in national and foreign observatories.

The study of Gouin shows that the larger part of the earthquakes epicenters are related to the major rift structures. The power plant region is at least 100 km far from the most active seismic centers. Consequently, the energy caused by each earthquake originating in these zones would be considerably attenuated at the site.

Some statistical analysis have been carried out in accordance with some of the parameters indicated in Gouin's studies and other parameters indicated in other authors' studies.

Such analysis (carried out by the ETHIOPIAN GEOLOGICAL OFFICE in 1995), indicates that, with a 1% exceeding average probability and a 100 year recurrence period (a good compromise in terms of safety for important structures and public buildings) the maximum ground acceleration expected will be 0.05g.

A seismo-tectonic approach should be more suitable. Considering the high possibility of significant earthquakes along the nearest border of the Ethiopian Rift active tectonic structure .

In fact the known earthquakes are limited to the main rift structures.

The value of the peak horizontal ground acceleration to be considered in power plant design should be higher than 0.1g (conservatively of about 0.12g), to keep into account the lacking of seismological data and moreover the poor distribution of measurement points to detect the seismic activity in the country.

5.1.3 Slope stability

In general, the problems related to the slopes stability within the environmental context may be considered as the final treatment (mitigation measures) of the areas where slopes are to be left for long time stables.

The slopes may be classified as:

- Final surface of the slopes of the excavated areas (permanent works)
- Slopes of the disposal areas
- Natural slopes that may require specific measures to keep the stability
- Slopes protection during the construction operations (temporary works)

5.1.3.1 Upstream area

For the structures:

- Slope at the intake structure area for the entire length of the trench where the intake structure and the power tunnel inlet portal are located.
- Slopes at both sides of the weir (storage area)

For the disposal areas and others:

- Slope of the disposal area (right bank downstream of the weir) of the material from the excavations at the intake area.
- Slopes of the quarry area upstream.
- Slopes for the camps and installation areas

5.1.3.2 Downstream area

For the structures:

- Slope at the outlet portal
- Slope at the surge shaft collar
- Slope at the powerhouse structure
- Slope at the inclined penstock trench

For the disposal areas and others:

- Slope of the disposal area (right bank downstream of the weir) of the material from the excavations at the intake area.
- Slopes of the quarry area upstream.
- Slopes for the camps and installation areas

5.1.4 Hydrology

Deneba, located at the dam site is the nearest hydrometric station to the power plant zone, but only few sets of yearly data are available. We considered two sets of yearly data. The first set was relevant to Deneba, for the years between 1967 and 1971, the second set was the one relevant to Gilgel Gibe River for a longer period (1967-2000) near Asendabo.

The first data set is not enough to provide an indication on long-term average river flow but, using the second set (1967-2000), it is possible a data integration in order to obtain a better flow analysis. Asendabo yearly mean discharge is 36.7 m^3/s in the considered period. This discharge is equivalent to 849.26 million m^3 mean yearly runoff. This datum is quite different from the value mentioned in "Environmental Impact Assessment Report" written for the Gilgel Gibe I Project where the data set relevant to the period 1995-2000 has not been considered. In that period, in fact, Ethiopia was under a big drought. Between the dam site of the Gilgel Gibe I Project and the inlet to the Gilgel Gibe II Project additional runoff reaches the Gilgel Gibe River. The contribution of this additional runoff is less than the three percent of the upper reservoir catchment. However this is sufficient for reducing the biological and vegetational impacts on this part of the Gilgel Gibe River.

In Table 5-2, an extract (1996-1999) of Asendabo data set is provided. This chart shows three types of data:

- Mean monthly discharge
- Maximum Discharge (MDL): is the maximum flow rate calculated in one month from daily data
- Minimum Discharge (mDL): is the minimum flow rate calculated in one month from daily data.

The average long-term flow of the Gibe river (just few km upstream of the confluence with Gilgel river, where the construction of the Halele-Werabesa[1] dam is evaluated) is estimated in about 78 m^3/s.

Since the historical flood series relevant to Deneba station and Asendabo are incomplete, the estimation of flood flows, with return period exceeding 100-200 years, is impossible or can cause inaccuracies in flood evaluation. The local data missing causes the absence of valid results in the models used for the probability distributions evaluation.

However, considering that the probability distribution of hydrological events in a hydrologically homogeneous area is the uniform, in spite of the scaling factor, it follows that Deneba and Asendabo sites are similar since both are situated along the main course of the Gilgel Gibe River and have comparable catchment area. This consideration, that simplifies the data treatment and makes possible the data sets comparison and integration.

[1] Halele - Werabesa hydropower project is located within the Omo - Gibe Basin; the project is design to supply 96 MW of electrical power to Ethiopia's Interconnected Power System. The project aims to dam the Gibe River, creating a reservoir with a total storage of about 3300 Mm^3 and a total surface area of about 280 km^2.

Considering that the present weir site is close to the Deneba reservoir, the flows with return period of 100 years or more can be estimated as reported in Gilgel Gibe I Environmental Impact Assessment. The results of this computation follow in Table 5-4

Table 5-2: Data set collection from Gilgel Gibe Basin near Asendabo in different years

Station GILGEL GIBE near ASENDABO Ref. Year: 1999

	jan	feb	mar	Apr	may	jun	jul	aug	sep	oct	Nov	dec	YEAR
I	26.97	14.21	19.56	15.68	44.39	92.15	213.17	291.11	154.38	194.37	67.40	29.49	96.91
II	13.04	7.09	16.04	9.89	38.60	85.99	154.42	176.08	82.08	114.14	50.53	13.88	176.08
III	7.72	4.84	4.55	4.55	8.78	23.65	32.77	52.57	42.24	48.57	14.73	8.42	4.55

Station GILGEL GIBE near ASENDABO Ref. Year: 1998

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	Nov	dec	YEAR
I	76.12	38.96	43.58	30.32	55.16	78.13	226.85	458.64	257.03	226.38	88.51	39.91	134.97
II	39.20	22.38	23.94	18.54	41.00	43.40	128.20	265.80	164.00	105.60	54.80	19.92	265.80
III	11.45	11.31	12.11	8.31	11.31	12.11	51.30	131.00	60.40	56.20	20.40	10.92	8.31

Station GILGEL GIBE near ASENDABO Ref. Year: 1997

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	Nov	dec	YEAR
I	17.40	7.76	6.43	44.26	70.07	181.61	187.00	279.18	185.68		324.73	143.09	131.56
II	9.78	7.61	5.37	52.00	51.30	100.00	84.80	130.00	124.60		285.00	142.60	130.00
III	5.07	1.55	1.36	2.41	9.04	37.40	51.30	74.40	46.40		39.20	29.17	1.36

Station GILGEL GIBE near ASENDABO Ref. Year: 1996

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	Nov	dec	YEAR
I						228.73	232.99	329.45	232.22	122.77	44.39		198.42
II						112.00	149.00	172.00	199.20	96.00	24.46		199.20
III						49.40	60.40	83.20	59.00	20.88	12.94		12.94

I	Monthly runoff in Million m^3
II	Maximum discharge in m^3/s
III	Minimum discharge in m^3/s

The average monthly flows for the Gibe river are summarized in Table 5-3.

Table 5-3: Estimated Average Monthly Inflows (m^3/s)

Month	Inflows
January	10.9
February	9.1
March	8.2
April	10.1
May	13.4
June	32.7
July	159.8
August	271.9
September	232.9
October	129.0
November	36.0
December	20.7
TOTAL	78.4

Table 5-4: Characteristic discharges (m^3/s)

T_r (years)	Discharges (m^3/s)
100	1,165
500	1,981
1,000	2,330
5,000	3,145
10,000	3,495

5.1.5 Hydrogeology

It can be assumed that generally the rock mass is fractured with possible few intervals of truly massive rock. Lugeon tests carried out during the investigation of Gilgel Gibe I show that unweathered rock formations of basalt and trachyte have a secondary permeability included within 10^{-8} - 10^{-5} m/s. Water flows through partially re-cemented joints and fractures. Trachyte, due to its fractures, has a higher permeability than basalt Rhyolite rock formations and trachyte will have similar permeability values. Tuffs and palaeosol formimpermeable aquicludes at the upper contacts of basalt and trachyte flows. Often the individual flows are massive in the center and highly fractured at the margins. Sealed aquifers may occur therefore, above layers of soft tuff/paleosol.

The volcanic aquifers are fractured, and yield modest amount of water to wells and springs. Water wells usually have a specific capacity of about 0.5 $l*s^{-1}*m^{-1}$ and the mean permeability of the aquifer is in order of 2 m/d (Chernet, 1988). The groundwater has a very low dissolved solids, generally less than 500 mg/l.

5.1.6 Water quality

To better comprehend the differences of water chemical characteristics along Gilgel Gibe and Omo River, analyses have been carried out sampling river water from four station along the river.

The four stations have been carried out as follows:

1. upstream Gilgel Gibe I dam (reservoir)
2. downstream Gilgel Gibe I dam (weir zone)
3. at the junction between Gibe and Omo River (factory zone)
4. at the water out coming, downstream central turbine Gilgel Gibe II.

The sampling water has been analysed by Addis Ababa University, Department of Chemistry.

Chemical parameters analysed are:

- Dissolved Oxygen (DO)
- Phosphate (PO_4^{3-})
- Chloride (Cl^-)
- Sulfate (SO_4^{2-})
- Nitrate (NO_3^-)
- Calcium (Ca^{2+})
- Magnesium (Mg^{2+})
- Sodium (Na^+)
- Potassium (K^+)
- Iron (Fe^{2+})
- TDS (Total Dissolved Solids)

Other parameters measured are:

- Temperature (°C)
- pH (Units)
- Electrical Conductivity (µS/cm)

Analysis documentation given by Addis Ababa University, Dept. of Chemistry are collected in ANNEXES 2.

Table 5-5 shows the results of the analyses carried out in the four place of sampling. Quantities are expressed in mg/l.

Table 5-5: Chemical Analysis of Gilgel Gibe River

	Gilgel Gibe Upstream dam	Gilgel Gibe Weir zone	Gilgel Gibe Factory zone	Gilgel Gibe Outcoming turbined water
Altitude (m a.s.l.)	1640	1640	1200	1000
Ionic chemicals	mg/l	Mg/l	mg/l	mg/l
Ca^{2+}	3.173	2.753	2.723	2.433
Mg^{2+}	2.024	1.699	1.692	1.297
Na^{+}	0.738	0.856	0.781	0.776
K^{+}	0.823	0.319	0.873	0.513
NO_3^{-}	4.378	9.457	3.833	2.161
Cl^{-}	3.284	4.506	2.437	3.105
SO_4^{2-}	2.118	4.527	1.763	1.357
PO_4^{3-}	0.24	0.597	0.29	0.402
Fe^{2+}	1.655	2.085	1.144	1.196
Salinity	Nil	Nil	Nil	Nil

Table 5-6: Water Quality Parameter Measurements

Parameter	Measurement
Temperature	21.1°C – 22.5°C
Dissolved inorganic content	48 mg/l (1), 41 mg/l(2), 39 mg/l (3), 37 mg/l (4)
Oxygen content	7.5 mg/l (2) – 9.5 mg/l (1,3)
Salinity	Nil
pH	7.15 (1), 6.99 (2), 7.16 (3), 6.93 (4)
Electrical Conductivity	101 µS/cm (1), 88 µS/cm (2), 82 µS/cm (3), 79 µS/cm (4)

Considering very low salinity levels on the usual mineral water scale (Gualtierotti 1978), the Gilgel Gibe River water can be classified as earthy-brackish, alkaline, and with bicarbonate.

The comparison of the values carried out in four zones of the Gilgel Gibe River, measured at the beginning (close to the Deneba waterfalls) and at the end (downstream the incoming water turbined by Gilgel Gibe II Plant) shows that the water quality in this section does not change. Statistical analysis indicate that the values recorded are significantly the same. Statistically significant differences occur for suspended solids, total solids and concentration of phosphates (generally higher) downstream Gilgel Gibe I dam since upstream.

The chemical differences may be linked to the different flow rates above and downstream the dam: around the dam there are villages and living people with their own agricultural activities and the augmentation of the nutrients downstream the dam is probably due to the presence of these rural activities.

As well, just downstream the dam, there is Chilelo River, a tributary of Gilgel Gibe River. While the Gilgel Gibe River may be considered slow river, the Chilelo River has a typical torrent flow.

The higher presence of nutrients in the water sampled downstream the dam is due to the larger number of livestock in a smaller catchment and could explain the augmentation of nutrients downstream Gilgel Gibe I dam.

There have been considered also the data of two samplings carried out in 1998 and in 1999 on the Gilgel Gibe River. These samples were sent to the Ethiopian Institute of Geological Survey for analysis in order to determine Physical and Chemical characteristics. The analysis in the laboratory were carried out in accordance to the Standard Methods.

The parameter analysed in these samples are listed here below:

pH, Electrical Conductivity (Ec), Total suspended solids (TSS), Dissolved solids (DS), Total solids (TS), Calcium (Ca2+), Sodium (Na+), Potassium (K+), Mangnesium (Mn2+), Total Iron (Fe2+), Chloride (Cl-), Carbonate (CO3-), Bicarbonate (HCO3-), Nitrite (NO2-), Nitrate (NO3-), Ammonia (NH4-), Boron (B), Sulfate (SO4=), Fluoride (F), Silica (SiO2-), Phosphate (PO4-), Alkalinity as CaCO3, Hardness as CaCO3.

Water quality characteristics have been evaluated considering sampling data referred to Gilgel Gibe river water (refer to Table 5-7) and to Gibe river water upstream the confluence with Gilgel Gibe (refer to Table 5-8).

The data considered in the two different analysis are only partially comparable and, when possible a comparison has been done.

Referring to these data the following considerations can be done.

The measured values of pH for Gibe are in the neutral to slightly alkaline range (7.42-7.52). The average pH value (7.5) is in the range of the large part of rivers and allows the water utilization for different purposes. This value is also considered favorable for the growth of aquatic life.

Electrical conductivity provides a good indication of mineral content in the water. The measured values of EC of the Gibe water were between 137 and 139 µs/cm. The usual range for fresh water is between 10 and 1000 and it indicates that the water has a good mineralization and is adequate for all uses.

The average Chloride content in the Gibe-Omo river is 3.24 mg/l and in the Gilgel Gibe river is 1.13 mg/l.

The average Sulphate content in Gibe –Omo is 1 and in Gilgel Gibe river is 1.94, both values can be considered normal.

The average concentration of Sodium in the two sampled areas is: 6.45 (in the Gibe river) and 2.47 (in the Gilgel Gibe) and Potassium is included between 3 and 1.61 mg/l. These values come in the normal range for fresh water and are compatible with various uses of water.

The measured concentration of Calcium is included between 12.6 (in the Gibe river) and 4.4 (in the Gilgel Gibe). Calcium concentration in natural waters is typically less than 15 mg/l.

The general low level of phosphates and heavy metals indicates that the influence on river water quality due to human influence (agricultural and/or industrial) is very low.

The salinity levels are lower than the ones registered in many rivers in Ethiopia at similar elevations.

All these data summarize that the measured value of the river characteristics is included in the normal range and indicates good water quality values.

Table 5-7: Physical and Chemical characteristics of the Gibe River

Parameter	Value
Temperature (°C)	21°-24°
Dissolved Solids (mg/l)	58.5
TS (mg/l)	177.5
Ca^{2+} (mg/l)	4.4
Na^{+} (mg/l)	2.47
K^{+} (mg/l)	1.61
Mg^{2+} (mg/l)	1.27
Cl^{-} (mg/l)	1.13
CO_3^{-} (mg/l)	11.32
$SO_4^{=}$ (mg/l)	1.94
Total salinity	24.14
Oxygen content (ppm)	5.2-6.8

Table 5-8: Comparison of physical and chemical characteristics of the Gibe River within two sampling period (1998-99)

Sampling parameter	01-04-1998	20-03-1999	Average
PH	7.52	7.42	7.47
EC (µs/cm)	138.7	137	137.85
TDS (mg/l)	96	32	64
Dissolved solids (mg/l)	120	99	109.5
TS (mg/l)	216	131	173.5
Ca^{2+} (mg/l)	13.2	12	12.6
Na^{+} (mg/l)	6.9	6	6.45
K^{+} (mg/l)	3.4	2.6	3
Mn^{2+} (mg/l)	Trace	<0.1	
Mg^{2+} (mg/l)	4.62	4	4.31
Fe^{2+} (mg/l)	0.19	1.6	0.9
Cl^{-} (mg/l)	2.48	4	3.24
CO_3^{-} (mg/l)			
HCO_3^{-} (mg/l)		76	76
NO^{2-} (mg/l)		<0.12	<0.12
NO^{3-} (mg/l)	0.88	0.16	0.52
NH^{4-} (mg/l)	0.52		0.52
B (mg/l)	0.14	0.12	0.13
$SO_4^{=}$ (mg/l)	1	1	1
F (mg/l)		0.17	0.17
SiO_2^{-} (mg/l)		29	29
CO_2^{-} (mg/l)		4	4
PO_4^{-} (mg/l)	0.25	0.33	0.29
Alkalinity as $CaCO_3$	73.2	62	67.6
Hardness as $CaCO_3$	52	49	50.5

Since the data above, the last sample (August 2004) is generally in accord with data results of 1998-1999 sampling data as shown in Table 5-9, where there is a comparison with the average values measured in 1998-1999 sampling and 2004 sampling for the same parameters.

Table 5-9: Comparison of physical and chemical characteristics of the Gilgel Gibe River within old and new sampling campaign

Sampling parameter	Average (1998-1999)	Average (August 2004)
pH	7.47	7.05
EC (μs/cm)	137.85	87.50
TDS (mg/l)	64	41.25
Dissolved solids (mg/l)	109.5	
TS (mg/l)	173.5	
Ca^{2+} (mg/l)	12.6	12.6
Na^{+} (mg/l)	6.45	2.77
K^{+} (mg/l)	3	0.63
Mn^{2+} (mg/l)		
Mg^{2+} (mg/l)	4.31	1.68
Fe^{2+} (mg/l)	0.9	1.52
Cl^{-} (mg/l)	3.24	3.33
CO_3^{-} (mg/l)		
HCO_3^{-} (mg/l)	76	
NO^{2-} (mg/l)	<0.12	
NO^{3-} (mg/l)	0.52	4.96
NH^{4-} (mg/l)	0.52	
B (mg/l)	0.13	
$SO_4^{=}$ (mg/l)	1	2.44
F (mg/l)	0.17	
SiO_2^{-} (mg/l)	29	
CO_2^{-} (mg/l)	4	
PO_4^{-} (mg/l)	0.29	0.38
Alkalinity as $CaCO_3$	67.6	
Hardness as $CaCO_3$	50.5	

Since this comparison, based on the average of the chemical components analysed, it's possible to say that some parameters increased their value since Gilgel Gibe I dam was built.

In fact NO^{3-} and SO_4^{2-} value that increase with a scale factor of more than 100%, means that there is high concentration of these chemical ions in the basin above the dam, and as well the human agricultural activities around the basin even cause the increase of the concentration of these elements in the water sampled.

Considering also that the same values decrease just around the farm area, this is another sign of the influence of the Deneba reservoir above the water ions' concentration.

Definitively since this data, it's possible to confirm that the measured values of the river characteristics are included in the normal range and indicate good water quality values.

5.1.7 Soils

Considering the geomorphology of the zone, the project area can be divided into the following different groups:

- The Gilgel-Gibe river area (from the outlet of Gilgel Gibe I Hydroelectric project to the weir location). Due to the steepness of river banks, almost no vegetation and no soil are present in this area.
- From the inlet to km 15.3 of the tunnel stretch: this part is characterized by a relatively mature landscape, with blanket cover of residual soils and thick mantle of weathered rock.

  In this area the soils vary from Orthic Argisols in mountainous areas with steep slopes, to Orthic Luvisols in undulating hills between the slope that leads to Gilgel Gibe river and the highest and steepest part of the track;
- From 15.3 km to the outlet: the landscape has very young geomorphological features. In this area the topography is extremely steep and soil cover is sparse and most of the area is covered by weathered rhyolite talus and sporadic weathered outcrops. Locally there are some relict alluvial deposits.

The main characteristics of these different soil types are summarized in the following Table 5-10.

Table 5-10: Physical and Chemical characteristics of the Gibe River

Soil type	pH	Texture	Organic content (%)	Total nitrogen (%)	Exchangeable Ions (meq/100g)
Medium altitude hill soil	5.9	Sandy clay loam	4.6	0.2	30.0
Upper altitude hill soil	6.2	Sandy clay	2.0	0.09	39.4

These soils are not very rich in nutrient elements due to human intervention of exploiting and to their exposition to weathering and erosion. The pH factors, organic and nitrogen contents are related to data collected on the soils in the zone between Jimma and Bonga and reported by Dawit Deguefu (1969) and Murphy (1959, 1968).

To determine soil thickness near the weir, a boreholes campaign has been organized.

In this area a four boreholes campaign has been done to determine geo – pedological characteristics and thickness of soils covering the bedrock.

The campaign gives results as follows:

Table 5-11: Colluvium thickness

Area of investigation	Colluvium thickness
Intake	5 meters
Weir foundation	15 meters
Weir right bank	20 meters

Data collected could be considered enough to better define the geological and the geo-pedological framework of the investigated area. Moreover on the base of the results, the contractor decided to organize another boreholes and seismic campaign, at the inlet and outlet works, to better define the situation and to define the impact mitigations near the inlet.

5.1.8 Climate

The climate in Ethiopia is related to the topography and to the movements of the Inter-Tropical Convergence Zone (ITCZ) during the year.

The amount of rainfall varies with topography, location and elevation. Annual average rainfall can be considered almost the same in project catchment area and in the release zone.

All the considerations can be done on the data of the Sekoru meteorological station.

The climate in most of the catchment falls within the category of humid tropical with a mono modal rainfall distribution. Mean monthly rainfall values show maximum in August for most of the stations in the catchment. Mean annual rainfall varies between 1800 mm, where the Gilgel Gibe originates, to about 1100 mm where it joins Great Gibe.

Rain fall in the Yem special wereda varies from 600 to 1800 mm, registered respectively at Great Gibe gorge where the proposed power house is situated and at Fofa height. Mean temperature varies from 12°C at Fofa to 30°C at Great Gibe Gorge.

Ethiopia has a two-season tropical climate. A dry winter season between October and April and a rainy season (during the summer months) between May and September. In the project area, the average annual air temperature is 19.2 °C. Table 5-12 shows monthly mean values of selected meteorological and climatic parameters, recorded at Jimma station.

Table 5-12: Mean Values of Meteorological Data Recorded at Jimma Station

	Jan	Feb	Mar	Apr	May	June	July	Aug,	Sept	Oct	Nov	Dec
Temp (min)	8.8	11.3	12.3	14.0	13.9	13.9	13.5	13.3	13.2	11.0	8.8	8.3
Temp (mean)	18.9	19.9	20.9	21.3	20.9	20.1	19.1	19.1	19.5	19.1	18.6	18.5
Temp (max)	29.1	28.5	29.5	28.7	28.0	26.3	24.6	24.9	25.8	27.2	28.4	28.7
Humidity (%)	49.21	51.5	50.2	61.0	64.2	70.1	75.7	74.5	69.6	58.7	51.9	51.4
n Radiation hours per day	7.75	6.94	7.01	6.30	6.28	4.88	3.62	3.73	5.32	7.50	8.07	7.81

The annual rainfall of the Gilgel Gibe catchment area varies from a minimum of 1,300 mm near the confluence with the Great Gibe River, to a maximum of about 1,800 mm in the Utubo and Fego mountains. Rainfall decreases throughout the catchments with a decrease in elevation. The average annual rainfall calculated over the whole Gilgel Gibe basin where it joins the Great Gibe River (5,500 km^2) is 1,527 mm; over the Deneba catchment (4,225 km^2) it is 1,535 mm; over the partial catchment between Asendabo and Deneba (1,295 km^2) it is about 1,479 mm, and over the partial catchment area between Deneba and the Great Gibe River (1,275 km^2) it is 1,429 mm. It appears that 60 per cent of the total amount of annual rainfall occurs between June and September, 30 per cent from February to May, and only 10 per cent between October to January.

The natural evapotranspiration rate is estimated by subtracting the average flow height for unit of surface from the mean annual precipitation. This is calculated as follows:

the mean yearly precipitation over the catchment between Asendabo and Deneba (S = 1,295 km^2) is about 1,479 mm; the annual mean flow for the same basin can be estimated as the difference between the yearly mean flow at Deneba (50.35 m^3/s) and Asendabo (36.83 m^3/s), or 13.52 m^3/s. This discharge corresponds to an average flow height for unit of surface of:

$$\frac{13.52 * 31{,}536}{1{,}295} = 329 mm / year$$

where 31.536 10^6 are the seconds in a year; the total losses due to evapotranspiration without reservoir are estimated as 1479 - 329 = 1150 mm/year.

5.2 Natural Environment

5.2.1 Natural vegetation

The vegetation in Gibe Valley is part of the Broad-leaved deciduous woodland of Western Ethiopia described in Picchi Sermolli 1957. The vegetation is characterized by woodland species that shed their leaves during the dry season and regain them during the wet season just like temperate trees respond to the cold and dry climate in winter and the warm and wet climate in summer. The shrub and small tree density is sparse and the under canopy and the open area is covered by long grass which burns during the dry season. Important species include *Boswellia papyrifera, Lannea schimperi, Anogeissus leiocarpus, Terminallia browni. Combretum sp., Commiphora africana, Erythrina abyssinica, Stereospermum kunthianum* and *Gardenia trnifolia*. As an integral part of the broad-leaved vegetation there is distinct layer of riverine vegetation along riverbanks owing to the relatively moist conditions. Riverine vegetation is also indicated in the Gibe and Gilgel Gibe River System on the map accompanying the description of the vegetation in Picchi-Sermolli (1957). Description of the vegetation in the Environmental Impact Assessment of the Reservoir (Ministry of Mines and Energy, 1997) dealt mainly on the vegetation of the plateau to be inundated by water.

The altitudinal ranges, temperature, humidity and the floristic and physiognomy composition of the vegetation in Gilgel Gibe and Gibe proper provide ideal conditions for Tsetse fly infestation (Getachew, 1983; NMSA, 1996; Reid, R., et al. 1997, Reid et al., 2000). As the result of the Tsetse fly infestation and the consequent occurrence of cattle disease, trypanosomiasis, there is very little farming activity especially in the Gilgel Gibe valley. The steepness of the slope on either side of the valley appears to be one important factor which has discouraged the use of the valley for agricultural purposes.

The general objective of the investigation is to determine the impact of the redirection of the Gilge Gibe River (through a tunnel to a new confluence for the purpose of generating hydropower at Gilgel Gibe 2 which is 22 km east of the Gilgel Gibe 1 Hydropower Station) would have on the vegetation and the associated animals and the agricultural activities on the area. The investigation focuses more on the floral aspect of the impacts.

The specific objectives include:

- to determine vegetation composition and identify community types in the greater Gbe and Gilgel Gibe Valleys
- to determine if there are endangered plant species or communities that would be affected by the complete diversion of the Gilgel Gibe river and the reduction of the water flow in the greater Gibe river System
- to determine if agricultural activities would be affected by the diversion of the water in Gilgel Gibe river or the reduction of the water flow in the greater Gibe River system
- To propose mitigation options to prevent or minimise the damage that may be caused by the activities.

The investigation of vegetation composition, abundance, cover, physiognomy and other relevant ecological information of Gilgel Gibe and Greater Gibe Valleys was conducted by approaching them from four different points.

Several stops were made along the road or along the way to the river valley from the four different starting points. The number of stops made was dictated by the frequency of change in the vegetation structure and composition.

The vegetation was traversed in different directions to obtain a complete impression of the vegetation and to include all the plant species in the inventory.

Plant species were listed and the per cent canopy cover of each plant species was determined visually. The presence of charcoal pits and other forms of human interference in the woodland were noted.

The geographical coordinate of each stop is recorded as degree decimal or UTM using a SILVA GPS.

The presence of terrestrial and aquatic animals species i.e. insects, lizards, birds, primates, ungulates, warthogs, forest hogs, porcupines, various ungulates and marks of carnivores such as the hyenas, and aquatic animal species such as fish, crocodiles and hippos as well as birds were noted and their food web speculated.

The vegetation could be broadly classified into two parts, namely the Woodland and the Riverine. The dry woodland had two distinct steps (Step 1 and 2) and one the riverine vegetation (Step 3).

5.2.1.1 The dry Woodland landscape

The dry woodland landscape can be partitioned into two distinct types namely

- the highland vegetation which is remnant of the vegetation of the plateau referred to as the dry evergreen montane forest and the associated grasslands in Picchi-Sermolli, 1957) and
- the broadleaved deciduous woodland of the low-lying attitude.

The Highland Vegetation

The highland vegetation was encountered only once, on the way to the proposed intake.

Table 5-13 shows the vegetation composition of a highly degraded remnant highland forest. It is possible to note that there are some lowland elements in this vegetation type.

Table 5-13: Step 1 vegetation data on the way toward the intake

Species	Family	Growth Form	% Cover
Acanthus polystachius	Acantahceae	shrub	10
Bridelia sp.	Euphorbiaceae	small tree	5
Combretum molle	Combretaceae	tree	20
Croton macrostachyus	Euphorbiaceae	tree	5
Maesa lanceolata	Anacardiaceae	small tree	5
Maytenus arbutifolia	Celastraceae	shrub	5
Osyris .sp.	Santalaceae	shrub	5
Rhus glutinosa	Anacardiaceae	shrub	5
Schefflera abyssinica	Araliaceae	tree	5
Solanum incanum	Solanaceae	shrub	20
Syzygium guineense	Myrtaceae	tree	5

The Lowland Broadleaved Deciduous Woodland

The plant species in Gilgel Gibe and Great Gibe have over time developed adaptive mechanisms and traits that allow them either to survive fire or to regenerate after a fire episode. The selective pressure of fire on the plant communities has produced plant species, which are fire resistant, or Pyrophytes (Kuhnholtz-Lordat 1938). These are plants that owe their survival to fire resistance. The majority of the fires in the region occur between late February and early April. This is the fire season, the period of the year when fires occur. The combination of climatic factors such as maximum temperature and humidity contribute to the increase of the probability of fire. Fire season is therefore an aspect of the regime to which plants adapt phenologically.

In these valleys where fire has played an important role over evolutionary, historical, and ecological time (influencing their composition, physiognomy and fuel availability) the relationship between fire and the plant and the associated animal communities are the result of mutual compromise among the various factors. Thus it is possible to suggest that vegetation brings certain properties to the ecosystem that condition the fire regime, and the fire regime determines in part, the maintenance, regression, or succession of plant and animal communities. The animal populations in the woodland also follow the seasonal pattern of the bush fire. At the peak of the bush fire, the small animals may find hideouts in the nooks and rock and wood crevices while the larger animals either migrate to the highland or to the riverine forests in groups or individually. Those, which may not make to next lush of grass are the ones which migrate to the highland and are encountered by humans. Those, which migrate to the valley bottom where they will find the riverine vegetation will find a temporary safe haven until the bush fire culminates and the burnt grass stumps sprout new lush of fresh material.

The trees and shrubs in the Gilgel Gibe and Gibe valley have thick barks and their seeds require fire shock to germinate as part of the adaptation to the fire regimes. The burnt grass and herbaceous species restart at their rhizomes, bases and bulbs which are normally subterranean and the meristems or the growing parts of the plant are protected by the insulating soil. The Vegetation, which has evolved as response to the frequent fires, is poor in species composition (Packman 1970). The Vegetation on most of the length of the slopes of the Gibe and Gilgel Gibe River System is mainly dominated by *Combretum molle.* Only 37 woody (shrub, small tree and trees species) distributed in 30 different Families were encountered. The fire has decimated the herbaceous and the small shrubs during the time of sampling and therefore could not be identified.

The vegetation data of the lowland deciduous woodland (Step 2) are shown in Table 5-14 to Table 5-19.

Table 5-14: Vegetation on the western side of the hill towards the powerhouse (step 2). The altitude of the area on the western side does not allow Step 1 vegetation

Species	Family	Growth Form	% cover
Combretum molle	Combretaceae	tree	40
Erythrina abyssinica	Fabaceae	tree	1
Hypericum revolutum	Hypericaceae	shrub/tree	10
Protea gaguedi	Protaceae	shrub/small tree	5
Sclerocarya birea	Anacardiaceae	tree	1
Syzygium guiniense	Myrtaceae	tree	5

Table 5-15: Vegetation data on the eastern hill along the road to the Powerhouse, at 1774 m.a.s.l., 7° 54' 29 N, 37° 23'05 E (step 2)

Species	Family	Growth Form	% Cover
Dodonea angustifolia	Anancardiaceae	shrub	10
Hypericum revolutum	Hypericaceae	shrub/small tree	5
Measa lanceolata	Anacardiaceae	shrub/small tree	10

Table 5-16: Step 2 vegetation - Medium altitude, 7° 55,42. N, 37° 23'59. E

Species	Family	Growth Form	% Cover
Acacia sieberiana	Fabaceae	tree	5
Adansonia digitata	Passifloraceae	shrub	1
Combretum molle	Combretaceae	tree	30
Croton macrostachyus	Euphorbiaceae	tree	5
Dodonea angustifolia	Anacardiaceae	shrub	5
Entada abyssinica	Fabaceae	tree	1
Ficus vasta	Moraceae	tree	10
Gardenia ternifolia	Rubiaceae	shrub	2
Grewia bicolor	Tilaceae	shrub	2
Lannea schimperi	anacardiaceae	tree	5
Leuca sp.	Lamiaceae	shrub	2
Ocimum saveolens	Lamiaceae	shrub	10
Pappea capensis	Sapindaceae	small tree	5
Phonix reclinata	Araceae	tree	2
Pliostigma thonningii	Fabaceae	small tree	2
Protea gaguedi	Protaceae	small tree	5
Schefflera abyssinica	Araliaceae	tree	2
Syzyguim guineense	Myrtaceae	tree	5
Vernonia auriculata	Asteraceae	shrub	2

Table 5-17: Step 2 vegetation at Mekanissa, 8° 06 912N, 37° 25'50E, 1921 m.a.s.l. The area suitable for Step 1 vegetation is occupied by human habitation and is therefore cultivated

Species	Family	Growth From	% Cover
Bridelia sp.	Euphorbiacese	small tree	5
Calpurnia aurea	Fabaceae	shrub/small tree	2
Combretum molle	Combretaceae	tree	50
Croton macrostachyus	Euphorbiaceae	tree	5
Ficus vasta	Moraceae	tree	10
Gardenia ternifolia	Rubiaceae	shrub	5
Lannea schimperi	Anacardiaceae	tree	5
Protea gaguedi	Protaceae	shrub/small tree	5
Streospermum kuntianum	Bignonaceae	small tree	2

Table 5-18: Step 2 vegetation data on the hill towards Abelti

Species	Family	Growth form	% Cover
Acacia polyacantha	Fabaceae	tree	30
Acacia seyal	Fabaceae	tree	20
Cadaba farinosa	Capparidaceae	herb	5
Combretum molle	Combretaceae	tree	20
Lonchocarpus laxiflorus	Fabaceae	small tree	2
Securinega virosa	Euphorbiaceae	shrub	20
Streospermum kuntianum	Bignonaceae	tree	2

Table 5-19: Vegetation data on lower side of the Gibe Bridge, on the way to the Hippo pool before the river, 8°13’93 N, 37° 35’25 E, 1072 m.a.s.l.

Species	Family	Growth Form	% Cover
Acacia polyacantha	Fabaceae	tree	30
Capparis tomentosa	Capparidaceae	shrub	5
Combretum molle	Combretaceae	tree	30
Dichrostachys cinearea	Fabaceae	shrub/small	20
Lannea shcimperi	Anacardiaceae	tree	10
Securinega virosa	Euphorbiaceae	shrub	10
Sterculia.sp.	Sterculiaceae	tree	10
Ximenia Americana	Olacaceae	shrub	5
Zizipus mucronata	Rhamnaceae	small tree	5

5.2.1.2 The Riverine landscape

In the Gibe and Gilgel Gibe River Systems as else where, connectivity, which is a critical phenomenon in riverine system, occurs both laterally and along the river course. The most obvious and most dynamic linkages in riverine ecosystems are those between channel of a river and the surrounding vegetation. (Amoros & Roux, 1988). Connectivity is a seasonal phenomenon, subject to the occurrence and magnitude of flooding. With the onset of the long dry season, the flooding abates and much of the riverbanks become part of the terrestrial landscape (Junk Bayley & Sparks, 1989).

Riverine landscapes differ significantly from “land” landscapes in many critical ways. They are partly embedded in a water medium that exerts a strong and variable physical force on the system that is highly directional. Water flow makes the patch structure of riverine landscapes quite dynamic. Patches move and change shape and composition as stream flow varies. Floodplain landscapes shift between terrestrial and aquatic phases. The adaptations of many of the organisms that occupy rivers and streams are molded by hydrology, through its effects on food-resource availability, flood pulses, or simply the physical force of currents and the various functions of the ecosystem (Adis & Junk, 2002; Robinson, Tockner & Ward, 2002). The directional flow of water enhances the connectivity of the riverine landscape. In rivers and streams, connectivity is provided by the medium of the landscape more than by the structural configuration of the mosaic itself. On land there is little consistency to the directionality of this connectivity. Patch edges may be more important in riverine than in terrestrial landscapes because they are more effective in intercepting water-mediated flows and trapping moving materials or organisms (Palmer et al., 2000).

The Riverine vegetation along the riverbanks may be understood as giving ecosystem functions such as corridors connecting wet forests, being refugia for some plant species and biodiversity banks for wetter forest elements. They are also refugia for birds, invertebrates, reptiles, amphibians, ungulates, primates and their predators during the peak of bush fire period. The ungulates particularly find safe haven in the riverine forest until the bush fire culminated and the lush of grass sprout.

Change of the environmental conditions altering the wetter conditions which are the primary reasons for their existence would have some impact on both plant species composition which is the primary producers and shelters as well as the secondary producers (herbivores) and other organisms in the higher trophic levels. Data on the riverine vegetation are given in Table 5-20 to Table 5-23.

Table 5-20: Vegetation data on the River banks at the power house, 7°54'50 N

Species	Family	Growth Form	% Cover
Combretum molle	Comobretaceae	tree	20
Ficus vasta	Moraceae	tree	30
Milletia feruginea	Fabaceae	tree	20
Prunus africana	Rosaceae	tree	30

Table 5-21: Step 3 vegetation on the eastern Bank of the intake of Gilgel Gibe, 7°55'66 N, 37°23'36 E

Species	Family	Growth Form	% cover
Syzygium guiniense	Myrtiaceae	tree	20
Celtis africana	Ulmaceae	tree	20
Prunus africana	Rosaceae	tree	30
Lepidotrichlia volkensii		tree	20

Table 5-22: Vegetation data on lower side of the Gibe Bridge, at the bank of Gibe River, 8°13'93 N, 37° 35'25 E, 1072 m.a.s.l.

Species	Family	Growth Form	% Cover
Acacia.sp.	Fabaceae	tree	10
Ficus vasta	Moraceae	tree	30
Prunus africana	Rosaceae	tree	50
Tamarindus indica	Fabaceae	tree	20

Table 5-23: Flood plain tree and herbaceous species along the river bank, Gibe River Bridge, Upper side, 08° 13.74'. N, 37° 34.64' E. (Here there is a distinct flood plain allowing the growth of some herbaceous plant species characteristic of the condition)

Species	Family	Growth Form	% Cover
Clausena anisata	Anacardiaceae	Shrub/small tree	3
Combretum molle	Combretaceae	tree	20
Commiphora african	Burseraceae	small tree	2
Cynoglossum coeruleum	Boraginaceae	herb	5
Datura stramonium	Solanaceae	herb	5
Euclea divinorum	Ebenaceae	shrub	5
Mimusops kummel	Sapotaceae	tree	10
Prunus africana	Rosaceae	tree	30
Rhus glutinosa	Anacardiaceae	shrub	5
Salix mucronata	Salicaceae	tree	10
Senna orientalis	Fabaceae	Herb/shrub	5
Strychnos sp.	Loganiancae	Small tree	5
Syzygium guineense	Myrtaceae	tree	10
Xanthium spinosum	Astraceae	herb	5

5.2.2 Fauna

As a consequence of the Gilgel Gibe II construction, a small pond at the intake channel will form and the flow into the Gilgel Gibe River will be reduced between the diversion site and Gilgel

Gibe-II outfall structure. Thus there are anticipated ecological impacts on the aquatic and terrestrial fauna because of the complete/partial drying up of the Gilgel Gibe, the creation of a new pond near the intake channel and the possible changes at the Gibe-Omo confluence. These ecological changes and their possible impact are investigated and possible mitigation measures to avoid or reduce adverse biological effects are recommended.

The objectives of the Fauna Ecology Assessment for the proposed Gilgel Gibe II Hydropower Project include the following:

- to describe the present ecological status of the fauna (aquatic and terrestrial) around the project sites at the intake channel, Gilgel Gibe River Valley and the Gibe-Omo confluence;
- to assess the probable ecological impact on the aquatic and terrestrial fauna as a result of the creation of a lagoon, the drying up of the Gilgel Gibe river and the flow changes at the Gibe-Omo confluence and further downstream at the Gilgel Gibe II power house; and
- to propose mitigation measures to preserve the ecological condition of the fauna during the construction and operation phases of the Gilgel Gibe II Hydroelectric power project.

5.2.2.1 Methodology

During field investigation, the following sites have been visited to assess the potential impacts of the project on the fauna ecosystem.

Site 1

Two stations were considered between Gilgel Gibe II powerhouse and the Proposed Intake Channel site and these are the dry river bed area between the Gilgel Gibe-I dam site and powerhouse outfall (Site 1A) and between the powerhouse where the new intake site and the proposed weir site and pond area (Site 1B).

Situation analysis for 1A

This area of the Gilgel Gibe I plant had been drained to fill the reservoir, and at the time of sampling had only little water trickling from the spillway and precipitation. As a result, the riverbed was dry at most places, or had little water in some large backwaters. The river bedrock was exposed in many places, and little water flow was noticed in the very narrow channels.

The area had little water that it could not harbor large aquatic animals like hippos, crocodiles or even fish. During the reservoir filling (for Gilgel Gibe-I scheme), the fishes and the large animals have migrated downstream to the Gilgel Gibe and Greater Gibe rivers. Birds seen near the riverine forest include weavers, starlings and chatterers. Wild animals are still around including lion and cheetah.

In and around this site, except for the power station personnel, there was no human settlement observed, nor domestic animals.

Situation analysis for site 1B

Site 1B is downstream the powerhouse of Gilgel Gibe I at the proposed intake channel and weir site for Gilgel Gibe-II. Much water from the turbine station was released at this site, although only two of the three turbines were operating at the time. The fast current and turbid water does not support aquatic invertebrates and plankton and the tow nets sampled had no such aquatic animals. Nevertheless, the surrounding riverine vegetation of shrubs, grass and trees was noted to harbour diverse invertebrates such as wasps, butterflies, ants, crickets, and the like. The site had no endangered or endemic vertebrate and invertebrate species.

Around this stretch of the river, some inflows from small streams on the other side of the gorge were also observed. However, due to the steep gorge and inhospitable terrain, there were no human nor domestic animal incursions in this site at all.

Fast and voluminous water flow was observed. No large aquatic animals were seen or reported by the local guides. The current velocity was very strong to be resisted by animals or plants. No plankton life is expected in such fast flowing river stretches. Still, the riverbank and associated riverine forest from the river bottom up to the top of the gorge (perhaps 500 meters high) harboured some fauna and the list of wildlife reported are given in Table 5-25. Although this was not a routine activity, residents of the nearby villages have complained of cattle loss to wild animals when the cattle ventured down the river gorge for watering and grazing. However, this activity may increase after the access road to the intake channel is completed; thus the man-wild animal conflict situation will have to be taken into consideration in the future.

No aquatic invertebrates (especially plankton) are expected in such rapid river flows. Perhaps the blockage of this stretch in future may favor the development of lentic invertebrates such as mosquitoes, which may pause medical problems if the infectious cycle is maintained in the local people who occasionally visit the gorges.

People reported that Tseste fly was common and infected the cattle, which appeared emaciated due to nagana. The change of the river velocity does not appear to have made any difference in the wide incidence of trypanosomiasis in the area.

Terrestrial and forest invertebrates were diverse and include crickets, grasshoppers, butterflies, ants, dung beetles, red fiery and large black ants, dragonflies, wasps, etc.

No endemic or endangered invertebrate or vertebrate animals were noted. The guides reported that some tilapia and Barbus fishing is practised by the local people when they visit the river occasionally. This fish stock could be seed for the fishery to establish in the lagoon. Similarly, there was a large number of crocodile and hippo at this site.

<u>Site 2</u>

Gilgel Gibe middle gorge (Dobi-Mekannissa area)

Difficult to reach the river bed because of the steep inaccessible gorge. The nearest human settlement from the river bed is probably 4 km away. Tsetse fly and wild animals discourage human and animal habitation. Sparse and isolated tukuls and emaciated cattle were observed in this Terminalia woodland ecosystem (gambello trees). The flow density was moderate but we couldn't get access to the river, so no sampling for aquatic fauna was done. This is an impression gained from the local guides and some people living nearby.

There are aquatic animals such as crocodiles, hippos and fish as confirmed by the local inhabitants even though they venture down to the river rarely. Usually, watering of cattle is done from accessible parts of the Gilgel Gibe further upstream near Saja or Sekoru.

Birds living close to the gorge in the trees include barbets, warblers, sunbirds, weavers, silverbills and starlings. Some of the starlings observed could be of the rare type.

Wild animals such as lion and colobus, anubis and vervet monkeys are common.

Site 3

Gibe-Omo bridge confluence

Two stations were considered for this study – 3A and 3B. The geographical coordinates (GPS) for this site are 8°13'93" N and 37°35'25"E.

Situation analysis for site 3A

Site 3A is below the Gibe bridge on the upper side of the Gilgel Gibe and downstream of the last stretches of the Gibe river. This site should have lowered water level after the diversion of the Gilgel Gibe but at the moment of visit, the people said that they had larger than average volume of water for this time of the year, because of the regulated flow from the reservoir after fill-up in 2004.

Site 3B is on the opposite side of 3A, about 2 km from the confluence of the Gibe with the Omo river. The site had large volume of water due to the joining of the water from the two Gibes (Gilgel and Greater Gibe) before they drained into the Omo.

Situation analysis for site 3B

The river channel is wide (20-30 m) and the volume flow is relatively large. This site is a critical one for watering cattle (about 500 visit it every day) and human activities such as laundrying, ablution and fishing (tilapia) were quite common. A religious healing hot spring further upstream augments the importance of the site.

The surrounding vegetation is dry savannah with Acacia dominance. Despite the presence of Tsestse infestation, there were quite large number of emaciated cattle, including some from the state farm upstream. Large animals are common in the river including hippos, crocodiles and lizards. They do not appear to have been impacted by the diversion of the Gilgel Gibe last year.

The faunal ecosystem assessment has been limited on the second stage development of the Gilgel Gibe Hydropower Project. In consideration of the nature and the location of the potential impacts, the following study limits were defined for this investigation.

The area to be studied encompasses the following:

- The Gilgel Gibe river, from the present dam up to the confluence with Gibe River
- The part of Gibe river, from the confluence with Gilgel Gibe River down to the proposed plant site
- The area between the two above mentioned rivers

The qualitative and quantitative characterization of the aquatic and terrestrial fauna was performed using field, laboratory and museum observations as follows.

<u>Aquatic animals - crocodiles, hippos, birds</u>

- Interview with the local population and field guides
- Observation and census

<u>Fish</u>

- Interview and observation on fish caught by local people
- Observation on spawning sites, migration routes, etc.
- Observation on established fishery

<u>Birds (aquatic and terrestrial)</u>

- Identification on site using field guide book
- Estimate relative abundance as less common or more common.

<u>Invertebrates (aquatic and terrestrial)</u>

- Tow nets for aquatic invertebrates. Preservation and storage in formaline.
- Tree and grass invertebrates - beat trapping
- Taxonomic identification using guides and the Natural History Museum, AAU

<u>Domestic animals and Human uses</u>

- Observation on domestic animals- interview with local population and field guides
- Observation of feeding and watering sites of livestock
- Observation and interview on human activities at river banks.

5.2.2.2 Fauna description

In this chapter the various aspects of the fauna ecosystem within the project environment are described. The main content of these chapters is fishery, other aquatic resources, wildlife and bird resources, invertebrates and domestic animals.

5.2.2.2.1 Fishery and Other Aquatic Resources

The Gilgel Gibe sub-basin is part of the Omo-Gibe catchment covering an area of 78.2 x 10.3 km^2 (Zelalem Teferra, 1994). The Omo-Gibe drainage has a rich fish fauna as documented by Hopson & Hopson (1982), Dgebuadze et al. (1994), and the JERBE studies of 1995. A total of 14 Families and 35 species of fish have been reported from the Omo-Gibe basin as compared to only 4 species in 2 families for the Gilgel Gibe sub-basin. Thus the Gilgel Gibe is depauperate with respect to fish species, and the same may hold true for other aquatic fauna such as birds, invertebrates and other trophic groups related with fish.

The Omo-Gibe basin is richer in fish diversity and endemism when compared to the Omo-Gibe system. The presence of the endemic African loach Nemacheilus abyssinicus in both basins is one exception (Dgebuadze et al., 1984).

The large aquatic fauna of the Omo basin include crocodiles, hippos and African rock python, all of which appear to inhabit the Gilgel Gibe sub-basin also. Thus, one notes a general paucity of terrestrial and aquatic fauna in the Gilgel Gibe sub-basin as opposed to a rich diversity of the fauna in the Omo-Gibe catchments. Ecological changes in the sub-basin therefore may not impact the larger Omo-Gibe basins significantly.

There is no established fishery near the site or further downstream of the Omo river. Fishing on tilapia and Barbus is done by some fisherfolk, but mostly for consumption or local use.

It is noteworthy that out of the fish species present in the Gibe river upstream, only two families are present at the confluence site while three families are entirely absent (Mormyridae, Characidae, Bagridae).

The fish species observed are given in table 5-24.

Table 5-24: List of the fish species found at the Gibe-Omo confluence sites

No	Family	Species	relative abundance
1	Cyprinidae	*Labeobarbus sp.*	++
		Garra dembensis	++
		G. quadrimaculatus	++
		Labeo sylindricus	+
2	Cichlidae	*Oreochromis niloticus*	+++

Note: Relative abundance + is less common, and ++ is relatively more common.

5.2.2.2.2 Plankton and Nutrients

Due to the high sediment load in the Gilgel Gibe river, plankton samples did not yield, as expected, much phytoplankton and zooplankton species. However, this does not preclude the possibility that plankton may develop and bloom in the lagoon/reservoir after the first few years of impoundment. The two primary nutrients that regulate growth of phytoplankton in rivers (Phosphate and Nitrate) were not analyzed in detail in this survey. However, from the literature, it is suggested that a balanced ratio of 1:30 for P:N is ideal for algal and bacterial production in reservoirs. It is noted that nutrient limitation will not be a major concern for reservoirs, at least during the first few years of formation. 'Young' reservoirs pass through a productive phase a few years after impoundment (referred to as 'trophic surge phase' in limnological terminology) where there will be high production of plankton, fish and macrophytes due to release of nutrients from decomposing trees, plant matter and soil leachates from former river valleys. Thus it is anticipated that there will be no nutrient limitation of Phosphates or Nitrates after the first few years of the impoundment of the second Gilgel Gibe limited storage area. The same experience of a productive phase is already being witnessed in the Gilgel Gibe I reservoir.

5.2.2.2.3 Wildlife Resources

High species diversity also hold true for the vegetation and wildlife of the Omo river basin. The riverine forest is dominated by river-edge trees such as tamarind (Tamarindus indica), shola (Ficus scymora), sausage tree (Kegalia aethiopica), weyba (Terminalia browni), Acacia and Euphorbia sp. The wildlife consists of monkeys (vervet, anubis, colobus), warthog, wild pig, waterbuck, duiker, oryx, zebra, gerenuk, greater and lesser kudu, giraffe, antelope, gazelle, elephant, etc. Wild carnivores such as lion, leopard, cheetah, golden cat abound, and elephants and the rare Burchell's zebra are found in the Omo National Park.

The 1997 EIA report also states finding the endemics Lelwel's hartebeest (A. busephalus lewel) and bushbuck (T. scriptus) around the Gilgel Gibe-I project area. List of some wild animals at intake channel site are shown in Table 5-25. Hippos are frequent and crocodiles are rampant. Wild animals such as lions and leopards and aquatic crocodiles are a serious human hazard. The local inhabitants complained of maiming and killing of domestic animals by wildlife.

Table 5-25: List of some wild animals at intake channel site

No	Wild animal (common name)	Scientific name	Relative abundance
1	warthog	*Phacochoerus africanus*	+
2	bush pig	*Potamochoerus sp.*	++
3	hyena	*Hyaena hyaena*	++
4	lion	*Panthera leo*	+
5	leopard	*Panthera pardus*	+
6	cheetah	*Acinmyx sp.*	+
7	colobus monkey	*Colobus guereza*	++
8	vervet monkey	*Cercopithecus aethiops*	+
9	olive baboon	*Papio cyanocephalus*	+
10	hippopotamus	*Hippopotamus amphibious*	+++
11	nile crocodile	*Crocodylus niloticus*	++

Note: Relative abundance legend + is less common, and ++ is relatively more common.

5.2.2.2.4 Bird Resources

The bird fauna of the Omo-Gibe basin comprises predominantly of the Somali-Masai Biome species and a few of the Sudan-Guinea Biome species. There are no endemic birds recorded from the Omo river basin although the blue-breasted kingfisher is considered a recent introduction to the area (EWNHS, 1996). The most commonly observed species from the Somali-Masai Biome include parrot, bustard, nightjar, hornbill, barbet, lark, shrike, thrush, chaterrer, cisticola, warbler, flycatcher, sunbird, canary, sparrow, silverbill, starling and the rare Shalley's starling. Only the fox kestrel and dusky babbler of the Sudan-Guinea Biome species are recorded from the Omo River basin.

Thus the literature indicates that the larger Omo-Gibe basin which encompass the Gilgel-Gibe sub-basin is rich in bird species diversity but lacks rare, endangered, endemic or red-list bird species in general. The endemic Hardwood's francolin was reported in the 1997 EIA report for the Gilgel Gibe I project as being present in riparian forest, swamp and marsh bushes around the project area, but this could not be authenticated during this survey. The bird population was quite high and diverse as shown in table 5-26.

Table 5-26: List of some bird species at the Omo- Gibe confluence site.

No	Bird common name	Scientific name	relative abundance
1	Heron	*Egretta gularis*	+
2	egret	*Egretta garzetta*	+
3	woodland kingfisher	*Halcyon senegalensis*	++
4	barbet	*Trachyphonus sp.*	+
5	chat	*Cossypha sp.*	++
6	thrush	*Turdus sp.*	++
7	woodpecker	*Thropus sp.*	++
8	pigeon	*Colomba sp.*	+
9	shrike	*Caracina sp.*	+
10	warbler (Rufous)	*Cercotrichas sp.*	+
11	flycatcher	*Parisoma sp.*	+
12	cisticola	*Cisticola sp.*	+
13	starling	*Spreo sp.*	+
14	plover	*Koplopterus sp.*	+
15	nightjar	*Caprimulgus sp.*	+

Note: Relative abundance legend + is less common, and ++ is relatively more common.

5.2.2.2.5 Invertebrates

No aquatic invertebrates were sampled. The terrestrial invertebrates from trees, grass and the forest litter are listed in table 5-27. The invertebrates in the backwaters of the Gilgel Gibe river include wasps, muscid flies, green hoppers, dung beetles and a rare dragonfly specimen. The invertebrates also include the Colotis butterfly and some dragonfly species, both of which appear to be attractive for collectors. However, these are species found elsewhere in Ethiopia and indeed in many tropical countries. Benthic invertebrates such as aquatic snails and bivalves, crustacean copepods and mayflies (Ephemeroptera) were captured in the tow net. The murky water had little plankton indicating that the fish fauna is sustained mainly by detrital and macroinvertebrate diets. It appears that this site had more invertebrate species because of its wide channel.

Table 5-27: List of some terrestrial invertebrates at the Gilgel Gibe valley

No	Invertebrate common name*	Relative abundance
1	cricket	++
2	grasshopper (green)	+++
3	butterfly (*Colotis sp*)	++
4	butterfly and moths	++
5	ants (black)	+++
6	ants (red)	++
7	ants (large black)	++
8	wasp	+
9	dung beetles	++
10	unidentified bugs	+++
11	tree spiders	++
12	aquatic spiders	+
13	tsetse fly (*Glossina sp*.)	+++
14	beetles (coleoptera)	++
15	unidentified homoptera	++

Note: Relative abundance + is less common, and ++ is relatively more common.

* Taxonomy of many groups still to be authenticated

5.2.2.2.6 Domestic Animals

Presently, cattle and humans only sparsely populate the Gilgel Gibe river channel and its environs. The wild carnivores such as lion and cheetah, the steep and narrow gorge and Tsetse infestation discourage human settlement. The gorge is surrounded by a thick forest of Terminalia which harbours typical fauna and flora of such ecosystem.

5.3 Socioeconomic Environment

5.3.1 Introduction

Hydropower projects, that are intended to produce electric energy, may cause environmental and socio-economic impacts on the population over a wide geographic area. The most effective and economic way of maintaining the quality of the environment, and solving the adverse socio-economic impacts of the affected area and enhance sustainable development is to assess and eliminate or at least minimise the environmental and social problems as early as possible.

The Gilgel Gibe II Hydroelectric project is designed to enhance the economic development of the country, and to bring a better standard of life to the people of Ethiopia, but it could have some marginal adverse environmental and social effects during its construction and operation phases.

The area of influence of Gilgel Gibe II Hydroelectric project extends from the present dam of Gilgel Gibe I up to the confluence of Gibe River and Omo River that includes parts of Sekoru Woreda of Jimma Zone in Oremiya region and parts of Yem Special Woreda and Gurage Zone of the Southern region.

The primary objective of this assessment is to identify the major socio-economic environment impacts that could take place during the construction and operation phases of Gilgel Gibe II Hydropower Project and to propose the possible mitigation measures for the possible adverse effects. The assessment includes the socio-economic environment features of the area to be affected by the project components (i.e. constructions of proposed weir and intake, access roads to the intake and powerhouse, power tunnel and construction camps and other facilities).

The findings of this assessment are presented in three main sections including the following description of the existing socio-economic conditions, the potential impacts (see 7.3) and recommended mitigation measures (see 9.3).

The main objective of this Social Impact Assessment for the proposed Gilgel Gibe II Scheme is to:

- provide baseline information on social, cultural, demographic and economic characteristics of the population in the project area;
- determine the impacts of the proposed scheme on the socioeconomic environment and provide estimated potential loss of livelihood assets, residential units, public infrastructure, institutions and social service facilities, etc.;
- gather official and community attitudes towards the project and identify potentials and challenges for mitigation strategies; and
- provide information that would help to formulate compensation strategies and related mitigation options.

The approach and methodology used to carry out the socioeconomic impact assessment is described below.

Collection of Available Information: The consultants collected and reviewed published regulations, guidelines, national policy papers, and documents. Various statistical and analytical reports published by Central Statistical Authority (CSA) were extensively used to determine the socio-economic and demographic profile of the population and settlements in the project area. Furthermore, topographic maps prepared by Ethiopian Mapping Agency (EMA) and Central Statistical Authority were also used to identify and delineate villages, resources and facilities that would be affected when the proposed scheme is constructed.

Characteristics of the project: A review of the Gilgel Gibe II Hydropower Project report and other relevant issues has been carried out, with particular reference to establishing the form and scope of the works, probable construction methods and materials, and operational characteristics. This was carried out to identify potential sources of impact of the project on the environment.

Field Visits: Detailed site investigation was carried out in order to gain first-hand knowledge about the existing environmental conditions and also to put the proposed works into context. The field visits were also carried out to supplement the available information with emphasis on those areas identified as being of environmental interest. During the field visit, information on economic development activities, socioeconomic aspects, health, cultural and other values in the project area has been collected.

Identification of Socioeconomic Impacts: Key potentially adverse impacts on the socioeconomic environment associated with the project construction and operation phases of the project have been identified. The assessment is expected to provide a rational basis for any recommendation.

Mitigation Measures: Mitigation measures that may reduce potentially significant adverse impacts and enhance beneficial impacts are recommended.

Public Consultation: The field investigation included consultation with various Project Affected Person (PAP), local authorities and various stakeholders at all the project sites. This was carried out in order to obtain supplementary information on social, socioeconomic and socio-cultural conditions. The consultation was also carried out to obtain the views of the PAPs on various aspects of the project including background information relevant to impact assessment (in particular, to identify any areas of specific concern which needed to be addressed in this assessment) and identification of mitigation measures.

5.3.2 Demography Features

Jimma Zone, as of the year 2002, has over 2.26 million populations. About 89% of the population resides in the rural areas while the remaining 11% belong to 29 towns and locations considered being urban settlements. Sekoru is among the most densely populated Woredas in the Zone. According to the 1999 CSA population projection, the total population of Sekoru Wereda is 132,764 of which the urban population is 14,788 while the rural population is 117,976.

The population of Yem Special Woreda, according to 1999 CSA population projection is estimated to be 77,664. But currently the Woreda population is 85,552 of which the total population of the town is estimated to be 1450. The share for male population of the Woreda is 49.94% while female population is 50.06%. Of the total population, about 44% are of young age group of less than 15 years, about 50.3 % fall between 15 and 64 years and the remaining 4.6 % are of old age group of more than 64 years old. The rural population constitutes 98.4% and the urban is 1.6%. The assumed average growth rate is 3% for rural and 4% for urban population. The population is estimated to reach about 90,557 in 2005 and about 105,060 in 2010.

There are four semi-urban settlement areas market centres and 32 rural kebeles in Yem Woreda of the rural kebeles, 10 are heavily populated, 14 are moderately populated and the remaining 8 are sparsely populated with densities of 150 – 350, 75 -150, and less than 75 persons per km^2 respectively.

Sekoru Woreda has a total of 38 Kebele Administrations of which 9 are bordering with the Gibe River. These are Borre, Liben-Borre, Liben, Okure, Deneba, Wolmera, Yero Sekoru and Gengeleta.

5.3.2.1 Ethnic Distribution of Yem Woreda

According to the 1994 census, the residents of the Woreda are predominantly Yemsa who constitute 91.8% of the population. Oromos are 5.6% followed by Hadia 0.8%, Gurage 0.6% and others 1.1%.

5.3.2.2 Religion Affiliation of the people

The religion affiliation of the population of Yem is 70% Orthodox, 20% Muslim, and 10 % protestant. In the Woreda, about 18 Orthodox churches and significant numbers of protestant churches are found.

5.3.2.3 Gender Issues in Yem Society

In Yem special Woreda, community and household division of labour is based on gender lines only. Men carry out activities that have more economic and social value and receive cultural acceptance and respect while women carry out activities that have low level of social value but which are economically and socially vital activities for households and the community. On the other hand, women bear the burden of work in a family and have responsibility for the indoor activities, fetch all the domestic needs and work in fields.

Women rarely own assets including houses, land, cattle and pack animals and it is impossible to decide on property sales. Parents do not treat boys and girls equally and girls are less likely to be sent to school due to parental misconceptions. The male –female rate of students in the Woreda is 70:30. The traditional belief or cultural outlook that looks down to the education of girl child has highly affected the participation of girls in education. Families or the community in general encourage girls to marry early or engage in petty trading activities instead of attending or going to school.

5.3.3 Economic Activities

Sekoru and Yem Special Woreda are suitable for various agricultural activities, which include crop and livestock. However, the major constraint to crop production is soil fertility depletion caused by poor agricultural practices. Yem is endowed with significant level of water sources potential and is designated generally as a water surplus area. There are about nine perennial rivers and numerous tributaries, which flow across most of the Woreda and drain into Gibe and Gilgel Gibe Rivers.

5.3.3.1 Land Use

The main land use of the Woreda (Sekoru and Yem Special Woreda) is cultivation, livestock grazing and forest/bush land. The cultivated area comprises about 42% and 41.3% of the total area of Sekoru and Yem Woreda respectively. The present land utilization of Yem Special Woreda is estimated to be 45% cultivated, 20% grazing and shrub land, 9% woodland and forest, 15% potentially cultivable and 11 % wasteland. In Yem Woreda the landholding area per rural household ranges from 0.5 to 2 hectares. The land use of Yem Woreda is shown in the Table 5-28.

5.3.3.2 Crop production

The livelihood of the population of Sekoru and Yem largely depends on agricultural activities (crop production and livestock rearing). Sekoru and Yem are particularly known in Enset production. Enset is a perennial herbaceous plant, the main source of food, which matures in 3 - 5 years. With regard to Yem Special Woreda, the Dega and Woina Dega parts amounting to 16% and 73% respectively are highly suitable for Enset production while the remaining part is Kolla (11%) and is suitable for animal production. Root crops also constitute an important part of the food crops in Yem. The known root crops include Taro, local potato, Irish potato and others.

Moreover, there are about 1600 hectares of the flat area in the vicinity of Gibe River (downstream of the proposed Gilgel Gibe II powerhouse) within Ashe and Saja Laften kebeles with potential for irrigated agricultural development. Currently in Yem about 75% of the farmers are covered under the extension package. The major crops under extension and regular package with their yield/ha and price are shown in the table below (Table 5-28).

Table 5-28: Yield of Major Crops under Extension and Regular Package

Major Crops	Yield (Quintals)		Price of crops (in Birr)	
	Extension	Regular	Lower side (in Birr)	Higher side (in Birr)
Teff	8	5,5	150	180
Wheat	15	6	120	180
Barely	16	8	90	120
Peas	9	4,5	90	180
Horse bean	12	6	90	180
Maize	39	10	90	150

The major problems of agriculture in the Woredas include soil erosion, shortage of draft power, intermittent deficiency of water, prevalence of crop pests, seasonal shortage of labour, food diseases and weeds, late delivery and high price of fertilisers and other inputs, lack of access to services and market distortions. Inputs like fertilisers, improved seeds and herbicides are very much expensive while the prices of crops, livestock, and livestock products are sharply declining.

5.3.3.3 Livestock

Livestock production is equally important as crop production in all parts of Sekoru and Yem Woreda. Cattle have a multipurpose benefit. They provide draft power, meat, milk, hides and manure and service as an asset, which could fetch cash income when the need arise.

The major livestock problem of the Woredas is the prevalence of animal diseases and parasites. The common diseases, which affect livestock, include anthrax, black leg, pastrolosis, bobisiosis and parasitic for cattle. Although livestock is an integral part of the farming system in the Woredas and cattle population is no small, dairy industry has not yet developed into a commercial activity. The major livestock feed in the Woreda is the traditional open field grazing, crop residues and hay. The livestock population of the Woredas is shown in Table 5-29.

Table 5-29: Livestock population of Yem and Sekoru Woredas

Type of animal	Yem	Sekoru
Cattle	38750	69622
Sheep	11436	3394
Goats	9009	4433
Donkeys	1172	726
Horses	518	-
Mules	133	-
Poultry	14470	17378
Bee-hive	-	3487

5.3.3.4 Income and Expenditure

According to the Yem Woreda Integrated Development Program, the average per capita income and expenditure is 1150 and 1200 respectively. About 62% of the rural income comes from agriculture and the remaining 38% from other sources. Regarding the expenditure about 52% goes for food and the remaining 48% for other consumption items. On the other hand, according to the response given from the development agent of the Woreda, the average annual income of a rural household ranges from less than Birr 800 to Birr 1500.

5.3.4 Social Services and Infrastructure

5.3.4.1 Health Situations in the Woredas

Health Status

The health coverage of Sekoru and Yem special Woredas is 59.4% and 43% respectively. Moreover according to the 2004 Woreda health bureau data, intestinal parasites, TB, URI, helmentiasis, schystomisis, malaria and other diseases are prevalent in Sekoru Woreda while in Yem Woreda the major diseases are URI, hepatitis phenomena, diseases of eye, diseases of ear, dysentery, nephritis, gastritis, typhoid, bronchitis, malaria and other diseases.

The Bidru rural communities where the diversion weir and the access road to the in take are located use the health facilities found in Sekoru town.

According to the information from the Sekoru Woreda health personnel, the Gilgel Gibe I Hydropower project has brought some adverse impacts to the local people of Sekoru town. Since the starting of the project the population and the transmission diseases has increased, as well as the number of patients and cases, and the Sekoru Health Centre faced problem to give adequate services for patients. With regard to malaria cases, 27 out of 38 kebeles of the Sekoru Woreda were affected by malaria in 2003.

Health Services

The available health institutions and health personnel are presented in the table below.

Table 5-30: Health Institutions and personnel in Sekoru and Yem Woredas

Descriptions	Sekoru	Yem
Health Institution		
Health centre	1	1
Clinic	5	4
Health post	-	5
Rural drug	-	
Health Personnel		
Vender physician	1	1
Senior nurse	-	2
Nurses	11	-
Junior clerical nurse		2
Health assistant	11	1
Sanitarian	2	-
Mid wife	1	1
Senior laboratory technician		1
Lab technician	3	2
Health coverage	59.4%	43%

In Yem Woreda, according to the information from the Fofa Health Centre Office, four health posts will be upgraded to clinics in the near future. Those are Deri, Saja, Toba, Sumonama clinics.

5.3.4.2 *Education*

The numbers of schools available in Yem Special Woreda are 20 (see Table 5-31) of which only one is secondary school and all are government. The secondary school is situated in Fofa town and it has 16 sections, 23 teachers and 721 students. Of these students 68% are males and only 38% are females. As it is discussed in Yem Woreda Integrated Development Program, May 2003 the major problems of the schools are shortages of class rooms, desks, diploma level teachers, and lack of water and toilet facilities. Except Fofa primary school, the quality of education provided in all primary schools is poor. At Woreda level, there are about 13,804 students of whom 54.5% are males and 45.5% are females.

Table 5-31: Type and Number of Schools in Yem Woreda

Types of School	Grade	Number of Schools
Primary School	1 to 4	6
Primary school	1 to 6	4
Primary school	1 to 8	9
Secondary school	9 to 10	1
Total	-	20

On the other hand, the Bidru rural communities do not have school in their community. However they use schools of Sekoru town since they are not very far from them.

5.3.4.3 *Water supply*

The Bidru rural communities and their environs have several springs that are used for drinking. Some of the springs are Bidiyo, Meleka Abadira and Billea. For their cattle watering point there is a river called Bidru. It serves all year round for the rural communities.

The Yem Woreda is rich in water resources, drinking water supply dominantly being from springs and ground water. It is discussed in Yem Woreda Integrated Development Program that there are 13 kebeles, which do not have any kind of potable water supply system. Those do not have water schemes collect water from open springs and streams are easily exposed to water borne diseases. The potable water supply of Fofa town is also in poor condition. There are only three public taps to serve the whole population of Fofa town. The large number of the town population use traditional springs available in their localities. The water tariff of the public tap is Barr 0.5 per 6 litres of water. It is about Barr 8.35/m^3.

5.3.4.4 Communication Facilities

There are post office and telephone services in Fofa town. However these facilities need to be improved. Transport and communication facilities and services in Fofa town are very poor for the fact that there is no public transport. The gravel road from the main road of Addis Ababa-Jimma to Fofa town was constructed very recently. There are some private mini-buses from Fofa town to Sekoru and then to Jimma, but the transport cost is very high as compared to public transport costs in other areas. One has to pay Birr 25.00 for mini-bus transport for 134 km, which is from Fofa to Jimma but the public transport cost for 102 km, which is from Sekoru to Jimma, is Birr 15.00. On the other hand, Sekoru town is much better than Fofa in terms of transport, telecommunication, and other facilities.

5.3.4.5 Other Facilities

Electric facility has started in the town this year in 2004. At present there is no other facility such as hotels and restaurants in the town. However, in Fofa and in other market centres there are few Kiosks and bars for serving local food, and beverage, soft drinks, coffee and tea. As of the year 2003, there are about 33 grinding mills in the Woreda out of which 17 are in the 4 semi-urban centres, namely Fofa, Deri and Saja. Since the grinding mills are unevenly distributed and there is no competition, the women are forced to make long-distance trips on foot to towns carrying 23.6 kg of maize or Teff, pay exorbitant prices, about Birr 10-15/quintal, and suffer intolerable queuing and poor services.

5.3.5 Gibe State Farm

The Gibe Farm was established by private entrepreneurs in 1956/57 and was confisicated by the Socialist Regime. Since then the farm is managed as a State Farm under Horticultural Development Enterprise. The other farm area that is within the Gilgel Gibe II Hydropower project area is the Gibe State Farm. The Gibe 1 farm is located in Gurage Zone (at the left bank of the Gibe river) and Gibe 2 in Jimma Zone, Sekoru Woreda (at the right bank of the Gibe river).

The total area under irrigation is about 300 ha. The State Farm irrigates the area with three pumps, two pumps for Gibe two and one pump for Gibe one. The main crops of the farm are cash crops, which are cotton, onions, tomatoes, pepper, oranges, and grapefruit.

The State Farm has about 450 to 700 temporary employees and 166 permanent employees and the livelihoods for an estimated 3000 people depend on the Gibe farm. The monthly income of a permanent employee ranges from Birr 266 to 2700 while the salary of a temporary employee is only Birr 266. Anyway, temporary employees will have the chance to earn am amount of money greater than their usual salary in the time of cotton collection.

The sources of the temporary workers are Woliyta and Arba Minch in the Southern Region. Moreover worker will be shifted to Gibe farm from other state farms where there is no much work to be undertaken.

The Gibe State Farm is also among the main sources of income for the rural communities who live around. The other sources of income to the rural communities are agriculture and livestock rearing. The area around is suitable for cattle and goats but not for sheep and pack animals. There is a livestock research centre near the state farm. The rural communities get benefits from the research centre to handle their livestock. Although the local communities use the Gibe River for drinking and for their cattle watering point, they do not use the river for irrigation purposes.

5.3.5.1 Social Service Conditions in the State Farm

Malaria, water born diseases and pneumonia mostly affect the farm and the area around. The prevalent livestock diseases are ‘Gendi’ and ‘Goloba’. The state farm has two clinics, one for Gibe 1, the other one for Gibe 2. The clinics are not well equipped with health technicians and other facilities. There is only one health assistance in one clinic and one nurse in the other clinic. The state farm clinics sometime give service for its environs. They usually go to other public clinics such as Wolkite and Abelti health services found very far from the communities.

Water supply service in the farm and in the rural kebele is the main problem of the communities. There is no other alternative source of water except the Gibe River. The rural people do not have the knowledge how to prepare river water for drinking. This is one of the reasons that most of the people are affected by water borne diseases.

Regarding to education facility, there is a junior school (1 to 8) at Gibe 1 and an elementary school (1 to 4) at Gibe 2. The media of teaching is Amharic in both schools because the students are from different ethnic groups. Although the schools give service to the surrounding communities, the rural communities have no interest to send their children to school.

The other important available facility in the farm is grinding mills. There are four grinding mills in total for Gibe 1 and Gibe 2 farm, and the mills also give service for rural communities.

Most of the farm workers use kerosene for light at night while very few of them use electric light from generator.

With regard to market facility, there is a small market called Medale, which operates on weekly basis in the market days of Tuesday and Saturday. The market is located at the distance of 1 km from the farm state. Other alternatives are big markets, which are Kumbe and Wolkite located at the distance of 30 and 37 km respectively.

The farm workers and their families use either shared or private pit latrines while the rural communities reside at the proximity of the Gibe farm use open areas.

There are religious institutions such as church and mosque in and around the state farm for both the farm and the nearby rural communities.

6 PROJECT BENEFITS

A new hydroelectric plant along Gilgel Gibe - Omo River cascade represents a relevant step towards the country modernization. It will produce advantages for the country in terms of working opportunities, global economic growth, environment improvement, development in roads construction and communications, growth of new social activities along the main new roads, better health conditions correlated to the social growth. Other benefits related to the power plant construction are represented by the satisfaction of regional water needs and the control of Gilgel Gibe river annual flows. This control will allow an agricultural development free from the water flow level variations during the rainy season.

In that area, the main economic benefit will be the temporary, but considerable, labour opportunities for the local population. Approximately 1,000 temporary jobs will be available for unskilled and semi-skilled workers. The benefit will last only during the power plant construction period, producing approximately 2,000 unskilled and semi-skilled employment per year. Since most of the wages derived by all the labour connected with the power plant construction will be spent and invested in that zone, the local economy will grow. Contractor will spend money to purchase food and services locally if the local entrepreneurs can be positioned to take advantage of the potential local economic windfall. Moreover, when contractors will spend their money for the services purchasing, the local entrepreneurs will take advantage from the potential local economic windfall.

In terms of roads and settlements, Gilgel Gibe II Project will require some efforts. In fact, new roads will be built to reach the powerhouse and the tunnel adits. Particularly, on the left side of Omo River, a road will be built for 34 km, from Kose to Omo River. Other roads will be built near the tunnel site camp, linking to adit camps and site installations.

A new bridge will cross the Omo River, few meters upstream the power house.

This new road net construction will give a boost to the commerce growth. In the whole region, the project will have a positive impact on the local economy. Transportation companies, hotels, small factories and other outlets providing goods and services will take advantage of the project, the purchase of goods and services will generate income, and contribute to salaries and employment during power plant construction.

Some of the small entrepreneurs without aspirations of long-term economic growth probably will move in other zones after power plant construction, but a large portion of the commercial growth will remain.

Moreover, as it was the case for Gilgel Gibe I project, hydro plants contribute to the national grid and assist in meeting country's demand for electrical energy that is an essential part of economic development. Similar projects, as Gilgel Gibe II allow the country to mitigate the expenses (in foreign currency) for fuels and thermal power import and their transportation charges.

Hydro power plants, and particularly Gilgel Gibe II, offer a further benefit: they allow the regulation and the control of possible floods in the plain area of the Gilgel Gibe and Gibe River confluence. Moreover, thanks to the power plant building some problems relevant to the stability of the lateritic colluvium covering the bedrock and the outcrops of tuffs (which offer a slight stress resistance and slight geotechnical parameters of equilibrium during rainy season) will be solved.

The proposed access road construction and hydropower project would provide several positive impacts. The major positive impacts are described below

- Job Opportunity to Local People

  The creation of temporary job can be considered as one of the positive impacts of the access road and hydropower construction to the local people. Some individuals may involve as daily workers and gain skills that can be applied in other construction projects too. Further direct opportunities include entrepreneurial development as a result of the increased population flow. This includes items such as supplies, accommodations, food outlets, restaurants etc. The general economic improvement of the area due to increased access and increased work force flow will create further indirect job opportunities too.

- Access to Health and Education Facilities

  The proposed access road would create easy access to educational and health facilities and market access to people living alone the project area, particularly for those who are living in the low land and inaccessible part of the area.

- Economic Growth

  With enhanced movement and accessibility created in the project area, the economy of people served by these infrastructures will be improved and shared with the overall economic improvement of the country. Other benefits such as reduction of travel time, reduction of mud and dust emission and associated health improvements would be achieved. These and other positive impacts would help to increase overall economy of the people living around the project area and that of the country.

- The Access road will help the connection among other zones

  Besides giving access to the power house site, the proposed access road can be extended to connect Yem wereda with other zones of the region such as Hadiya, Gurage etc, and it can reduce travel time and expenses which otherwise required to go through long and tedious routes.

- Gender Impacts

  Women during the access road and hydropower construction could work as daily labourers and as well as in other similar activities in the project implementation. Female headed households in particular could benefit from these projects work through employment opportunities that would be created. They also gain working skill that can be applied in other similar activities.

The other benefit of the project for the women during the construction phase is that it would help to start small business such as opening tea houses, small restaurants, small shops etc. These activities will help to generate additional income to the family, thereby contribute to empower women in the family as well as in the community. The constructed access roads also provide easy access for market places and other social infrastructures, which contribute in reducing burden of women and save time of travel.

Therefore, in order to exploit these advantages, the project owners should encourage use of local people during the construction phase of the project, giving priority for women where possible.

7 IMPACT ASSESSMENT

7.1 Physical Environment

In order to estimate the Environmental Impact of the proposed project and foresee which component of the environment will be subjected to some (positive and/or negative) impact by the project, a description of the "*Environmental receptors of impact*" has been carried out.

The following table describes the potential impact on each environmental component during the construction and the operation phases .

Table 7-1: Environmental receptors of impact

Receptor	**Description of the potential impact (positive and/or negative)**	
	Pre-during construction	*During normal working operations*
Air quality	dust production; transport pollution.	CO_2 emission reduction
Surface water	river flow alteration; pollution hazards; water resources availability	river flow alteration in the Gilgel Gibe; flood control; better use of water resources
Underground water	water disturbances	water disturbances
Soil	land occupation for allocating the excavated material	reduction of soil erosion due to the reduction of wood cutting for local energy production
Geomorphology	construction spoils	stability of the disposal area
Flora	destruction of natural forest	destruction of natural forest in the disposal areas
Ecosystems	local ecosystem disturbance	alteration of the local ecosystem
Socio-economy	employment opportunities	employment opportunities
	health risks	family income and structure
	custums of imported workers	opportunities due to the availability of power; infrastructure development
Health	sanitary conditions at camps; car accidents; diffusion of sexually transmitted diseases;	sanitary conditions inside the powerhouse and in the substation area; water quality, due to waste water production in the powerhouse;

7.1.1 Geothermal activity

There are not certified occurrences of geothermal activity in that zone, but under Mt. Bor, where the tunnel lays under 1,400 m of rock cover, a gradient of 3°C per 100 m is reasonable. Local and isolated hot spots in excess of the gradient temperature may occur in fault zones where they should carry thermal and juvenile water.

7.1.2 Seismology

The project area is more than 100 km far from the most important seismic centers.

Any seismic event that could happen would have negligible effects on the project area.

In case of an earthquake in the project area, the basin upstream the tunnel wouldn't have any significant influences neither on the reology nor on the main geotechnical characteristics of the rocks around the basin that constitute the sides of the Gilgel Gibe River. This fact is due to the basin above the alternative weir that is quite little and the water inside could go through Gilgel Gibe river bed.

Due to the geological formations outcropping in the area, which present fractures, there could be slides from the sides, but their consequences are not foreseeable. Also the residual, subtropical lateritic soils, which have been formed on hill and ridge foot slopes, could slide into the basin during an earthquake, generating a water wave in Gilgel Gibe river bed.

The water movement in the basin above the weir could generate micro-earthquakes with minor effects on the tunnel; in fact the expected RIS (reservoir induce seismicity) is very low because of the modest quantity of water in the basin above the tunnel. The area involved should be only the one nearest to the basin, and it does not involve human lives, or facilities.

In this area RIS is very low because the population does not live in the buffer zone, which is the most critical for RIS.

About the effects on the hydraulic packing in the tunnel, the consequences of an earthquake are comparable only with the completely tunnel plugging, with water flow and power plant turbine blocking. This fact does not involve neither people, nor structures.

7.1.3 Hydrology

While the weir is under construction, temporary diversion tunnel will allow the river to bypass the work site. The river downstream would maintain its natural flows during this phase including the potential for heavy floods, even if controlled by the Gilgel Gibe I Dam.

The presence of Deneba reservoir has regulated the water flood in Gilgel Gibe River, and flood events have become insignificant for the population living between the dam and the confluence of Gilgel Gibe River in Gibe River.

Building a weir about 33 meters height, with a minimum guaranteed runoff of 2.0 m^3/s, the potential for downstream flooding still exists although reduced in extension and frequency of occurrence, because all water turbined by the Gilgel Gibe I Power Plant (about 100 m^3/s) will be accumulated in the basin and diverted to the tunnel.

The predicted daily drawdown is 3.3 hours; the reservoir will reach its full area of 0.15 km^2 which will occur when the spillway would be close into the tunnel.

During diversion, the water level into the basin above the dam rapidly drawdowns of 7.5 meters in 3.3 h; this pressure abatement may generate a side collapse around the new basin. The problem will be kept under control within limits acceptable for the lifespan of the reservoir.

Downstream the weir there is only one significant river, called Bidru River. In this area this represent the most important river, with a catchment area of about 46 km^2.

An alternative diversion weir project to locate the structure just downstream the confluence of Bidru River in Gilgel Gibe River and to use also its water to product hydro power is been discarded for the following reasons:

- this river is the only one that could guarantee a minimum runoff downstream the dam between the weir and the confluence of Gilgel Gibe River in Gibe River
- the solid transport of Bidru River includes large blocks, so that it could be at least onerous to use this water.

7.1.4 Hydrogeology

From the published studies among the Ethiopian Hydrogeology, it's not foreseeable for the area if there are water springs potentially affected by the tunnel building.

Water capture could happen and this means that people on the plateau will have no more water from their wells.

The geology assessment with fractures in the bedrock, suggests that there is interstitial water in those fractures, but it's not foreseeable at present.

Newer information could be taken from the test hole done in borehole 2, from which it could be possible to understand the underground water circulation.

7.1.5 Storage sedimentation

During the construction phase, substantial effects on the characteristics of the sedimentation regime in the river section below the weir are not expected as the environmental management plan envisages erosion control caused by the construction through a constant on-site surveillance.

In terms of operation, granulometric analysis indicates that most of the suspended sediment is represented by very fine particles of silt and clay.

From the data obtained for the Gilgel Gibe I Project, the trap efficiency was expected to be in the range of 80 to 90%; this means that the remaining 10 – 20% part would be the solid part of the water turbined by the Gilgel Gibe I Power plant. With a sediment content of the water outflowing from the power plant of 0.0255 mg/l, the minimum volume of sediment content is 0.28 million m^3/year, and the maximum is 0.34 million m^3/year.

Given the very small size of the particles and the limited head, no special abrasion problem are expected.

The drawdown time (3.3 hours) is very fast to avoid sedimentation of these particles, so that it's expected that landfill phenomena will be negligible, and the dead storage of 1 million m^3 is considered sufficient to ensure the proper operation for an economic life period of 25 years.

7.1.6 Water quality

Contamination of the future reservoir water from faecal matter and domestic wastes will not be a serious problem since all villages and individual house are far away form the reservoir location.

Moreover due to the daily regulation, the retention time within the reservoir will be very short.

The quality of water into the reservoir will maintain the main characteristics of the water upstream.

There may be some pollution risks during the construction works: proper storage, handling and disposal of construction materials, particularly chemicals, fuels and lubricants must be strictly followed in order to prevent this kind of risks.

Moreover during normal operation activities, the provision of treatment facilities for human and domestic wastes at camps, at the powerhouse and at the substation location will reduce the threats of water pollution.

7.1.7 Climate

No negative effect may be expected by the project on local climate characteristics: the reservoir created is to small to produce any changing on local climate.

Some positive effects may be considered due to the fact that:

- hydroelectric power generation, on air quality point of view, is a totally clean way to generate electricity: there is no emission of dust, CO_2, NO_X, SO_X, etc…;
- the possibility to use electric power for cooking and for heating, may reduce the local consumption of forest wood. The deforestation is one of the main environmental assets of Ethiopian environment: cutting trees, spoiling soil, leads to soil erosion and, on a longer term, may produce desertification.

7.1.8 Downstream effects

Due to the small dimension of the reservoir, the expected evaporation from lake surface will be insignificant.

Considering that the distance covered by the water on the free surface, and thus the relevant evaporation phenomenon will be reduced, a bigger amount of water is expected to reach the Omo river downstream the powerhouse. Moreover this water will reach the Omo river in a constant quantity during the year, increasing the whole quantity of water that may reach the Turkana lake.

The discharge of a big amount of water (100 m^3/s) in a concentrated area along the Omo river, may cause some disturbance to local river fauna,

Flow diversion due to Gilgel Gibe II dam will influence the downstream stretch as far as the plant outlet on the Omo river. This impact will affect mostly the Gilgel Gibe reach between the Gilgel Gibe II inlet and the Gibe confluence; downstream this confluence the impact will be negligible because of the significant discharge of Gibe river.

The management plan of the new plant envisages the utilisation of the same water volumes discharged by Gilgel Gibe I plant. Because of that, the compensation flow in the most affected stretch will be set up by the following:

- Gilgel Gibe I compensation flow (1 m^3/s)
- discharge from the residual catchment between the Gilgel Gibe I dam and the Gilgel Gibe II weir.

All these flows can be estimated in about 2.0 m^3/s on average, based on the catchment area of tributaries and the specific discharge computed from Deneba river station data.

Moreover the river flow in this stretch is further increased by the Bidru discharge which enters the main watercourse just downstream the Gilgel Gibe II weir and by the Chilelo river.

7.1.9 Landscape

Some small impacts may be expected on landscape:

- the weir is located in a deep and steep valley, and its visibility will be very low from every point of view;
- the lake created will have a small extension and will not create any impact on landscape point of view;
- the allocation of the disposal materials will produce the filling of an unexploited small valley;
- the powerhouse as the substation will be located on the Omo river banks, and will have a certain visibility, even if in that area the Omo river is almost a gorge;
- the construction and the permanent roads may be locally highly visible.

7.2 Natural Environment

7.2.1 Natural vegetation

Water is an increasingly valuable resource to humans in most parts of the world, and rivers and streams have been the focus of human culture and activities since the dawn of civilization. It has been shown that here are connectivity and linkage problems at all scales relevant to human perception and actions as well as to other communities emanating from interference. The interference may be justified from the point of view that humans are part of the landscape rather than external forces. To other organisms occupying the riverine and the surround landscape, however, these interferences may be expressed in differences in patch quality and in the cost or benefit of being in a particular patch type at different times (Wiens, 1997).

The scales on which human influences operate are often quite different from the scales on which ecological interactions take place. Biodiversity is known to be greater at ecotones or boundaries between patches in the riverine landscape (Amoros, Gibert & Greenwood, 1993; Ward & Wiens, 2001; Ward & Tockner, 2001), perhaps as a consequence of the attraction of some organisms to the boundary and the accumulation of others at the interface between hospitable and inhospitable patches. Because different taxa may respond differently to landscape properties, the spatial patterns of diversity may also vary among groups.

Although the changes in the surrounding area that accompany flow regulation are traditionally thought of in terms of local disturbance and succession in the vegetation, a landscape perspective draws attention to the importance of altering the seasonally pulsed connectivity between the aquatic and the terrestrial ecosystems.

Thus the width and composition of riverine vegetation bordering a river, for example, can influence such things as the occurrence and rate of predation by terrestrial predators on aquatic organisms, or the movement of aquatic insects into the riverine zone. Less obvious, but perhaps no less important, are exchanges that occur across the boundaries beneath a river or stream, into and out of the sediments (Stanford & Ward, 1988; Ward, 1989, 1997; Palmer et al., 2000; Ward & Wiens, 2001. Reduction of river water flow would restrict both the lateral connectivity between the river and the surrounding area and the temporal and spatial variance in connectivity in the main stem of the river (Ward & Stanford, 1995; Kingsford, 2000). It is therefore necessary to reiterate that the season flood pulses and the resulting patch dynamics are essential for the existence of riverine systems. Management without giving due consideration to scaling effects of the alteration is therefore likely to be risky since the ecosystem functions of the valleys namely the functions such as service as corridors, refugia and biodiversity bank of the system will be disrupted and the effect will be felt all along the length of the Gibe River System. The complete cessation and drying up of the river bed of the water in the Gilgel Gibe would disrupt the whole ecological process.

Although comparison of the species list of the riverine and the surrounding vegetation with the list of endangered and endemic plant species of Ethiopia (Ensermu et al., 1992) does not indicate any endemic or endangered species in the area, the altitudinal partitioning of the vegetation would be affected by the drying up of the river bed. It is worthy to note that it is not only the species composition that should receive attention but also the assemblage of the species and their stratification and the energy flow across the landscapes and trophic levels. The alteration of the water flow in the river and the accelerated human interference by way of harvesting the vegetation for various domestic uses and charcoal production could disrupt the ecological balance and the effect could cascade to the animal communities. The opening of the access roads to the powerhouse and to the intake point of the tunnel is likely to accelerate the human interference on the vegetation.

7.2.2 Fauna

In this chapter potential impacts on the fauna ecosystem have been identified. Fauna Ecosystem will be affected in the following three ways:

- Disruption of the continuous river flow through the construction of the weir; this interrupts upstream and downstream migration routes of aquatic animals.
- Severe reduction of river flow below the dam, thus reducing the habitat for the species.
- Formation of a pond, which completely changes the living conditions for aquatic species; some species will thrive under the new conditions, while others will not be able to adapt and will therefore disappear or being reduced to further upstream habitats.

Once this stretch of water will be ponded on behind the proposed weir, some ecological changes are anticipated from a flowing (lotic) to a standing (lentic) system. The volume of water to be enclosed in the future pond will have some ecological bearing. Large animals such as hippos and crocodiles will have to be encouraged to move further downstream and ultimately to the Gibe and Omo river basins before the weir is constructed. This will help to reduce the population that will be trapped in the lagoon where otherwise a trapped population beyond the carrying capacity of the lagoon may exhaust food supplies and ultimately thin out itself. Whatever scenario we anticipate, there appears to be no danger of loss of unique, endangered or rare large aquatic animals in this area.

The flooded riverbank vegetation will increase biological productivity in the lagoon for a few years. Small animals such as fish and invertebrates will also be impacted after the construction of the weir. Lentic and planktonic invertebrates will be positively favoured. Rheophilic fish species such as characids, cyprinids and Garra may not do well after the disappearance of the riffles. Mosquito may breed profusely; lentic adaptable fish such as Barbus and Oreochromis will flourish and may even support a small fishery (as they have done in the reservoir already). Benthic fauna such as Simulium may be negatively impacted and may even be wiped out, but this may be a blessing in disguise (No Oncocerciasis case was seen during this study though).

As regards the aquatic vegetation, undesirable macrophytes may increase due to infestation and cause mechanical problems in the intake system. This experience seen in large dammed reservoirs such as Koka and Finchaa may not however be severe in this scheme.

It is anticipated that birds may not be impacted because of their mobility while the forest invertebrates and wildlife may still persist.

Both during construction and operation phases, not much impact is expected at the project site on the fauna, terrestrial, domestic or wildlife, because this area is already devoid of human and animal populations due to the inhospitable environment.

Siltation may increase at the river due to disposal of soil and construction fillings. The effect of enhanced sediment load on the fauna may be directly harmful on the smaller invertebrates and perhaps fish. It was noted during this survey that the two rivers studied, viz, Gilgel Gibe and Greater Gibe generally had very turbid and silty waters, which could be a seasonally observed phenomenon as in most other Ethiopian large rivers. Large animals such as crocodiles and hippos may be indirectly affected due to reduced fish food in the river.

7.3 Socioeconomic Environment

7.3.1 Impacts Related to the Diversion Weir

The proposed diversion weir is located about 4 km downstream from the present powerhouse of Gilgel Gibe I Hydropower Project. Yero Sekoru and Kore rural communities at the right bank of the Gilgel Gibe River, and Rukensa and Gosu rural communities at the left bank of the river bound the Diversion Weir. The area where the diversion weir is situated is known as Degosa. There are no settlement areas in and around the weir and relatively small impoundment area.

The Degosa area where the diversion weir is located is the source of firewood and charcoal for the closer communities such as Bidru. They use the area for grazing during dry season despite the fact that it is not accessible for cattle grazing and also they also use the river as cattle watering point.

The area between the present powerhouse and the proposed diversion weir is not accessible for the surrounding communities neither for grazing nor for farming. Moreover, at present there is no crossing points or footpath on the Gilgel Gibe River (between that provide services to the rural communities). Currently, the rural communities use the dam crest road built at the Gilgel Gibe I and the bridge near the dam to cross the river.

Development of subsistence and commercial fishing at the Gilgel Gibe I Hydroelectric dam is underway. Fishery development enables the local communities to diversify their economy. The introduction of fishery development could help to improve the nutritional status of the local people. Moreover it could be a source of cash income due to commercial fishing. The construction of the diversion weir and creation of a small pond will also create a favourable aquatic environment for fishery development.

7.3.2 Impacts Related to Construction of Access Road

Environmental impacts due to the proposed access roads to diversion weir site and Omo river power house of Gilgel Gibe II Hydropower project was assessed during the fieldwork. Necessary data were collected from field observation and appropriate sources and other sector studies of the project. Consultations with local officials and local people were made to obtain local interests and existing problems. Review of pertinent policies and guidelines were made to abstract data and information useful for the environmental assessments. Finally, the collected data and information as well as data generated by other sector studies were analysed and this environmental impact assessment report was prepared.

Key potentially beneficial impacts associated with the access road project implementation are all related to the post-construction phase and are as follows:

- In terms of positive impact, the proposed access road development will improve communication and market outlet to a higher extent for the existing population. Government officials and local people strongly believe that the road improvement will facilitate the provision of agricultural inputs to the remotest part of the Woreda. The absence of accessibility to inner parts so far hampered the agricultural extension effort to a considerable degree.
- Significant reduction in transport time and costs which will benefit all communities served directly or indirectly by the access road.
- Improved communications for communities on or near the access road.
- Improved access to health facilities.
- During construction considerable number of people will also be expected to be involved as a casual labourer. There should be a need for consideration in employing women and other disadvantages group.

Benefit enhancement measures are based on the incorporation of appropriate features in project designs, and adoption of a high standard of routine and periodic road maintenance so that benefits are sustained in the long term.

7.3.2.1 Access Road to the diversion weir Site

The access road to the diversion weir is located at Bidru sub-rural kebele of Yoru Sekoru Kebele in Sekoru Wereda, Oromiya Region. The distance of the access road is some 5 km from the main asphalt road and it passes through grazing land and woodland. The access road also touches a very small Teff crop land. The area along the access route is not suitable for crop cultivation since the wild animals like monkeys and porcupines could easily damage the crops. Therefore, crop production along the access route is not manageable for the communities since the nearest settlement to area is far from the diversion weir site mainly due to malaria cases.

7.3.2.2 Access Road to the Proposed Powerhouse

The access road to the proposed powerhouse is about 30 km from Fofa town as far as to Shosho rural Kebele of Yem Special Woreda. It passes Fofa and five Kebeles of Yem Woreda, i.e. Gurumena Haneger, Meleka, Kerzidoyo, Shosherna Alman and Shosho. As it is observed, most of these Kebeles will not be affected due to the access road since the large parts of the area along the road is neither grazing land nor cropland.

One of the potential impacts due to the construction of the access road to the proposed powerhouse is the loss of few residential houses, crops and some trees around the homesteads, indigenous natural forest and woodland. In this regard, the most affected area is Fofa town. During this impact assessment, it is observed that a committee for compensation arrangement has already been established by the local authorities. The committee has five members; two members represent the Yem Special Woreda Council, one from kebele administration, the other one is from the Woreda Rural Development Office and one representative from Project Affected People (PAP). The committee made estimation for the properties that are likely to be affected by the construction of the access road. According to the Committee, the numbers of the affected households in the town are 15 and of which only 5 households could lose their residential houses. Moreover, some amount of perennial crops such as Enset, coffee, chat, ‘gesho’ and parts of the fence of Fofa elementary school, and different trees around the homesteads of the households, could be affected. In Meleka rural Kebele about three households will lose their Enset around their homesteads.

The loss of Enset would bring a crucial problem for the affected households since it is their main stable food and takes more than five years to be matured. The loss of Enset is classified in three stages by the Committee. Based on this classification, the loss of Enset in numbers per household in Fofa town could reach up to 313 matured Enset, 508 averages Enset and 85 young Enset. The estimation made for the above loss of Enset is Birr 20, 10 and 0.50 per single Enset based on the above category set, respectively. Based on this assumption, a household will lose about Birr 11,382 only from Enset damage.

The committee has set unit cost for the damaged properties in Fofa town for estimation as shown in the table below.

Table 7-2: Unit Cost for the Loss of the Properties

No.	Loss of Properties	Estimation for the loss
1	Corrugated iron house	Birr 117/ an area of one square metre
2	Thatched house	Birr 1040 for 25 square meter
3	**Enset** Stage one (matured) Stage two (medium) Stage three (young)	 Birr 20/single Enset Birr 10/single Enset Birr 0.50/single Enset
4	**Eucalyptus tree** Stage one (fully matured) Stage two Stage three Stage four Stage five Stage six	 Birr 44.20/tree Birr 9.60/tree Birr 5.00/tree Birr 2.70/tree Birr 1.35/tree Birr 1.35/tree
5	Zigba	Birr 132/tree
6	Koke	Birr 10/tree (matured)
7	Coffe/Gesho	Birr 10/tree (matured)
8	Chat Stage one (matured) Stage two (not matured)	 Birr 12/tree Birr 3/tree

As the effect of the access road construction, the rural communities could easily reach to the woodlands to collect firewood and prepare wood charcoal.

A direct conseguence of the access road during construction is the production of dust (air) pollution, noise pollution and soil erosion. Increased dust levels on local settlements and vegetations are limited to Fofa town and some minor rural settlements. Noise and vibration from earth moving trucks and other vehicles can also affect the town and rural settlement areas. The construction of the access road could also increase risks of soil erosion.

During the construction of the access road, a number of people in and around the project area will have the opportunity to be employed for some times.

7.3.3 Impacts Related to Construction of Camps, Stores and Office

Camps, stores and project office will be constructed on the selected sites. According to the Fofa Woreda Administration Bureau, the camp, which would be constructed at Meremet, will occupy an area of 5000 m^2 of grazing land, which is used by rural communities. The other camp that would be constructed at Kerzidoyo rural Kebele would occupy not less the area taken by the camp that will be constructed at Fofa town. A big mine store would be made at the area called Zofkare/Ckekera on one hectare of land. Project office and store are the other construction activities that would be undertaken down nearby the powerhouse.

The other negative impacts of these construction activities are dust pollution and soil erosion.

During these construction activities, numbers of people from the project area and elsewhere will have opportunities to be employed. Some employed workers will continue as permanent employees of the project.

7.3.4 Impacts Related to the Workforce

7.3.4.1 Disease Transmission

During construction, there will be job opportunities that attract labour force from out side the area. This influx of large number of people will change the existing population structure in number, age, and health history. The main effects could be the exposure of workers and their families to locally endemic diseases such as malaria through contact with insect vectors. In-migrant workforce who may bring non-endemic diseases to the area might aggravate the situation. There could be increased risks of transmission of endemic diseases and sexually transmitted diseases including HIV/AIDS, due to the increased movement and interaction between the local community and the incoming population.

7.3.4.2 Cultural Diffusion

The in-migrant people for job opportunities could have different cultural backgrounds and behaviours that might not be comply with the culture of the local communities. During the socio-economic impact assessment it is identified that the peoples of Yem Special Woreda are known in their good culture. To mention some of them, they are very hard working and faithful for their partners. In Yem society, a male or a female person do not start sexual practice before marriage, and they do not have other partners after marriage. On the other hand, the cultural diffusion that could be caused by the influx of people could bring social interaction, skill and other socio-cultural development in the Yem society.

7.3.4.3 Unstable Market and Escalation of Market Price

Yem Special Woreda is not a food self-sufficient Woreda and at present could not support/feed its population more than seven or eight months a year. In-migrant labourers and technical personnel coming from out side and their families will exacerbate the problem. The local residents due to the increased trading possibilities might easily accept the construction activities and the camps. The suddenly created demands on the items such as food, drinks, fuelwood etc. and different services may considerably raise the prices of local products/services. The more cash may also temporarily inflate local prices and cause bad feelings in the local population. The people selling their products or services will benefit, while those local people who are dependant on the same purchases may suffer in the form of increased prices. Therefore, occasional and personal conflicts will be expected due this and many other reasons.

Employment opportunities, for skilled and unskilled laborers will be created during construction. However, the potential for direct local employment creation and the resulting contribution to rural poverty alleviation is relatively low as a result of the fact that contractors usually bring in most of their skilled and semi-skilled workforce from outside the project area, because suitable skills are not available in rural communities. Development of major conflicts between local communities and contractor's migrant workers are not to be expected in this project area. However, minor contractor/local community disputes concerning real or perceived issues will undoubtedly arise during the construction period, particularly if labor is predominantly from communities not in the immediate vicinity of the roads.

Although labour recruitment is a matter for the contractors, who have the right to determine whom they shall and shall not employ, they should be formally encouraged to hire locally wherever possible, in order to maximise the benefit distribution and social acceptability of the project.

- The contractor should be required to use his best endeavours to maximise local hire of labour, in so far as this is compatible with his skill requirements.
- Contractor should be required to assign responsibilities for liaison with local communities and local authorities to a named individual from the Contractor's organization who is permanently on site, and to require effective liaison to promote social integration, and the development of mutually satisfactory solutions to problems affecting local communities.

7.3.4.4 Housing/Accommodations

A number of people will in-migrate to Fofa town in search of job opportunities since most of the project component sites are located in Yem Special Woreda. Therefore, people coming from out side need shelter, food and other services. However, Fofa town has not any capacity to give such kinds of services to the large number of people for the fact that at present there is no any hotel and restaurant in the town. The non-availability of such accommodations and other social services in the town will create a new demand which may cause social disturbance within the local communities.

7.3.4.5 Impacts on Social Services

Construction is inherently a relatively dangerous industry, and accidents invariably occur. In the Yem Special Woreda, which already has relatively poor resources in terms of medical services, the presence of contractor's workforce can impose additional strains, reducing their effectiveness as far as the local population is concerned. It is also reasonable to expect that the contractor should exercise a duty of care towards his workforce in relation to injuries sustained at work.

7.3.5 Impacts Related to Gibe State Farm

At present the Gibe State Farm is the only irrigation farm, which uses Gibe River. The total irrigated area so far is about 300 hectares. There is potential irrigable land to expand the farm. The Farm is the main sources of income for many people reside around and for the workers those who have come from different areas of Ethiopia.

Among the main tributaries of the main Gibe River are Gilgel Gibe and Walga rivers. The impact occurred on either of these rivers would have definitely an effect on the main Gibe River. During the implementation of Gilgel Gibe I Hydropower Project, the volume of the main Gibe River has been decreased so much to the extent that the pumps could not pump out water easily to the irrigable lands and the state farm had to make some arrangements to hold the water at appropriate direction to make the pumps functional. This happened in 2003 at the time of Gilgel Gibe I reservoir filling period.

At present, the volume of the main Gibe River is much higher than its normal volume that had before the construction of the Gilgel Gibe dam. The construction of Gilgel Gibe II hydropower Project will alter this condition as it happened in the filling of Gilgel Gibe Dam. According to the information from the state farm workers, the main Gibe River volume will be decreased and as the result of this the pumps will not get sufficient water to pump out water to the irrigable lands unless a sort of dam is not constructed.

The impacts on the Gibe State Farm would worsen during the time when development activities start along the Walga River. The threats of the state farm are that some irrigation development activities along the Walga River will take place so that the Gibe state farm will face some problems. These threats have some grounds for the fact that the government encourages at national level to use any approperaite rivers for the development of irrigation developments for food-self-sufficiency. According to the information from the Gibe farm community members, an organized farmers assisted by NGO have started irrigation development activities along the Walga River at an area called Telilih in Gurage Zone of the Southern region.

7.3.6 Impact on cultural, religious and archaeological sites

During the field investigation the importance of the project area and the immediate surrounding were assessed for their potential archaeological and religious importance by interviewing the local residents and authorities. According to these officials and local residents, the Gilgel Gibe II site has no signs of archaeological artefacts or cultural sites which could give such importance as to hinder the execution of the project.

The Gilgel Gibe II hydropower project does not require a creation of reservoir and the only affected areas are the construction sites around the diversion weir, intake, access road and the river banks downstream of the powerhouse.

The proposed project area is out of paramount archaeological and cultural importance. Therefore, there will be no impact on archeologically and culturally important sites.

The field investigation indicated that the project area is sparsely populated. There are also no churches or mosques that could be affected as the result of the flooding and/or construction activities.

Traditional believes which consider some streams, hills, trees, etc, as holy places is still strongly represented around the project area. These places are away from all construction related activity sites and will not be affected by the project.

7.3.7 Feelings and Expectations of the People in the Project Area

This section deals with the expectations and feelings/threats of the people of the project area in order to give approperaite considerations in the process of solving the likely social and economic issues that could arise during project construction activities and to support in the fulfilment of their needs.

7.3.7.1 Bidru Rural Communities – Sekoru Woreda

The impact assessment team made contacts with some of the members of the Bidru rural communities. The team interviewed community members about their feelings and expectations from the project. Their responses are summarised and presented as follow.

- They are not new about the proposed project.
- They knew that the electric power is the basis for social and economic development.
- Some of them were employed as labour workers during Gilgel Gibe I Hydropower Project construction.
- They are very happy about the project for they will have new job opportunities.
- They explained that people have started to fish from the Gilgel Gibe reservoir and the people around the reservoir have benefited from this fishing. If the diversion weir and its associated pond creates conducive environment for fishery development they will be the first beneficiaries since their settlements are not very far from the site.

7.3.7.2 Sekoru Town

The impact assessment team has also made contacts with Sekoru Health Personnel to collect data on the health conditions of the Woreda. As Sekoru community members they were asked to explain their feelings about the construction of Gilgel Gibe II Hydropower project. Their responses are summarised and presented below.

- Gilgel Gibe II Hydropower Project will have various construction activities and many people will get job opportunities.
- Many different peoples will in-migrate to the project area and the influx of people could increased communicable diseases to the local people. From the experience, it is observed that TB cases in Sekoru town have increased since Gilgel Gibe I Hydropower Project started its construction activities. TB is one of the main indicators for the spread of HIV/AIDS.
- The population of Sekoru town increased very significant due to the Gilgel Gibe I Project construction and hence the existing social service facilities were not in the position to give adequate services for the local and out comers.
- The influx of different peoples to the town of Sekoru and to other urban areas has brought a diffusion of culture to the local peoples. It is believed that this could bring negative impacts on the local social behaviours of the communities.
- The required prearrangements were not made for the local society before the beginning of the Gilgel Gibe I project construction activities. The pre-requisitions should have been included:

Provision of awareness in HIV/AIDS, improvement of social service facilities such as health facilities.

7.3.7.3 Fofa Town

The impact assessment team has also made contacts with Fofa town administration, other government offices and some community members in the town. The team interviewed them about their feelings/threats and expectations due to the project. Their responses are summarized and presented below.

Expectations of the town community

- They explained that they strongly believe that the project could benefit the town in many aspects to enhance the endeavours taken in the development of Yem Special Woreda of the Southern region.
- They believe that many people from the town and out side will have opportunities to get jobs.
- They think that transport facilities and communication networks will be improved.
- They expect that the project will give support to solve the severe water supply problems of the town.
- The community members believe that private businesses will be developed in the town as the result of project construction activities.

Threats of the town community

The team has also attempted to identify the threats of the town during the project construction activities.

- Yem society has good culture, which could protect the people of Yem from HIV/AIDS. These good cultural practices could get loose gradually with the influx of in-migrant people.
- Yem Woreda is a backward Woreda in terms of all aspects. The Yem people life is simply hand-to-mouth. The influx of the people to Fofa town and to other communities will bring severe consumption productions shortages in the market.
- Most of the students of the Yem Woreda are learning on self-help basis since they do not get full economic support from their families. Therefore, many students will be employed in the project as labour workers and quit their education. As the result the number of students in the Yem Woreda schools will decrease and thereby the status of the Woreda education will decline.
- According to Yem Woreda administrator, some problems have already occurred. He explained to us that there was a conflict between the local farmers and the project people during construction activities. The administration has tried to settle the conflict by convincing the affected farmers. The Woreda administrator says that there should be some arrangements made by both Yem Woreda administration and the responsible body of the project to settle the likely social and economic issues before the starting of the project activities. But until this impact assessment studies no one has approached the Yem Special Woreda Administration to discuss common issues and make arrangements.

7.4 Conclusions

A table summarising the results of the impact assessment has been compiled in order to give a comprehensive evaluation of positive and negative impacts caused by the new plant.

This table contains the environmental and socio economic impacts of the construction and operation stages.

The assessment has been carried out through technical meetings among the assessment team experts.

Table 7-3: Synthesis of Environment Impact Matrix

Environment Component	Construction Stage Activity Component					Operation Stage Activity Component				
	Weir	Tunnel	Roads	Powerhouse	Substation	Weir	Tunnel	Roads	Powerhouse	Substation
Physical										
- Seismology	0	0	0	0	0	5	5	0	0	0
- Hydrology	3	0	0	0	0	2	5	0	3	0
- Hydrogeology	0	2	0	4	0	0	4	0	4	0
- Storage sedimentation	3	0	0	0	0	5	0	0	0	0
- Water quality	0	0	0	0	0	0	0	5	4	3
- Climate	0	0	0	0	0	0	0	0	B	0
- Downstream effects	3	0	0	0	0	2	0	0	3	0
- Landscape	5	0	3	1	3	0	0	3	1	3
- Slope stability	4	0	3	3	5	2	0	3	C	D
- Disposal materials	0	2	3	5	0	0	0	0	0	0
Natural										
- Natural vegetation	3	3	2	4	3	2	0	4	0	0
- Fauna	3	4	2	2	3	5	0	5	0	0
Socio – economical										
- Dislocation of people	0	0	4	4	0	0	0	0	0	0
- Agricultural resources	0	4	3	5	5	0	0	0	0	0
- Infrastructures	0	0	0	0	0	0	0	A	A	C
- People's health	3	3	3	3	3	0	0	A	D	D
- Worker's health	3	2	3	2	3	0	0	0	5	5
- Employment opportunities	A	A	A	A	A	E	E	B	C	C
- Economic development	C	C	B	C	C	0	0	B	A	A
- Gender Issues	0	0	D	D	D	0	0	C	C	C

Positive Impact	**Negative Impact**	
A = Very Important	1 = Very important	O = No Impact
B = More Important	2 = More important	
C = Important	3 = Important	
D = Fair Important	4 = Fair important	
E = Less Important	5 = Less important	

8 ENVIRONMENTAL COMPARISON

8.1 Forewords

In March 2001 the Ethiopian Power System Expansion Master Plan was published by EEPCO.

The contract for the Ethiopian Power System Expansion Master Plan project was signed in 1999 between the Ethiopian Electric Power Corporation (EEPCO) and BKS Acres.

The EEPCO had identified various possible hydroelectric projects that have potential for development. At that date the share of hydropower (about 378MW) was more than 95% of the total electric energy consumed in Ethiopia. The primary objective in the preparation of a development plan for the power sector of Ethiopia, was economic efficiency, to ensure that electric power is provided at the least possible cost. Costs would include investment costs, operating and maintenance costs and environmental costs.

For these reasons environmental aspects of the different schemes considered were deepened in the EPSEMP.

In this work several different power generation options are considered and a comparison between all is made with the same EIA methodology.

At the end a ranking of the options considered is done.

In order to understand the Environmental Impact Assessment of the project in relationship with other hydroelectric projects in Ethiopia in the following pages an attempt was carried out in order to make a comparison between Gilgel Gibe II Hydroelectric power project and the other hydroelectric projects considered in the EPSEMP.

8.2 Ranking methodology

In the EPSEMP seven criteria were selected in order to rank the different schemes in terms of their environmental impact:

- Land lost;
- People affected;
- Access;
- Cultural heritage;
- Downstream effects;
- Aquatic ecosystems.

For each criterion, a scoring system was developed to give it a relative value.
The score for each scheme was normalised by using a weighting system for the criteria.

8.2.1 Land lost

Land, especially arable and/or grazing land is a scarce commodity in Ethiopia where the largest part of the population is dependent on agriculture and on cattle. Furthermore, as the population is mostly dependent on firewood as a source of energy, the remaining forests are of high value. For this reason the weights reported in Table 8-1 will given to the criterion:

Table 8-1: land lost weight

Loss in land	Weight
Forest	5
Agricultural land	15

In the different cases the impact of the land lost was scored as reported in Table 8-2:

Table 8-2: the impact of land lost (Ha)

Score	Land lost (Ha)	
	Forest	Agricultural land
0	None	None
1	<500	<1.000
2	500-1000	1.000 – 5.000
3	1000-2000	5.000 - 10.000
4	2000-3000	10.000 - 20.000
5	>3000	>20.000

8.2.2 *People affected*

In hydroelectric projects the resettlement of people represents one of the major impacts. There are not many opportunities for people to find employment and more people are affected by the project more difficult it becomes to assimilate them in the surrounding communities. For this reason a weight of 35 will be given to the criterion and the impact was scored as described in the following table.

Table 8-3: the impact of affected people

Score	People affected (n°)
0	None
1	<500
2	500-1.000
3	1.000-5.000
4	5.000-10.000
5	>10.000

8.2.3 *Access*

Most people in the rural areas walk to the neighboring villages or to markets, while donkeys and/or horses are used to convey their products. A large water body may therefore completely cut them off from the markets and communities on the other side, which previously could be reached. For this reason a weight of 15 will be given to the criterion and the impact was scored as described in the following table.

Table 8-4: the impact of access reduction

Score	Impact
0	None
1	Low
2	Medium
3	High

8.2.4 Cultural heritage

Cultural impacts may be associated with the loss of churches, mosques, historical monuments, archaeological sites and cultural heritage areas. A weight of 10 will be given to the criterion and the impact was scored as described in the following table.

Table 8-5: the impact of cultural heritage

Score	Loss of monuments, etc… (n°)
0	None
1	0 - 2
2	2 - 5
3	> 5

8.2.5 Downstream effects

Inundation of the river crossings, loss of scenic river areas such as rapids and waterfalls, access to the water, variations of flow during the day due to peak electricity demands are only some of the possible downstream effect that can be considered. A weight of 10 will be given to this criterion and the impact will be scored as described in the following table.

Table 8-6: the impact of downstream effect

Score	Downstream effects
0	None
1	Low
2	Medium
3	High

8.2.6 Aquatic ecosystems

A weight of 10 will be given to this criterion and the impact was scored as described in the following table.

Table 8-7: the impact on ecosystems

Score	Expected Ecosystem modification
0	None
1	Low
2	Medium
3	High

8.2.7 The Scheme Impact Score

The weighting and the score range for the seven criteria that were selected in order to rank the different schemes in terms of their environmental impact is summarized in the following table:

Table 8-8: the Scheme Impact Score

Criteria		Weight	Score Range
Land lost:	Forest	5	1-5
	Agricultural land	15	1-5
People affected		35	1-5
Access		15	0-3
Cultural		5	0-3
Downstream effects		10	0-3
Aquatic ecosystems		15	0-3
TOTAL		**100**	

The maximum score will amount to 100; a higher score means a higher impact.

The score for each scheme will be calculated as follows:

$$SIS = \sum \frac{Cw * Cs}{Mps}$$

where:

SIS is the scheme impact score;

Cw is the criterion weight;

Cs is the criterion score;

Mps is the maximum criterion possible score

8.3 The Impact of Gilgel Gibe II Hydroelectric power project

As described in chapter 7 the Gilgel Gibe II Hydroelectric power project is likely to have no impact on the main environmental issues. The only impacts that may be expected are related to some low impacts on forest land lost due to the disposal of the excavated materials; some other minor impacts to the aquatic ecosystem and some downstream effects.

The main issues of the Gilgel Gibe II Hydroelectric power project scheme are summarized in the following Table 8-9:

Table 8-9: the Impact Score of the Gilgel Gibe II Hydroelectric power project

Criteria		Weight	Score Range	Score	Weighted score
Land lost:	Forest	5	1-5	1	1
	Agricultural land	15	1-5	0	0
People affected		35	1-5	0	0
Access		15	0-3	0	0
Cultural		5	0-3	0	0
Downstream effects		10	0-3	1	3.3
Aquatic ecosystems		15	0-3	1	5
TOTAL		**100**			**9**

A comparison between the Gilgel Gibe II Hydroelectric power project scheme and the schemes discussed in the EPSEMP is reported in the following Table 8-10:

Table 8-10: the Impact Scores of the different schemes considered in the EPSEMP and of Gilgel Gibe II Hydroelectric power project

Scheme	Land lost	People affected	Access	Cultural	Downstream	Aquatic Systems	Score
Beles	0	0	0	0	2	1	12
Geba 1 and 2	8	2	1	0	1	1	41
Halele-Werabesa	10	1	1	0	2	2	49
Baro 1 and 2	6	2	3	0	1	2	50
Aleltu East	2	3	2	0	1	3	55
Aleltu West	2	3	2	0	1	3	55
Chemoga-Yeda	4	4	3	2	1	3	75
Genale 2 and 3	4	5	3	3	3	2	85
Gilgel Gibe II	**1**	**0**	**0**	**0**	**1**	**1**	**9**

As shown in the above table Gilgel Gibe II Hydroelectric power project scheme, compared to all the hydroelectric schemes reported in the EPSEMP, has the lowest score due to the fact that only a small reservoir is created by the weir and consequently no people are affected and almost no land is lost.

9 ENVIRONMENTAL MANAGEMENT PLAN

A primary goal of EIA is to develop procedures to ensure that all mitigation measures and monitoring requirements specified in the approved EIA will actually be carried out in subsequent stages of project development. These mitigation measures and monitoring requirements are normally set out in an Environmental Management Plan (EMaP).

A well-structured EMaP usually covers all phases of the project, from pre-construction right through the commissioning.

The Plan outlines mitigation and other measures that will be undertaken to ensure compliance with environmental laws and regulations and to reduce or eliminate adverse impacts.

The main mechanism for implementation of the EMaP is the establishment of an Environmental Management Unit (EMU).

The EMU is to be established, with sufficient staffing and budget, as part of Project Implementation Unit (P.I.U.) wich has been formed within EEPCO to properly monitor and control the implementation of project to ensure that all activities will be completed with a pre-determined quality.

Environmental staff in this Unit shall undertake day to day monitoring of the implementation of the proposed mitigative measures and requirements outlined in the EMaP.

The establishment and funding (to be borned by the Employer's Administration) of an EMU is essential insurance for the environmental soundness of the project.

In particular, implementation of the EMaP requires that:

- the detailed final design (plans and specifications) for the project incorporates all mitigation measures specified in the approved EIA. In the case of Gilgel Gibe II this is facilitated since the EIA is conducted as an integral part of the project feasibility study/final design;
- the contract for construction (i.e. EPC contract) of the project includes all mitigation measures to be implemented during construction phase;
- the construction contractors' performance is duly monitored for compliance with the EMaP by competent environmental construction inspectors furnished by the EMU. This means implementation of the construction stage portion of the Environmental Monitoring Program specified in the EIA;
- on completion of construction, inspection takes place to check that the works, as built, meet all significant environmental requirements before the project is officially accepted;
- the operations stage monitoring program is implemented as specified in the EMaP;
- there is effective reporting by the EMU, through the Project Implementation Unit, to show that the EMaP is being properly managed.

During construction stage, the focus is on ensuring that the construction contract requirements are fulfilled. These requirements include basic health and safety requirements as well as ensuring that the project works and mitigation measures are environmentally sound (cost to be borned by the EPC Contractor). During operations the role of the EMU will shift to identify the problems and recommend the corrective actions to the Employer's Administration.

9.1 Physical Environment

9.1.1 Climate

Due to the very small dimensions of the reservoir formed by the diversion weir no impacts on climate are expected by the project, so no compensation measures and/or management plan shall be considered.

In any case the fact that the project will produce electric energy without burning fossil fuels and without stack emissions will generate at country level a potential reduction of air pollutant: for this reason the project itself may be considered positive on climate changes perspective.

9.1.2 Hydrology

The operations at weir site will affect natural flows downstream, with the most significant effects felt from the tunnel intake to the confluence of Gilgel Gibe River in Gibe River. In fact, during dry seasons, when Gilgel Gibe I dam would not be spilling, the stretch downstream the dam is dry for 4-6 months each year. The minimal flow to guarantee the biology life in the stretch downstream the weir should be at least equal to the low flow of the river (0.128 m^3/s). No human population would be affected in this first stretch of the river as it is uninhabited and will remain that way because of the buffer zone. A compensation flow is part of the mitigation plan.

Considering the low water levels of the river during the dry season, an increased release of 2.0 m^3/s may be considered for maintaining the downstream ecosystem. The operators of the power station of Gilgel Gibe I and weir of the Gilgel Gibe II will be responsible for the maintenance of the compensatory flow.

A valid compensation flow for the areas downstream Gilgel Gibe II weir could be given by Bidru River, a right bank affluent of Gilgel Gibe River. Its catchment area (about 46 km^2) could guarantee a valid water flow for the areas downstream the weir.

9.1.3 Hydrogeology

During tunnel drilling, a well capture could happen. In this case it will be necessary to verify the integrity of wells above and eventually to drill other wells for the population living above the tunnel area over the plateau.

No influences on the water quality are foreseeable, for two reasons:

- the tunnel is under a mean rock deep of 500 meters, and wells are not expected to reach depth that could be influenced by the tunnel;

- geological characteristics, with low fractured formations, do not permit any contamination by the tunnel operation.

Since this consideration, it's foreseeable that tunnel construction works won't affect people living above the tunnel area and quality of the water taken from the wells above the plateau.

9.1.4 Seismology

During the construction stage activity, no impacts shall be considered due to the small dimensions of the reservoir. During the operation stage activity, instead, weir and tunnel may cause micro-earthquakes due to the fast water level abatement in the reservoir and no particular compensation measures shall be considered.

9.1.5 Slope stability

The inlet area is characterized by basalt bedrock on the right side and tuff bedrock on the left side, both covered by a thin instable surface of lateritic soils, whose stability is not guaranteed in case of abundant rainfall. Particularly during the first phases (removal vegetation and cover) any removal should be carry out manually to prevent erosion caused by machinery and the work area should be marked to prevent any accidental removal of vegetation. Since unstable soil condition, reservoir area sides' stability should be investigated to prevent rock falls or slumpings of the cover material. This aspect is very important since the fast daily drawdown of over 7 m in only 3.3 hs. About this aspect the effects of pressure abatement on these fractured rocks should be also investigated.

In principle, all the slopes of the permanent structures (obtained by excavation) are considered to be in sufficiently sound rock and therefore steady. This because the designer has considered in the definition of the depth of the excavations the geo-mechanical characteristics of the rock detected by seismic campaigns.

It is therefore evident that in each specific case, after the reaching of the final excavation lines, the geo-mechanical characteristics of the rock will be duly analysed by the geologists and the permanent treatment (mitigation measures) if required will be immediately applied.

9.1.5.1 Final slopes of the excavated areas

All the following measures shall be considered by the designer and clearly indicated in the construction drawings.

- Rock bolting of the slopes surface. Type of the rock bolts (expansion shell, grouted dowels etc.) and the length of the rock bolts will be defined according to the rock condition on the spot.
- Application of shotcrete in different thickness
- Application of shotcrete reinforced with welded wire
- Adequate berms with suitable width and spacing (distance in elevation between the berms)
- Drainage system protecting the area of the slope from the running rainwater mainly from the surrounding areas. The ditches shall be concrete lined or executed with stone pitching. The

sloped ditches shall be provided with energy dissipaters to avoid fast erosion by the water flow speed.

- Identification of the dry retaining structures (gabions walls) at the toe of the slopes.

9.1.5.2 Slopes of disposal areas

In order to prevent and mitigate the environment impact of the disposal areas, the conctractor has defined measures as follows:

- Identification of the disposal areas considering the environment. minimization of the impact to the flora (trees felling).
- Definition of a proper slope according to the nature of the materials to be disposed.
- Identification and definition of the drainage works to protect the area from the running rainwater.
- Identification and definition of the drainage works (culverts, dykes) to protect the disposal area from the erosion of any water flow (creeks) crossing or adjacent to the slopes. This to avoid any uncontrolled water flow underneath of the materials of the disposal area and any obstruction to the existing creeks.
- Identification and definition of the any retaining structure (gabions walls, concrete retaining walls) at the toe of the slopes to avoid landslides.

9.1.5.3 Temporary measures for the protection of the slopes during construction

- Regular monitoring of the surface stability by surveying. On the spot will be installed a greed of bench marks (this greed, defined in the environmental impact study, will be also used for the monitoring of the movement of the disposal areas slopes) to be regularly checked. The comparison of the readings will give the trend of the movement of the slopes if any.
- Temporary protection and support of the excavated slopes by rock bolting, gunite layers application, systematic scaling of the surface. Drainage works, mainly during the wet seasons, to divert the main rainwater flows outside the slopes surface.

9.1.6 Disposal materials

All the materials bored from the tunnel will be dispose in appropriate areas near the power inlet/outlet adits. The large amount of disposal materials should be disposed to guarantee long stability period and a complete recover of the disposal areas.

During the construction stage activity negative impacts have been considered. To reduce those impacts, materials dug from the tunnel should be disposed from the bottom to the top of the filling valley as parallel beds, and during this phase the bottom beds should be recovered by vegetation with local trees for reducing erosion to prevent a negative impact on the landscape. Once a borrow area is no longer required, its slopes should be reduced and rehabilitated with stockpiled topsoils; stabilizing structures should be installed to provide effective drainage into natural watercourses.

Analysis should be done to evaluate mucking content areas and eventually to find other fill areas.

9.1.7 Storage sedimentation

The sedimentation inside the new reservoir created by the weir, will be very limited, due to the retention of solid and suspended materials by the Gilgel Gibe I dam.

However a certain amount will reach the basin. If during the life of the project this amount will exceed an established value, the cleaning of the reservoir may necessary. In this case a particular attention must be given to the river water turbidity increasing due to sediments release.

This fact may create big problems to river Ichtyofauna.

An alternative could be the extraction of the sediments and their allocation in proper disposal area.

Both hypothesis must be considered and evaluated in the executive phase of the design activity, taking into account the fish spawning period and evaluating the areas where the disposed materials shall be allocated.

9.1.8 Water quality

Contamination of the future reservoir water from faecal matter and domestic wastes will not be a serious problem since all villages and individual house are far away from the reservoir location.

The pollution risks during the construction works can be avoided managing properly the construction materials, particularly chemicals, fuels and lubricants: a materials management plan and wastes management plan shall be prepared during the executive design.

During normal operation activities, treatment facilities for human and domestic wastes at camps, at the powerhouse and at the substation location in order to reduce the threats of water pollution must be considered.

9.1.9 Downstream effects

Some effects on the downstream areas may expected during contruction works due to the interruption and/or alteration of normal water circulation during weir erection.

A proper by-pass letting water flow in the Gilgel river downstream during this phase will avoid this negative effects on Ichtyofauna continuity, on wild animals and on riverine vegetation.

During normal operation the effects of discharging of a big amount of water (about 100 m^3/s) in a concentrated area along the Omo River, may cause some disturbance to local river fauna.

Water diversion during the plant operation will mainly affect the Gilgel Gibe river downstream the weir up to the Gibe confluence. The negative effects will be partially mitigated by the release of a compensation flow together with the uncontrolled flow of the Bidru tributary which enter the main river just downstream the Gilgel Gibe II weir. In particular the compensation flow will be constituted by:

- Gilgel Gibe I compensation flow (1 m^3/s)
- discharge from Chilelo river just 1 km downstream Gilgel Gibe I dam
- discharge from the residual catchment between the Chilelo confluence and the Gilgel Gibe II weir

All these flows can be estimated in more than 2 m^3/s, based on the catchment area of tributaries and the specific discharge computed from Deneba river station data.

This can be compared with the Gilgel Gibe low flow (0.128 m^3/s) and the annual average flow at Daneba station (50.4 m^3/s).

The effect of the reduced flow will be evaluated by the Environmental Management Unit with the technical assistance from EPA. Any change recommended in the compensation flow would be subjected to a cost/benefit analysis. EEPCO, as operator of the power plant will be responsible for the maintenance of this flow.

9.1.10 Landscape

Even if the impacts expected on landscape can be considered very small as described in prf. 7.1.9, some attention must be paid to reduce the visibility of the project works:

- A detailed management plan of the disposal material shall be prepared evaluating the possible alternatives such as reuse of the excavated materials for secondary uses (roads, walls, construction activities, etc…). If no secondary use is found the excavated materials must be properly disposed in order to prevent their instability, and should be vegetated with local trees for reducing on one side the erosion by wind and rain and on the other side to reduce the visibility of the disposal area.
- For the powerhouse and for the substation a specific landscape impact reduction plan must be prepared during the executive design;
- The construction roads if no more necessary and not useful to local population, must be dismantled at the end of the works.

9.2 Natural Environment

9.2.1 Vegetation

Although the impact of the management of the water of Gilgel Gibe and Great Gibe on the species composition and community types is restricted to a narrow zone, the practice of giving attention to environmental safety should be highly emphasized. The Convention on Biodiversity calls and National Policy and Strategy for Plant Genetic Resources Conservation and Development, (1993) for putting all possible efforts to preserve biodiversity in general and mountain and riverine vegetation in particular (Agenda 21).

ILRI is conducting a research on methods of reducing the Tsetse fly density and their vectorial capacity with the purpose of introducing sustainable agricultural activities in Greater Gibe Valley. The possible increase of livestock in the valley in the foreseeable future would need more water for the livestock and the human settlement.

Agricultural practice in the Gilgel Gibe is very little and its role in the livelihood of the people living the area is minimal. This is because the steep slope of the valley and the high tsetse fly infestation. We therefore have to see the importance of the Gilgel Gibe River Systems from the ecosystem point view and preserving these functions should be the primary concern.

The mitigation actions to be considered should include:

- A tradeoff with the volume of Gilgel Gibe at the intake point to the 26 km tunnel would be a feasible action. Some compensation flow of water along the Gilgel Gibe river course especially during the dry season. This is necessary for the maintenance of the riverine vegetation and the ecosystem functions. The cost of this mitigation option does not compromise the implementation of the project since the volume of the water required for the maintenance of the ecological system is presumably very small.
- Building a few small impoundments at watering points along the Greater Gibe River to secure water for the livestock and the people during dry season would accommodate the rights of the downstream users.
- The possible accelerated human influence on the vegetation as the result of the opening up of access roads can be avoided by strict monitoring of human impact at control points along the roads leading to the powerhouse and weir. This does not need additional man power but only raising the awareness of the gate keepers at the entry of these structures.

9.2.2 Fauna

In the previous chapter potential impacts on the fauna ecosystem have been identified and in this chapter mitigation measures that should be adopted to avoid or minimize potential adverse impacts are recommended. Of which, some involve good engineering practices.

The aquatic fauna requires regulated regime with compensation flow during the low water/dry months so as to allow animals to migrate downstream to the Gilgel Gibe- Gibe confluence or survive in the larger backpools.

Currently there is no confirmed knowledge on any endangerment of endemic or rare species in the project areas.

Some mitigation measures to take at the power tunnel intake site include allowing large aquatic animals to escape and thin out before the closure of the weir

It is also recommended to discourage human settlement near the gorge where the new road to the power tunnel intake is to be built to minimize possible establishment of malaria should the vector mosquitoes happen to breed successfully in the enclosed small lagoon.

The implication of the change of flow regime in the downstream areas showed that compensation releases are required because effects on aquatic ecosystem are considered to be significant.

The implication of the change of flow regime in the downstream areas showed that compensation releases are also required because effects on human and livestock water demand around the Gibe bridge is considered to be significant. This could be facilitated by adjusting the compensation flow from the reservoir during the critical months and concentrate water for human and domestic animals use during the dry months.

Because of the absence of rare, endangered or endemic fish species in the Gibe river system, expensive option for fish ladder or fish pass need hardly be considered for the near future. Very great care should be taken to ensure that no alien aquatic species, especially fish, should be introduced into the Gilgel Gibe II lagoon and river. The monitoring phases should include regular check of the ichthyofaunal composition.

There has not been any follow up monitoring of the effects of the creation of the reservoir on the fish stocks and other aquatic fauna since then, although media sources and anecdotal evidences claim that a thriving fishery has been established and an increase in the aquatic bird diversity and reservoir productivity is observed. In limnological terms, this is what is referred to as "trophic surge" and is a phenomenon observed in young reservoirs. A research proposal to study the limnological and fishery characteristics of the Gilgel Gibe reservoir since its establishment two years ago has been forwarded by the Zewai Fishery Resources Research Center to the Oromiya Agricultural Research Organization (OARI) and is awaiting response (Dagne Tussa, Personal Communication).

Therefore, it is recommended to carryout monitoring activities during all stages of the project (namely: pre-construction and construction, commissioning, and operation) to ensure that the impacts are no greater than predicted, and to verify the impact predictions. The monitoring program will indicate where changes to procedures or operations are required, in order to reduce impacts on the environment.

9.3 Socio-economic Environment

Possible mitigation measures that could help to minimise the adverse impacts are discussed in this section.

9.3.1 Loss of Land and Fixed Properties

Effective procedures for minimising the impact of land and property expropriation have yet to be fully developed in Ethiopia. However, in order to reduce the impacts associated with land and property expropriation, it is recommended that a threefold approach should be adopted involving:

- preparation of engineering designs which minimise land acquisition for access road, construction camps, and in particular acquisition of land occupied by housing or business/commercial premises
- EEPCO in collaboration with local authorities, to stop all construction works within the future construction activity areas
- payment of full and fair cash compensation, which leaves those affected by relocation at least no worse off than they were previously.

The following set of criteria is recommended to be adopted for adequately compensating and properly rehabilitating the would be affected people:-

- The process of land reallocation and compensation should be preceded by a detailed inventory of individual and communal properties.
- The inventory should include size of individual holdings of agricultural land, homestead permanent plantings and gardens including immovable property.

- In the case of agricultural land, the area of replacement land should be determined so as to take into account productivity, so that crop production remains as previously.
- Allocation of financial compensation for perennial crops and trees lost should be on the base of time and labour necessary for the work and the income could be obtained.
- Assessment of cash compensation for property should be carried out in a wholly transparent manner, resulting in payments that truly reflect current rebuilding costs.
- All affected persons should be freely allowed to salvage building materials, trees and other assets on affected land as additional compensation for displacement.
- All of these activities will have to be carefully planned and completed well in advance of actual construction to allow enough time for appropriate compensation and relocation of project affected persons.

9.3.2 Health and Sanitary Issues

Of the potential adverse social and health impacts, some of the most serious are the transmission of sexually transmitted diseases. Mitigation measures to minimise these and other potential adverse health impacts include:

- Utilisation of preventive and curative measures to reduce transmission of communicable diseases between the work force and the local population.
- Health education campaign about sexually transmitted diseases and their prevention measures.
- Organise awareness campaign on hygiene and sexually transmitted diseases and their prevention methods in advance of the construction work. Workers and residents alike should be sensitised to the risks, particularly of HIV/AIDS.
- Medical screening and treatment of workers coming from outside the project area.
- Establishment of health centre in the project area and adequate health service to provide service to the workers and the local communities.
- Provision of assistance to the Fofa Health Centre to maximise its services.
- Sanitation and hygiene education to the workforce.
- Provision of potable water supply and sanitation facilities for the project workers and the local communities.

9.3.3 Dusts and Noise Pollution during Construction Activities

Noise and vibration result from construction activities in general but particularly from operation of heavy machinery. Other operations generating significant noise include concrete mixing plants, blasting in areas of rock excavation and stone crushing. Sustained noise levels during construction are expected to be much higher than the ambient noise level in the project area. Therefore, to cause the list disruption to the population around the sites, it is recommended use approved suppressors to control increased dust levels or pollutions and not to undertake activities producing nuisance noise level at night around residential areas, around places of worship on locally recognized saints/holy days and other religious holidays. It is also recommended to inform the local community members while working with explosives.

9.3.4 Housing/Accommodation

To meet the newly created demand on housing it is recommended to:

- Construct camps for the construction workforce accommodation.
- Encourage individuals to construct hotels and restaurants to give adequate service for migrant workers.

9.3.5 Shortages of Market Consumable Productions

Encourage individuals to bring consumable productions (food items) from food-self-sufficient areas to the project area – Fofa town.

9.3.6 Gibe State Farm

The possible mitigation measures for the impact of Gibe State Farm that could be caused due to Gilgel Gibe II Hydropower project include:

- Construction of appropriate structure at Gibe River to holdback water at appropriate place/s to serve the pumps.
- Make arrangements to release sufficient amount of water to the main Gibe River.
- Using both methods: 1) constructions of structure structures and 2) release some amount of water from Gilgel Gibe River to flow in the main Gibe River to reach for the Gibe State Farm.

9.3.7 Mitigating measures on cultural, religious and archaelogical sites impacts

There is no important cultural, religious establishment, archaeological, relics that could be affected by implementation of the proposed Gilgel Gibe II project. Therefore, no mitigating measure is required.

9.3.8 Conclusions and Recommendations

The implementation of the proposed Gilgel Gibe II hydropower project will bring about a number of beneficial and some adverse effects. The major and the most important benefit of the project is the generation of electric power that is expected to alleviate the energy shortage in the country and augment the development of the national economy. Additional benefits can include job opportunities for the local communities and in-migrant population, and improvement of the local social and physical infrastructure. The latter, with particular reference to roads will allow easier links between the different area of the region. These and other benefits can support the Government objectives to enhance economic development and improve the living standard of the Ethiopian people.

As identified in this socio-economic environment impact assessment, the implementation of Gilgel Gibe II hydropower project will not bring any severe impacts on the social environment of the project area. Negative social impacts are limited to the establishment of constructions camps and other facilities, influx of labour force, loss of few (5) residential houses and loss of limited area of crops at homesteads.

This project will not cause population displacement because all the project components are located in areas where there is no settlement. The limited disturbance to human settlement is due to the construction of access road from Fofa town to the powerhouse and establishment of construction camps. With proper mitigation measures, these adverse effects will be manageable and can be reduced to acceptable levels. The important issue that should be given due attention is the social issue related to the influx of labour force during construction period. Particularly the potential spread of sexually transmitted diseases especially HIV/AIDS could increase unless proper control measures are taken.

The over all conclusion of this social impact assessment is that the project will support a national interest, but its negative impacts need to be properly addressed and mitigated in order to enhance its benefits and minimise the adverse effects on the socio-economic environment.

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ANNEX 1
DRAWINGS
(11 pages)

ANNEX 2
WATER QUALITY ANALYSIS
(5 pages)

Addis Ababa University
Department of Chemistry
Water Quality Analysis Report

Date of Sampling: August 3, 2004

Place of Sampling: Water coming from down stream central turbine Gilgel Gibe 2

Sampled by: Feleke Zewge

Chemical Parameters

Parameter	Concentration (mg/l)	Analytical Method
Dissolved Oxygen (DO)	8.5	Mettler Toledo Meter
Phosphate (PO_4^{3-})	0.402	Ion chromatography
Chloride (Cl^-)	3.105	"
Sulfate (SO_4^{2-})	13.57	"
Nitrate (NO_3^-)	2.161	"
Calcium (Ca^{2+})	2.433	Atomic Absorption
Magnesium (Mg^{2+})	1.297	Spectrometry
Sodium (Na^+)	0.776	"
Potassium (K^+)	0.513	"
Iron (Fe^{2+})	1.196	"
Total Dissolved Solids (TDS)	37	" HACH Digital meter

Other Parameters

Parameter	Value	Method
Temperature (T °C)	22.5	Mettler Toledo Meter
pH (Units)	6.93	HACH Digital meter
Electrical Conductivity (µS/cm)	79	HACH Digital meter
Salinity	Nil	HACH Digital meter

Analysed by: Amakelech/Elleni Date of Analysis: August 4-6, 2004

Supervised by: Feleke/Yonas

Addis Ababa University
Department of Chemistry
Water Quality Analysis Report

Date of Sampling: August 2, 2004

Place of Sampling: Down Stream Gilgel Gibe 1 Dam (Zone Wier)

Sampled by: Feleke Zewge

Chemical Parameters

Parameter	Concentration (mg/l)	Analytical Method
Dissolved Oxygen (DO)	7.5	Mettler Toledo Meter
Phosphate (PO_4^{3-})	0.597	Ion chromatography
Chloride (Cl^-)	4.506	"
Sulfate (SO_4^{2-})	4.527	"
Nitrate (NO_3^-)	9.457	"
Calcium (Ca^{2+})	2.753	Atomic Absorption
Magnesium (Mg^{2+})	1.699	Spectrometry
Sodium (Na^+)	0.856	"
Potassium (K^+)	0.319	"
Iron (Fe^{2+})	2.085	"
Total Dissolved Solids (TDS)	41	" HACH Digital meter

Other Parameters

Parameter	Value	Method
Temperature (T °C)	22.5	Mettler Toledo meter
pH (Units)	6.99	HACH Digital meter
Electrical Conductivity (µS/cm)	88	HACH Digital meter
Salinity	Nil	HACH Digital meter

Analysed by: Amakelech/Elleni Date of Analysis: August 4-6, 2004

Supervised by: Feleke/Yonas

Addis Ababa University
Department of Chemistry
Water Quality Analysis Report

Date of Sampling: August 2, 2004

Place of Sampling: Junction Between Gibe And Omo (Factory Zone)

Sampled by: Feleke Zewge

Chemical Parameters

Parameter	Concentration (mg/l)	Analytical Method
Dissolved Oxygen (DO)	9.5	Mettler Toledo Meter Ion chromatography
Phosphate (PO_4^{3-})	0.29	"
Chloride (Cl^-)	2.437	"
Sulfate (SO_4^{2-})	1.763	"
Nitrate (NO_3^-)	3.833	Atomic Absorption
Calcium (Ca^{2+})	2.723	Spectrometry
Magnesium (Mg^{2+})	1.692	"
Sodium (Na^+)	0.781	"
Potassium (K^+)	0.873	"
Iron (Fe^{2+})	1.144	"
Total Dissolved Solids (TDS)	39	HACH Digital meter

Other Parameters

Parameter	Value	Method
Temperature (T °C)	22.2	Mettler Toledo Meter
pH (Units)	7.16	HACH Digital meter
Electrical Conductivity (μS/cm)	82	HACH Digital meter
Salinity	Nil	HACH Digital meter

Analysed by: Amakelech/Elleni   Date of Analysis: August 4-6, 2004

Supervised by: Feleke/Yonas

Addis Ababa University
Department of Chemistry
Water Quality Analysis Report

Date of Sampling August 2, 2004

Place of Sampling Upstream Gilgel Gibe 1 Dam (Reservoir)

Sampled by Feleke Zewge

Chemical Parameters

Parameter	Concentration (mg/l)	Analytical Method
Dissolved Oxygen (DO)	9.5	Mettler Toledo Meter
Phosphate (PO_4^{3-})	0.24	Ion chromatography
Chloride (Cl^-)	3.284	"
Sulfate (SO_4^{2-})	2.118	"
Nitrate (NO_3^-)	4.378	"
Calcium (Ca^{2+})	3.173	Atomic Absorption
Magnesium (Mg^{2+})	2.024	Spectrometry
Sodium (Na^+)	0.738	"
Potassium (K^+)	0.823	"
Iron (Fe^{2+})	1.655	"
Total Dissolved Solids (TDS)	48	" HACH Digital meter

Other Parameters

Parameter	Value	Method
Temperature (T °C)	21.1	Mettler Toledo Meter
pH (Units)	7.15	HACH Digital meter
Electrical Conductivity (µS/cm)	101	HACH Digital meter
Salinity	Nil	HACH Digital meter

Analysed by: Amakelech/Elleni

Date of Analysis: August 4-6, 2004

Supervised by: Feleke/Yonas