REVIEW OF THE ENVIRONMENTAL IMPACT SURVEY - EIA

COPAM PROCESS Nº 01403/2002/002/2002

PIEDADE SHS – MARCH/2007

VOLUME I/II – TEXT

LIMIAR ENGENHARIA AMBIENTAL

PIEDADE USINA GERADORA DE ENERGIA S/A

VOLUME I/II – TEXT

PRESENTATION

This document was prepared to align the Environmental Impact Study for the Piedade SHS with the new project engineering layout.

The basic, consolidated 2000 project and engineering surveys for Piedade SHS were carried out by RA Engenharia e Consultoria and contracted by Piedade Usina Geradora de Energia SA. The project surveys were prepared according to the instructions issued for developing SHS projects and ANEEL regulations, specific Brazilian regulations and guided by previous studies of the area.

After field investigations and analysis of existing surveys, we can safely say that the location specified for the respective SHS works are in good condition for deployment, within the criteria established by ANEEL and FEAM.

The proposed hydroelectric project, to generate electricity, is located on the Piedade river, with a dam 50.40 km from its mouth, in the municipal region of Monte Alegre de Minas, with the dam at latitude 18° 41’20” and longitude 49°03’48” (Drawing PIE-LOC-001).

The hydroelectric project is characterized as a water level plant with a regulating reservoir of water level at an elevation of 650 m, covering an approximate area of 1.5 square kilometers with a volume of 17.52 x 10^6 at maximum normal N.A., as presented in drawing PI-MA-006.

This study is separated into two volumes, with volume 1 containing the text in volume 2 the exhibits (Drawings).

Chapter 1 presents the main engineering characteristics for the project and Chapter 2 presents the general methodology used to prepare the document. Description of the Physical, Social and Economic and Biotic Environments is conducted in chapters 3, 4 and 5, respectively, alongside alignment with the new design.

Chapter 6 comments on the possible, new environmental impacts caused by alterations to the engineering designs. Please note that the environmental impacts forecast in preceding studies remain valid.

Volume 2 contains the following exhibits:

Exhibit 1 - Drawings

- PI-MA-001 – GENERAL LAYOUT - PLANT
- PI-MA-002 – GENERAL LAYOUT - DAM
- PI-MA-003 – GENERAL LAYOUT – DAM – PROFILE - TYPICAL SECTIONS AND DETAILS
- PI-MA-004 – RIVER DIVERSION SEQUENCE – 1ST PHASE

- PI-MA-005 - RIVER DIVERSION SEQUENCE – 2nd PHASE
- PI-MA-006 –RESERVOIRS GROUND PLAN - CHARACTERISTICS OF THE FLOODED AREA - HEIGHT OF 650 M
- PI-MA-007 – PIEDADE RIVER DROP PARTICIPATION
- PI-MA-008 –ELECTRICAL CENTRE–GENERAL LAYOUT–TRANSVERSAL CROSS-SECTION
- PIE-LOC-001 –ACCESS ROUTE MAP
- PIE-VEG-002 – VEGETATION
- PIE-PAF-001 –FAUNA SAMPLING POINTS
- PIE-LMA-001 –SOCIAL AND ECONOMIC ENVIRONMENT INFLUENCE AREA
- PIE-GEM-001 - GEOMORPHOLOGY
- PIE-PED-001 - PEDOLOGY
- PIE-PAA-001 –WATER QUALITY SAMPLING POINTS
- PIE-PTN-001 –NATURAL HERITAGE POINTS
- PIE-PRO-002 –REGISTERED PROPERTIES

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COMPANY RESPONSIBLE FOR THE SURVEY

Founded in 1991, Limiar Engenharia Ambiental is an environmental consultancy and management company.

The company develops projects for the correct use of natural resources and continued improvement of environmental quality It studies, evaluates, innovates and manages the relationship between organizations and the environment in terms of their physical, biotic and social aspects.

The Limiar environmental management service covers:

- Consultancy for project amendment or compliance with applicable environmental regulations and laws;
- Preparation of studies, plans and environmental reports for project licensing;
- Execution of environmental programs for physical, biotic and socioeconomic environment;
- Environmental Management.

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TECHNICAL TEAM

Below is the Limiar Engenharia Ambiental technical team and the collaborators responsible for preparing the Piedade SHS Environmental Impact Study Review.

General Management	
Virgínia Campos	Sanitary Engineer - CREA 26714/D

Technical Team	**Education Professional Registration**	**Responsibility**
Rogério Yukio Suzuki	Chemical Engineer - CRQ 02301399 2ªR	Technical Management
Lucas Grandinetti Amado de Sousa	Biologist - CRBio 44067/4-D	Final Integration and Review
Flávia Lima Dolabella Teixeira da Costa	Chemical Engineer - CRQ 02301439 2ªR	Water Quality
Charles Pierre Parreiras	Sociologist MSc in Sociology	Socio-economic issues
Michel Kazuo Takahashi Obara	Biologist - CRBio 49074/4-D	Fauna integration
Raphael Medina	Forestry Engineer – CREA 91739/D	Flora integration
Raphael Romanizio	Advertising and Social Communication - MT46211.003395/00- 37	Archaeological Coordination
Rodrigo Augusto Ferreira	Draftsman	Drawings
Simone Valéria Passos Pessoa	Geographer - CREA 76880/D	Climate, Hydrography, Natural Heritage and Integration with the Physical Environment

Collaborators	**Education Professional Registration**	**Responsibility**
Edward Karel Maurits Koole (MC Archaeology)	Archaeologist	Archaeology

1 PROJECT

1.1 Project Description

The Piedade SHS deployment project involves the following structures:

- Works to divert the river along the left bank comprising the diversion channel with a diversion gallery in concrete and upstream and downstream cofferdams for construction of the dam on the river bed.
- Dam, comprising an earth them on the river bed and abutment on the right bank and other small closing down on the left bank.
- Still way with a free-flowing weir inside walls in rolled concrete as part of the dam which will be located on the left bank.
- Generating circuit comprising the water intake, water channel, penstock, power station and tailrace encompassing a group of independent works located along the right abutment at a height of 650 m, on the right bank of the river, except the power station and the penstocks which will be at elevations of 525 m (PH) and 525-650 m (penstock) thereby allowing execution of the respective works at any time of the year.
- 69 kV conventional pumping substation, with a single bus and two input bays and two line bays located on the left-hand side of the power station, in unavailable area of approximately 420 square meters, at an elevation of 525 m.
- 69 KV Transmission Line running approximately 11 km linking the Piedade SHS substation to the Avatinguara substation in the municipal region of Canápolis.

The general layout and location of the works can be seen in drawing PI-MA-001.

The following is a brief description of the structures:

1.1.1 River Diversion

The river diversion was conceived in order to enable construction of the dam without the presence of water and is a simple, low-cost diversion.

The river diversion will be carried out using a concrete diversion gallery comprising a cell 3 m wide by 3 m tall, which will be built on the left bank of the river. The river will be closed off during the dry period using rock and earth cofferdams upstream and downstream from the spillway, both built on the river bed.

These structures were scaled in order to provide a flow of $19m^3/s$, which corresponds to a flow with a 25 year return period and total length of 32.40, with a floor level at an elevation of 521 m. The portal will have grooves in order to close the metal cut-off floodgate.

The cofferdams built an elevation of 625 m, with a crest width of 6.00 m, will be comprised of rip-rap and transitions with external sealant using clay soil. Between the ground and the rip-rap filters and transitions will be built using granular material obtained in the region.

1.1.2 Spillway

The spillway will be a free-flow type 118.5 m total length and will have a spillway weir 30 m long and crest at an elevation of 650 m, which corresponds to the normal water level for hydroelectric usage.

The concrete sidewalls along the left and right banks of the River will crest at an elevation of 563 m, totaling 88.5 m in length with a vertical upstream face and downstream face with an incarnation of 0.75H:1.0V. Maximum foundation height will be 25 m for walls and 22 m for the spillway.

Alongside the left-hand concrete sidewall devices will be installed to ensure sanitary flow of 0.65 m^3/s.

The spillway will allow passage of maximum flooding levels, whose peak value is equivalent to 121 m^3/s. The downstream face, in a step design, will dissipate most of the energy from the excess flow.

1. 1.3 Earth Dams

The earth dams on the right and left banks in compacted earthworks and rip-rap will crest at an elevation of 653 m.

The main dam on the river bed and right-hand bank will total 294 m in length, with inclinations upstream and downstream at an inclination of 1.0V:2.0H. Maximum foundation height will be 32 m.

The small dam closing off the left-hand bank will be 40 m long and will complete the Piedade River dam.

1. 1.4 Environmental Flow Control Equipment – Diffusion Valve

Diffusion valve with a flow of 0.65 m^3/s will be installed in the structure of the concrete wall on the left bank, guaranteeing the environmental flow required downstream from the dam according to the flow calculation $_{Q7-10.}$ Upstream, the diffusion valve will be installed in a cut-off floodgate in order to be able to maintain the diffusion valve.

1.1.5 Generating Circuit

The generating circuit to be deployed in the abutment on the right bank downstream from the dam will comprise the following structures: Water intake, water channel, penstock, covered power station and tailrace.

The water channel, which has a water level elevation of 650 m, with a 6 m base trapezoid cross-section and approximate area of 20 square meters, was designed so that flow speeds would not exceed 1 m/s and does not include a concrete lining. The water channel will be approximately 6920 m long, excavated out of the ground, and in some sections small dikes will need to be executed using compact earthworks.

The water intake will be a gravity type concrete structure, with groups to install emergency, cofferdam type floodgates and protection and cleaning gratings. The structure will have a height of around 20 m.

The penstock, diameter 2.4 m, anchored on anchoring blocks and supported by supporting blocks, will be approximately 620 m long up to the bifurcation upon arrival at the power station. The two distribution bifurcation penstocks, 2.8 m in diameter, will be around 30 m long.

The internal operation power station on the right-hand bank of the river was designed to contain two turbo generators with Francis Horizontal turbines providing 8.0 MW power each and output of 16.0 MW.

Total length of the power station is 16 m and width is 32.6 m, including the assembly area. The electrical and mechanical galleries, as well as the control room, are located beside the units and will be supported by metallic structures.

Downstream, there will be a set of cofferdam floodgates activated by a motorized pulley system to close the unit suction tubes.
The tailrace was designed based on the hydraulic conditions, the size of the power station alongside the turbine suction tube and the topographic characteristics in the deployment area. The trapezoid channel will be 20 m wide at the mouth and around 45 m long.

1.1.6 Transmission System

The associated transmission system will comprise a 6.9 x 6.9 kV pumping substation and 69 kV transmission line.

The substation will be conventional, single bus with two entry and two line bays. The substation patio will be located on the left-hand side of the power station at an elevation of 525 m, in an open area covering approximately 420 square meters, protected by a fence.

The transmission line, connected to the Avatinguara substation, will be approximately 11 km long.

1. 1. *7 Summary of the Technical Record – PIEDADE SHS*

FICHA - RESUMO - ESTUDOS DE PROJETO BÁSICO			
NOME DA USINA:	*PCH Piedade*	DATA:	*mar/2007*
ETAPA:	*Projeto BásicoConsolidado2007*	Pot. (MW):	*16,0*
NOME DO(S) INTERESSADO(S):	*PIEDADE - Usina Geradora de Energia S.A.*		
CONTATO (resp. pelo empreendimento):	*Carlos André A. S. Lourenço*	TEL.:	*(11) 37890500*

1. LOCALIZAÇÃO					
RIO:	*Piedade*	BACIA:	*Rio Paraná*	SUB-BACIA:	*Rio Paranaíba*
DIST. DA FOZ:	*52,4* km	MUNICÍPIO(S) :	*Monte Alegre de Minas*	UF:	*MG*

COORDENADAS GEOGRÁFICAS:					MUNICÍPIO:			
BARRAGEM:	LAT.:	*18º41'20"*	LONG.:	*49º00'32"*	(BARRAGEM)	*Monte Alegre de Minas*	UF:	*MG*
CASA DE FORÇA:	LAT.:	*18º39'58"*	LONG.:	*49º03'48"*	(C.DE FORÇA)	*Monte Alegre de Minas*	UF:	*MG*

2.CARTOGRAFIA / TOPOGRAFIA						
PROJEÇÃO CARTOGRÁFICA:	ZONA:		DATUM:	*SAD 69*	DATUM LOCAL:	*2168-P*
CARTAS E PLANTAS TOPOGRÁFICAS:	DATA:		ESCALA:	*1:100.000*	FONTE:	*IBGE*
FOTOS AÉREAS:	DATA:	*1.982*	ESCALA:	*1:50.000*	FONTE:	*FAB*
RESTITUIÇÃO AEROFOTOGRAMÉTRICA:	ESCALA:	*1:25.000*				
LEVANTAMENTO PLANIALTIMÉTRICO:	ESCALA:	*1:1.000*				

3. HIDROMETEOROLOGIA								
POSTOS FLUVIOMÉTRICOS DE REFERÊNCIA:								
CÓD.:	*60381000*	NOME:	*Fazenda Letreiro*	RIO:	*Uberabinha*	AD:	*924*	km^2
CÓD.:	*60381005*	NOME:	*Estação Sucupira*	RIO:	*Uberabinha*	AD:	*1.344*	km^2
CÓD.:	*60850000*	NOME:	*Faz. Buriti do Prata*	RIO:	*Da Prata*	AD:	*2.492*	km^2
CÓD.:	*60620000*	NOME:	*Ponte Rio Piedade*	RIO:	*Piedade*	AD:	*1.727*	km^2
CÓD.:	*60835000*	NOME:	*Fazenda Paraíso*	RIO:	*Tijuco*	AD:	*1.923*	km^2
CÓD.:	*60226080*	NOME:	*APH Perdizes*	RIO:	*Araguari*	AD:	*3.000*	km^2

VAZÕES MÉDIAS MENSAIS (m^3/s) – PERÍODO: *JAN/1942 A DEZ/2005*

JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ
20,7	*22,3*	*19,9*	*14,0*	*10,0*	*8,2*	*6,8*	*5,7*	*5,4*	*6,9*	*10,3*	*15,1*

EVAPOR. MÉDIA MENSAL (mm) – PERÍODO: *1961 A 1990*

JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ
90,3	*84,4*	*97,0*	*98,6*	*103,2*	*115,2*	*144,3*	*198,8*	*196,4*	*158,2*	*113,5*	*98,5*

PREC. MÉDIA ANUAL:	*1.530,2*	mm	VAZÃO MLT – PERÍODO:	*(DE 1942 A 2005)* *12,10*	m^3/s
EVAP. MÉDIA ANUAL:	*1.498,4*	mm	VAZÃO FIRME (95%)	*3,3*	m^3/s
EVAP. MÉDIA MENSAL:	*124,9*	mm	VAZÃO MÁX. REGISTRADA	*48,6*	m^3/s
ÁREA DE DRENAGEM:	*967*	km^2	VAZÃO MÍN. REGISTRADA	*1,4*	m^3/s
			VAZÃO $Q_{7,10}$		m3/s

4. RESERVATÓRIO					
CARACTERÍSTICAS GERAIS			NA NORMAL de JUSANTE:	*520,70*	m
VIDA ÚTIL DO RESERVATÓRIO:	*316*	anos	NA MÁX. de JUSANTE:	*522,70*	m
PERÍMETRO:	*10,4*	km	CRISTA DA BARRAGEM:	*653,00*	m
PROFUNDIDADE MÉDIA:	*11,7*	m	ALTURA DA BARRAGEM:	*33,0*	m
PROFUNDIDADE MÁXIMA:	*30*	m	VOLUMES		
TEMPO DE FORMAÇÃO (Q_{MLT}):	*17*	dias	No NA MÁX. NORMAL:	*17,52*	$x10^6 m^3$
TEMPO DE RESIDÊNCIA:		dias	No NA MÍN. NORMAL:	*17,52*	$x10^6 m^3$
NÍVEIS			ÁREA INUNDADA TOTAL		
NA (TR. 100 ANOS):	*650,30*	m	NA (TR. 100 ANOS - para PCHs):		km^2
NA MÁX. NORMAL:	*650,00*	m	NA MÁX. NORMAL:	*1,50*	km^2
NA MÁX. MAXIMORUM (500 ANOS):	*657,50*	m	NA MÁX. MAXIMORUM:		km^2
NA MÍN. NORMAL:	*650,00*	m	NA MÍN. NORMAL:		km^2

ÁREAS INUNDADAS POR MUNICÍPIO (em ha) - NO NA MÁX MAXIMORUM

MUNICÍPIO (S)	UF	SEM A CALHA DO RIO	LEITO DO RIO	TOTAL
Monte Alegre de Minas	*MG*	*129 ha*	*21 ha*	*150*

CONTINUED . . .

5. TURBINAS					
TIPO:	*Francis Horizontal*		QUEDA DE REFERÊNCIA:	*123,70*	m
NÚMERO DE UNIDADES:	*2*		VAZÃO NOMINAL UNITÁRIA:	*7,5*	m^3/s
POTÊNCIA UNIT. NOMINAL:	*8.247*	kW	RENDIMENTO MÁXIMO:	*92*	%
ROTAÇÃO SÍNCRONA:	*720*	r.p.m.	PESO TOTAL POR UNIDADE:		kN

6. GERADORES					
POTÊNCIA UNITÁRIA NOMINAL:	*8.899*	kVA	RENDIMENTO MÁXIMO:	*97,0*	%
TENSÃO NOMINAL:	*6,9*	kV	PESO DO ROTOR:		kN
FATOR DE POTÊNCIA:	*0,90*				

7. INSTALAÇÕES DE TRANSMISSÃO DE INTERESSE RESTRITO À CENTRAL GERADORA					
SUBESTAÇÃO ELEVADORA - DADOS DO TRANSFORMADOR			SUBESTAÇÃO DE INTERLIGAÇÃO - BAY DE ENTRADA		
NÚMERO DE UNIDADES:	*1*		A CONSTRUIR ? (sim ou não):	*Sim*	
POTÊNCIA UNITÁRIA NOMINAL:	*18.000*	kVA	NOME:	*Avatinguara*	
TENSÃO ENR. PRIM.:	*6,9*	kV	CONCESSIONÁRIA:	*CEMIG*	
TENSÃO ENR. SEC.:	*69*	kV	NÚMERO DE UNIDADES:	*1*	
LINHA DE TRANSMISSÃO			POTÊNCIA UNITÁRIA NOMINAL:	*18.000*	kVA
EXTENSÃO:	*11*	km	TENSÃO ENR. PRIM.:		kV
TENSÃO:	*69*	kV	TENSÃO ENR. SEC.:		kV
CIRCUITO (Simples ou Duplo):	*Simples*				

8. ESTUDOS ENERGÉTICOS					
QUEDA BRUTA:	*129,30*	m	REND. DO CONJ. TURBINA/GERADOR:	*89,2*	%
PERDA HIDRÁULICA:	*4,3*	%	VAZÃO REMANESCENTE:	*0,65*	m^3/s
FATOR DE INDISP. FORÇADA:	*0,01*	-	ENERGIA GERADA:	*83.947*	MWh
FATOR DE INDISP. PROGRAMADA:	*0,02*	-	ENERGIA ASSEGURADA:	*9,583*	MW médios

9. CUSTOS					
OBRAS CIVIS:	*24.948,22*	X 10^3 R$	SIST. DE TRANSMISSÃO ASSOCIADO:	*1.663,75*	X 10^3 R$
EQ. ELETROMECÂNICOS:	*25.772,67*	X 10^3 R$	JUROS ANUAIS:	*10*	%
MEIO AMBIENTE:	*533,50*	X 10^3 R$	PERÍODO DE UTILIZAÇÃO DA USINA:	*30*	anos
SUBESTAÇÃO:	*1.155,00*	X 10^3 R$	C.O.M. ANUAL:	*1.007.37*	X 10^3 R$
CUSTO DIRETO TOTAL:	*52.409,40*	X 10^3 R$	CUSTO DA ENERGIA GERADA:	*95,97*	R$/MWh
CUSTOS INDIRETOS:	*6.475,68*	X 10^3 R$			
CUSTO TOTAL S/ JDC:	*58.885,08*	X 10^3 R$	DATA DE REFERÊNCIA:	*Janeiro/2007*	
CUSTO TOTAL C/ JDC:	*64.773,58*	X 10^3 R$	TAXA DE CÂMBIO:	2,18	R$/US$

10. IMPACTOS SÓCIO-AMBIENTAIS			
POPULAÇÃO ATINGIDA (N° HABITANTES):		FAMÍLIAS ATINGIDAS:	
URBANA:		URBANA:	
RURAL:		RURAL:	
TOTAL:	0,00	TOTAL:	0,00
QUANTIDADE DE NÚCLEOS URBANOS ATINGIDOS:			
INTERFERÊNCIA EM ÁREAS LEGALMENTE PROTEGIDAS ? (sim ou não)			
INTERFERÊNCIA EM ÁREAS INDÍGENAS ? (sim ou não)	*Não*	TRIBO (S):	
RELOCAÇÃO DE ESTRADAS ? (sim ou não)	*Não*	EXTENSÃO:	km
RELOCAÇÃO DE PONTES ? (sim ou não)	*Não*	EXTENSÃO:	km
EMPREGOS GERADOS DURANTE A CONSTRUÇÃO:			
DIRETOS:		INDIRETOS:	

11. CRONOGRAMA - PRINCIPAIS FASES					
INÍCIO DAS OBRAS ATÉ O DESVIO:	*11*	meses	TOTAL:	*19*	meses
DESVIO ATÉ O FECHAMENTO:	*7*	meses	MONTAGEM ELETROMECÂNICA (1° UNID.):	*14*	meses
FECHAMENTO ATÉ GERAÇÃO (1° UNID.):	*0,6*	meses	OPERAÇÃO PRIMEIRA UNIDADE:	*18,6*	meses

12. ASPECTOS CRÍTICOS DO EMPREENDIMENTO		
PARQUES NACIONAIS ? (sim ou não)	*Não*	(especificar, quando for o caso)
ÁREAS DE PROTEÇÃO AMBIENTAL - APA ? (sim ou não)	*Não*	(especificar, quando for o caso)
RESERVAS ECOLÓGICAS ? (sim ou não)	*Não*	(especificar, quando for o caso)
RESERVAS MINERAIS ? (sim ou não)	*Não*	(especificar, quando for o caso)
SÍTIOS ARQUEOLÓGICOS ? (sim ou não)	*Não*	(especificar, quando for o caso)

CAVERNAS ? (sim ou não)	*Não*		(especificar, quando for o caso)		
CANOAGEM NO LEITO DO RIO ? (sim ou não)	*Não*		(especificar, quando for o caso)		
OUTROS ? (sim ou não)	*Não*		(especificar, quando for o caso)		
13. DESCRIÇÃO SOBRE OS OUTROS USOS DA ÁGUA					
NAVEGAÇÃO (sim ou não)	*Não*		(especificar, quando for o caso)		
ABASTECIMENTO PÚBLICO (sim ou não)	*Não*		(especificar, quando for o caso)		
TURISMO LOCAL (sim ou não)	*Não*		(especificar, quando for o caso)		
LAZER (sim ou não)	*Não*		(especificar, quando for o caso)		
OUTROS (sim ou não)	*Sim*		Dessedentação animal		
14. OBSERVAÇÕES					
DADOS DE ARRANJO					
15. DESVIO					
TIPO:	*Adufa*		ESCAVAÇÃO COMUM:	*15.242*	m^3
VAZÃO DE DESVIO: (TR = 10 anos estiagem)	*19,00*	m^3/s	ESC. EM ROCHA A CÉU ABERTO:	*3771*	m^3
NÚMERO DE UNIDADES:	*1*		ESC. EM ROCHA ALTERADA:		m^3
SEÇÃO:	*9,0*	m^2	CONCRETO (CONVENCIONAL):	*230*	m^3
COMPRIMENTO:	*32,40*	m	ENSECADEIRA:	*13.103*	m^3
16. BARRAGEM					
TIPO DE ESTRUTURA / MATERIAL:	*terra e enrocamento*		FILTROS E TRANSIÇÕES:	*30.800*	m^3
COMPRIMENTO TOTAL DA CRISTA:	*294*	m	CONCRETO CONVENCIONAL:		m^3
ENROCAMENTO:	*8.600*	m^3	CONC. COMPACTADO A ROLO-CCR:		m^3
ATERRO COMPACTADO:	*432.000*	m^3	VOLUME TOTAL:		m^3
17. DIQUES					
TIPO DE ESTRUTURA / MATERIAL:			ATERRO COMPACTADO:		m^3
COMPRIMENTO TOTAL DA(S) CRISTA(S):		m	FILTROS E TRANSIÇÕES:		m^3
ALTURA MÁXIMA:		m	CONCRETO CONVENCIONAL:		m^3
COTA DA CRISTA:		m	CONC. COMPACTADO A ROLO-CCR:		m^3
ENROCAMENTO:		m^3	VOLUME TOTAL:		m^3
18. VERTEDOURO					
TIPO:	*Soleira Livre*		CONCRETO (CONVENCIONAL):	*2100*	m^3
VAZÃO DE PROJETO: *(TR = 500 ANOS)*	*121,00*	m^3/s	COMPORTAS:		
COTA DA SOLEIRA:	*650,00*	m	TIPO:		
COMPRIMENTO TOTAL:	*30,00*	m	ACIONAMENTO:		
NÚMERO DE VÃOS:		-	LARGURA:		M
LARGURA DO VÃO:		m	ALTURA:		m
ESCAVAÇÃO COMUM:	*2.410*	m^3			
ESCAVAÇÃO EM ROCHA A CÉU ABERTO:	*600*	m^3			
ESCAVAÇÃO EM ROCHA ALTERADA:		m^3			
19. SISTEMA ADUTOR					
CANAL DE ADUÇÃO:			TOMADA D'ÁGUA:		
COMPRIMENTO:	*6.920,00*	m	TIPO:		
LARGURA DA BASE / SEÇÃO:	*6,0 / 20,80*	m / m^2	COMPRIMENTO TOTAL:	*12,75*	m
ESCAVAÇÃO COMUM:	*963.000*	m^3	NÚMERO DE VÃOS:	*1*	-
ESC. EM ROCHA A CÉU ABERTO:		m^3	ESCAVAÇÃO COMUM:	*2.100*	m^3
ESC. EM ROCHA ALTERADA:		m^3	ESC. EM ROCHA A CÉU ABERTO:	*600*	m^3
CONCRETO PROJETADO:	*1.100*	m^3	ESC. EM ROCHA ALTERADA:		m^3
CONDUTO FORÇADO:			CONCRETO:	*960*	m^3
NÚMERO DE UNIDADES:	*1*		COMPORTAS:		
DIÂMETRO INTERNO:	*2,40*	m	TIPO:	*Ensecadeira*	
COMPRIMENTO MÉDIO:	*630*	m	ACIONAMENTO:	*Talha*	
DIÂMETRO APÓS DERIVAÇÃO	*1,70*	m	LARGURA:	*2,40*	*m*
DIÂMETRO DA VÁLVULA BORBOLETA	*1,20*	m	ALTURA:	*2,40*	m
20. CASA DE FORÇA / CANAL DE FUGA					
TIPO:	*Abrigada*		ESCAVAÇÃO COMUM:	*5.181*	m^3
NÚMERO DE UNIDADES:	*2*		ESC. EM ROCHA A CÉU ABERTO:	*10.400-*	m^3
LARGURA DOS BLOCOS:	*10,00*	m	ESC. EM ROCHA ALTERADA:	*2.410*	m3

CONTINUED . . .

ALTURA DOS BLOCOS:	*15,50*	m	CONCRETO:	*1.145*	m^3
COMPRIMENTO DOS BLOCOS:	*32.40*	m			
21. OBRAS ESPECIAIS					
TIPO:			ESC. EM ROCHA A SUBTERRÂNEA:		m^3
ESCAVAÇÃO COMUM:		m^3	CONCRETO CONVENCIONAL:		m^3
ESC. EM ROCHA A CÉU ABERTO:		m^3	CONC. COMPACTADO A ROLO - CCR:	4.692	m^3
22 . VOLUMES TOTAIS					
ESCAVAÇÃO COMUM:	*1.055.330*	m^3	ATERRO COMPACTADO:	*432.000*	m^3
ESC. EM ROCHA A CÉU ABERTO:	*25.711*	m^3	CONCRETO CONVENCIONAL:	*8.390*	m^3
ESC. EM ROCHA ALTERADA:	*27.600*	m^3	CONC. COMPACTADO A ROLO - CCR:	*13.202*	m^3
ENROCAMENTO:	*8.800*	m^3	TRANSIÇÕES	*42.700*	m3

The Piedade river basin is almost completely within the municipal region of Monte Alegre de Minas, covering a total surface area of 2607 square kilometers.

The Piedade river basin region is relatively homogeneous from a climatic standpoint, and can be classified as humid and tropical; there are reasonable seasonal variations, with well-defined seasons. According to the rainfall information from the Uberaba station, the period between October and March represents around 83% of total precipitation, and the driest quarter between June and August represents only 3%. Consultation of the Minas Gerais State Climate Atlas shows that the basin is located along the 1400 mm contour line, and it is interesting to note that annual totals grow towards the east, towards Araxá, reaching around 1700 mm, and also to the west, towards Ituiutaba, reaching levels of around 1500 mm.

The weather characteristics allow us to classify it as AW in the Köppen classification. It presents high summer temperatures, with average temperatures of around 22°C. This average is slightly lower in the winter, July being the coldest month, with minimum temperatures reaching 12°C. Rainfall distribution and high temperatures are responsible for the occurrence of a shortfall period followed by another with excessive water in the ground.

Systems affecting the area include Polar Front disturbed circulation which modifies the stability in the region, with discontinuity generated by the meeting of the polar and tropical air masses. This front, which is very mobile and affects almost the entire country, exerts its greatest effect during winter and spring. The disturbances from this front cause rain and, after it has passed, the polar mass following behind is responsible for good, dry weather, clear skies and significant temperature falls, especially during winter.

The flow regime study for Piedade SHS includes: rainfall/river characteristics, defining average monthly flow series, drawing up permanence curves, maximum discharge frequency studies and analysis of sedimentation.

For a comparative analysis, we also used data from the Araguari River (APH Perdizes) and and the intermediate area between the Cachoeira Dourada and Itumbiara UHEs, based on SIPOT information.

The average monthly flow series extended back to 1942, using correlations and relations between drainage areas. Floodwater flow was defined using a regional analysis of extremes, based on a statistical analysis of daily information from various river flow points available.

In the Basic Project Consolidation phase, new bathymetric and topographic surveys were carried out in the dam and power station region, in addition to a survey and demarcation of the reservoir water line. Two staff gauges were installed, one upstream from the axis of the dam and another downstream from the tailrace to measure the flow and take water readings, from which we were able to determine the discharge flow at the plant's tailrace outlet.

In order to establish the necessary coherence, the hydrological surveys for this consolidation were based on the information contained in the original Basic project reports, only updating the monthly average flow series, according to data available from the basin.

1.2 River Flow

In order to obtain the monthly average flow series on the Piedade SHS axis, we collected data from fluviometric stations along the Piedade river and neighboring basins and, when possible, from areas with the same physical and climate characteristics. Table 1.1 contains information on the main flow measurement stations in the relevant area and surrounding areas, whose data was obtained from the ANEEL/ANA database.

Table 1.1
Flow Measurement
Posts

Código ANEEL / SIPOT	Posto	Rio	Lat.	Long.	Entidade	Área de Drenagem (km²)	Período de Observações Processadas
60381000	Fazenda Letreiro	Uberabinha	19º00'	48º14'	ANA	924	74/02
60381005	Estação Sucupira	Uberabinha	18º46'	48º18'	ANA	1.344	50/65
60850000	Faz. Buriti do Prata	Da Prata	19º21'	49º11'	ANA	2.492	42/02
60620000	Ponte Rio Piedade	Piedade	18º33'	49º10'	ANA	1.727	52/75
60835000	Fazenda Paraíso	Tijuco	19º14'	48º35'	ANA	1.923	49/01
60226080	APH Perdizes	Araguari	19º41'	47º26'	SIPOT	3.000	31/96

In general, faults were detected in records from the stations used, especially: at Fazenda Letreiro, data is missing in the months of August and September, 1975, October to December 1978; several months in 1987 and nine months in 1988; at Fazenda Buriti do Prata, data is missing in January, February and March 1943, March 1946, January 1948; debris of 1950 to December of 1954, July and August 1955, March to August 1959, October 1960 to August 1962, December 1962, March to December 1965, April to June 1966, January to March 1969, January 1974, made to August 1980, June and December 1987, June, July, October and November 1988, January 1989, January and February 1990 and October 1990 to May 1991; at Fazenda Paraíso, data is missing in August and September 1954, from January 1958 to July 1962, from March 1963 to February 1964, from January 1965 to July 1966, from December 1968 August 1969, April 1970, from November 1972 January 1971, October 1974, April and August 1975, from September 1990 to May 1991 and from September 1991 to December 1994; at Ponte Rio Piedade, As the base station for the current study, information is missing from January to March 1952, from February 1958 to February 1959, August 1959, May 1960 to February 1962, November and December 1963 and February 1964.

The monthly average flow series for the Ponte Rio Piedade station can be extended by around 10 years because they were daily measurements available up to 1985, although the data available on ANA ends in 1975. Because of the inconsistencies from the Estação de Sucupira station on the Uberabinha river, it was not included in the study, opting to work with the Fazenda Letreiro data from the same river.

In order to standardize the information, all of the drainage areas were recalculated on the same cartographic basis, obtaining different figures for the Fazenda Paraiso stations, which increased from 1469 square kilometers to 1923 square kilometers and Fazenda Buriti do Prata, which fell from 2526 square kilometers to 2492 square kilometers. The original values from Ponte rio Piedade and Fazenda Letreiro were maintained, 1727 square kilometers and 924 square kilometers respectively.

The SIPOT database was used to obtain monthly average flows, covering the period between 1931/1994, for the UHE Cachoeira Dourada and UHE Itumbiara, on the Paranaíba river and UHEs Perdizes, Pai Joaquim, Nova Ponte, Miranda and Capim Branco II on the Araguari river.

The Piedade river basin presents a strange isohyetal configuration which may explain its lower specific contribution in comparison with neighboring rivers, for example the Prata, Uberabinha and Araguari. The total precipitation chart indicated in the Minas Gerais Climate Atlas shows increasing rainfall isobars towards the east, rising from 1400 mm at the source of the Piedade river to 1600 mm on the Araguari river. In the other direction, West, the isobars also grow in value from 1400 mm at the left bank of the Tijuco River to 1500 mm. This means that the Piedade river basin is indeed the sector with the lowest rainfall throughout the Minas Gerais triangle. Although the difference is not very big, it may justify the lower water yields of the Piedade River presented by the fluviometric data from the station of the same name.

On the Piedade river, the station capable of providing flow information at the project site is Ponte Rio Piedade (code 60620000), situated upstream from the BR-153 highway bridge, which crosses the river on its downstream stretch. The average monthly flow information initially obtained, covering a short period of historical time (1952 to 1975, with several missing sections and only 16 complete years) and including highly critical years such as 1953 to 1956, 1971 and 1972, result in a specific average contribution of 8.8 $l/s.km^2$, a low value and clearly not representative of the long-term average in dislocation, even considering the aforementioned isohyetal peculiarities.

Several analysis were carried out in order to increase the range available at the Ponte Rio Piedade station as far as possible, including layout and comparison of daily river heights, monthly hydrographs and correlations between monthly average flow and neighboring stations. Subsequently, the flows from the station were transferred to possible uses locations on the Piedade River based on a simple relationship between the drainage areas, based on the proximity of the Andusa. However, certain aspects had to be taken into account as follows:

Initially, we attempted to increase the flow series from the Ponte rio Piedade station, using the average daily river heights available for the period between 1976 and 1985, which had not yet been processed. Based on the discharge measurements obtained from ANEEL, we can draw the station discharge curve finding that the curve is unique and covers measurements carried out in the aforementioned period. The equation obtained for the discharge curve was:

$$Q = 0{,}03657 \, . \, (H - 50)_{1{,}45531}$$

where:

H = height in cm
Q = flow in m^3/s

We then sought to define the biggest common average monthly flow period between the stations at Ponte Rio Piedade, on the Piedade river, Fazenda Letreiro, on the Uberabinha river, Fazenda Paraíso, on the Tijuco river and Buriti do Prata, on the Prata river, in order to find and compare the respective specific contributions. This period was 1974 to 1985, which can be completely filled out with small adjustments and some additional data generated by correlation. Table 1.2 also includes data from the Perdizes location on the Araguari river, and the intermediate area between the UHEs Cachoeira Dourada and Itumbiara, for the same period, showing the results obtained.

Table 1.2
Specific Contribution in the Period between 1974-1985

Rio	Posto Fluviométrico / Local	Contribuição Específica (l/s.km²)
Piedade	Ponte Rio Piedade	14,4
Uberabinha	Fazenda Letreiro	15,5
Tijuco	Fazenda Paraíso	14,5
Prata	Buriti do Prata	15,3
Araguari	APH Perdizes	24,8
Paranaíba	Área intermediária entre as UHEs Cachoeira Dourada e Itumbiara	15,1

The information obtained allowed us to reach certain conclusions:

- The specific contribution from the Piedade river is lower than the neighboring rivers Uberabinha (Fazenda Letreiro) and Prata (Buriti do Prata), therefore confirming the evidence from the isohyetal configuration;
- A specific contribution of the Piedade river is similar to the Tijuco river (Fazenda Paraíso), as expected, as it is an adjacent river and subject to the same physical and geographical conditions.
- Data from the Araguari river, in Perdizes, obtained from SIPOT, indicate a high specific contribution, possibly a result of high levels of rainfall in the river basin region, around Araxá.
- The specific contribution obtained in the intermediate area (4700 square kilometers) between Cachoeira Dourada and Itumbiara is coherent with the characteristics of this section, given that it includes contributions from the Piedade, Tijuco and Prata rivers, as well as the tributaries from the right bank. This information only has value was supporting evidence as, apparently, part of the information from both plants

Is based on flow rate reconstitution using reservoir operation data;

- The specific contribution values indicated in the table are valid for the period stated are not representative of longer periods.

The next step was to complete the monthly average flow rates series for the Ponte rio Piedade station for the period preceding 1952 and fill gaps between this date and 1964.

An exhaustive analysis was conducted, which included comparison of daily hydrographs in order to establish possible information for months without any data, based on the relationship between the drainage areas and neighboring stations, subsequently defining the following hierarchy:

- The priority station used is Fazenda Paraíso, on the Tijuco river, because of its proximity and similarity with the rainfall and flow rate regime. With the information from the station we could have filled out the Ponte Rio Piedade series up to 1949 if it were not for several gaps, especially between 1958 and 1966;
- Then, in months where data is missing from Fazenda Paraiso, we used data from the Fazenda Letreiro station, on the Uberabinha river. In this case, the list of drainage areas was affected by the ratio between the respective specific contributions;
- We then used data from the Buriti do Prata station on the Prata river;
- Finally, for the remaining months that needed filling in, and to complete the series from the Ponte Rio Piedade between 1941 and 1931, we used information from Perdizes on the Araguari river. In this case, the list of drainage areas was also affected by the ratio between the respective specific contributions;

This procedure allowed us to complete a series of monthly average flow rates at the Ponte Rio Piedade station, encompassing the period between 1931 and 2005. Below is a list of the months which were filled in, the base stations used and the respective equations.

At Ponte Rio Piedade, the months of 01/86 208/90, 06/91 to 08/91, 01/95 to 12/01 and 05/49 to 03/52 were filled in using the Fazenda Paraíso station, on the Tijuco river, based on the expression $Q_{PIE} = 0,898.Q_{PAR}$, which represents the simple ratio between the drainage areas of both stations. The Fazenda Letreiro station was used for the months 09/90 to 05/91, 09/91 to 12/94 and 01/02 and 12/02 with the expression QPIE = 1,731.QLET, where the ratio between drainage areas is affected by the ratio between the respective specific contributions, 14.4 and 15.5 $l/s.km^2$. The months 02/3802/59, 05/6009/60, 11/63 to 12/63, 05/64, 11/41 to 12/42, 04/43 to 02/47, 04/47 to 12/47 and 02/4804/49 were filled in using the Buriti do Prata station, on the Prata river, using the equation QPIE = 0,693.QBUR, representing the simple ratio between the drainage areas. Finally, the additional months of 01/43 to 03/43, 03/47, 01/48, 08/59, 10/60 to 02/62 and also the period between 01/31 and 10/41, were completed using the local flow rates data from UHE Perdizes, on the Araguari river, based on the expression QPIE = 0,334.QPER, where the drainage area ratio between both areas is affected by the ratio between the respective specific contributions, 14.4 and 24.8 $l/s.km^2$.

Table 1.3 shows the monthly average flow rates series for the Ponto Rio Piedade station in the period between 1931/2005, obtained as described. Average flow rate is 20.95 m^3/s, which for a drainage area of 1727 square kilometres represents a specific contribution of 12.13 $l/s.km^2$, a coherent value in light of the specific nature of the rainfall and river flow in the river basin.

On the other hand, the period between 1931 in 1941 depended entirely on the Perdizes location on the Araguari river, therefore at the Ponte Rio Piedade location we decided to use only the series of figures from 1942 to 2005, which presents a substantial period of time (64 years), including the data from the interlinked system and missing information was provided by neighbouring stations. Table 1.4 presents the series from the Ponte Rio Piedade station between 1942 and 2005. All the following calculations therefore cover the series from this period, which was believed to be more reliable, with average flow rate of 21.59 m^3/s, which represents a contribution of 12.5 $l/s.km^2$.

Table 1.5 shows the average monthly flow rates series at Piedade SHS, obtained from the drainage area ratio with the Ponte Rio Piedade station. Figure 1.1 we have the monthly average flow rate permanence curve at Piedade SHS.

LIMIAR
ENGENHARIA
AMBIENTAL

Table 1.3

PIEDADE RIVER AT PONTE RIO PIEDADE (AD = 1.727 KM2) MONTHLY AVERAGE FLOW SERIES - PERIOD 1.931-2005.

Ano	Jan	Fev	Mar	Abr	Mai	Jun	Jul	Ago	Set	Out	Nov	Dez	Média
1931	38,40	67,50	67,80	49,80	26,80	17,70	15,90	13,60	13,30	13,00	13,20	17,90	29,58
1932	15,30	39,70	30,60	20,70	14,40	13,70	11,30	8,40	6,10	10,10	13,10	30,10	17,79
1933	50,40	41,80	30,10	27,70	18,00	13,90	10,20	9,00	8,10	10,00	11,70	23,40	21,19
1934	28,50	22,30	22,20	17,40	12,20	6,80	5,50	4,40	5,30	7,20	6,30	10,00	12,34
1935	39,70	48,10	28,30	42,80	26,00	16,10	11,60	10,10	5,60	9,30	10,40	17,50	22,13
1936	18,20	12,00	35,40	24,40	15,10	9,80	8,60	6,50	5,60	5,80	8,60	13,60	13,63
1937	29,50	12,20	16,10	18,70	13,20	11,10	7,70	5,70	5,00	5,90	14,10	28,00	13,93
1938	32,20	22,20	22,20	18,00	10,60	8,90	8,30	5,20	4,00	3,60	7,70	23,60	13,88
1939	35,10	36,40	16,00	13,50	11,50	9,60	6,90	6,00	4,50	4,90	9,60	13,60	13,97
1940	24,40	43,80	38,10	19,00	14,60	11,00	8,20	4,60	4,70	5,60	17,60	15,30	17,24
1941	30,30	19,90	17,00	20,50	10,30	8,10	6,80	5,10	5,10	6,50	21,40	18,50	14,13
1942	17,40	24,60	36,70	24,69	15,81	10,51	7,49	5,41	5,91	5,30	8,71	22,41	15,41
1943	57,11	52,40	46,40	23,10	14,59	11,90	8,30	6,21	5,10	15,40	22,80	19,61	23,58
1944	17,70	25,91	33,40	22,19	11,29	8,30	6,21	4,60	3,69	8,71	16,00	15,90	14,49
1945	15,00	48,60	37,40	31,29	16,90	12,29	8,90	6,21	4,69	15,31	29,10	40,30	22,17
1946	45,00	36,70	52,70	29,21	19,50	15,50	16,59	10,60	8,60	15,40	15,31	22,91	24,00
1947	41,69	43,19	61,50	28,80	22,00	16,90	14,59	12,10	15,90	17,31	13,70	48,49	28,01
1948	36,40	54,90	43,69	27,40	19,61	15,70	13,40	11,01	8,99	10,51	29,40	22,60	24,47
1949	32,40	54,90	35,70	20,00	22,80	14,01	10,90	7,90	5,99	23,80	14,20	22,60	22,10
1950	25,10	47,49	44,41	23,00	16,40	13,01	9,71	6,80	5,69	9,30	32,51	31,79	22,10
1951	52,60	56,20	50,70	26,10	19,61	15,90	12,01	9,30	7,30	10,10	11,40	15,40	23,88
1952	29,90	35,50	42,91	20,30	12,01	10,79	8,60	6,90	5,91	11,79	13,81	12,01	17,54
1953	10,01	11,90	20,70	16,40	9,90	7,60	6,80	5,30	6,40	12,29	9,30	17,70	11,19
1954	9,40	21,69	11,29	10,79	11,01	6,80	5,10	3,69	3,00	2,50	5,69	7,60	8,21
1955	23,19	13,60	11,79	10,79	5,80	4,80	3,69	6,80	4,00	5,00	4,00	20,70	9,51
1956	19,30	15,81	23,91	11,51	11,90	16,50	8,80	7,80	6,30	5,69	9,90	14,70	12,68
1957	25,91	26,99	22,80	31,29	18,50	13,10	11,20	7,60	8,80	4,60	9,79	16,90	16,46
1958	43,00	57,20	44,69	35,59	30,40	21,80	20,20	12,90	14,09	14,81	13,90	29,21	28,15
1959	50,01	37,09	39,11	17,59	13,29	11,51	11,60	11,20	9,79	7,21	11,60	20,80	20,07
1960	29,60	47,21	25,91	16,31	13,40	12,79	8,80	6,10	4,60	12,01	27,10	41,41	20,44
1961	67,49	68,80	59,11	30,70	29,60	20,20	16,70	14,31	12,10	11,20	16,90	15,90	30,25
1962	38,39	53,40	36,09	22,60	19,30	16,90	13,01	11,10	10,51	17,00	12,01	48,60	24,91
1963	41,00	40,00	22,80	18,31	14,50	12,60	11,60	10,21	8,40	6,80	9,10	5,30	16,72
1964	22,00	65,00	15,50	14,09	12,10	8,49	7,99	6,10	5,10	13,70	17,20	34,50	18,48
1965	37,89	41,11	41,61	24,30	19,39	15,00	13,40	10,40	8,80	15,09	18,70	25,10	22,57
1966	25,80	39,50	38,89	24,10	22,00	15,20	12,70	10,10	9,10	15,00	18,31	22,69	21,12
1967	28,40	35,00	28,30	21,91	16,81	13,90	10,90	9,10	10,51	11,01	18,80	28,49	19,43
1968	26,49	36,90	32,51	21,39	16,31	12,79	11,10	9,79	8,90	13,20	16,09	35,90	20,11
1969	32,70	28,10	18,31	17,20	11,79	9,60	8,49	6,99	6,21	11,10	23,91	15,59	15,83
1970	26,80	36,50	23,69	16,90	11,70	9,71	8,49	6,99	7,90	9,40	9,79	9,40	14,77
1971	8,40	9,60	11,01	6,99	5,10	5,19	3,91	3,60	3,10	4,69	8,49	22,91	7,75
1972	13,51	20,61	15,09	9,79	7,40	5,91	6,80	5,10	5,41	15,90	20,89	20,30	12,23
1973	25,71	29,79	38,70	26,10	16,09	12,90	10,60	8,60	8,10	12,51	20,80	23,41	19,44
1974	24,10	16,90	31,79	26,49	16,00	13,29	10,51	9,21	6,99	10,70	10,40	22,69	16,59
1975	27,21	19,50	16,81	20,89	12,20	9,49	10,10	7,21	5,60	9,10	18,39	26,71	15,27
1976	19,39	33,01	25,30	22,11	13,60	11,60	9,60	8,99	11,29	16,50	19,39	38,39	19,10
1977	40,20	29,10	22,30	23,60	17,09	14,31	10,90	8,99	9,60	11,01	25,41	31,79	20,36
1978	49,90	25,19	23,60	20,50	16,31	15,90	12,10	10,51	9,71	16,59	33,60	38,00	22,66
1979	40,00	44,00	30,01	25,00	23,69	20,80	18,50	14,81	20,20	13,60	21,69	24,80	24,76
1980	46,80	42,30	27,30	32,10	25,60	21,61	18,89	15,90	16,31	17,00	24,30	33,01	26,76
1981	42,50	25,71	28,10	19,00	17,00	15,90	13,51	12,10	9,90	19,39	23,50	31,51	21,51
1982	51,51	42,19	45,10	40,39	31,70	28,21	23,91	21,20	18,20	21,11	22,00	38,89	32,03
1983	74,81	69,79	76,20	48,80	33,81	30,70	26,99	22,80	24,41	29,60	32,60	53,10	43,63
1984	40,50	36,09	28,99	29,10	23,60	19,20	17,70	18,61	18,50	16,00	24,50	30,70	25,29
1985	52,20	48,90	54,70	39,89	26,49	22,69	21,00	18,61	17,81	17,09	20,11	23,30	30,23
1986	36,59	35,70	36,09	22,00	21,61	12,51	12,79	13,10	8,30	10,01	9,60	34,59	21,07
1987	41,91	51,20	47,99	27,40	22,50	15,59	11,70	9,21	8,49	7,90	23,91	34,31	25,18
1988	31,10	66,71	36,50	41,00	23,50	17,20	12,29	9,71	7,49	15,50	20,89	29,30	25,93
1989	34,20	56,90	40,39	21,00	15,81	13,01	10,79	12,60	11,29	7,60	12,79	27,10	21,96
1990	30,60	16,31	19,11	22,19	15,09	9,40	8,40	7,71	10,10	8,99	7,60	13,20	14,06
1991	27,90	51,20	57,50	63,50	20,00	18,50	14,81	10,10	8,71	10,90	12,79	26,71	26,89
1992	52,40	72,01	45,99	34,90	23,80	17,20	16,31	13,01	16,50	21,50	59,20	37,31	34,18
1993	27,60	54,31	39,89	45,30	22,60	25,30	16,81	14,20	15,81	18,39	20,50	28,10	27,40
1994	60,20	26,90	45,99	28,49	21,91	15,81	13,90	12,79	10,90	12,01	15,59	32,60	24,76
1995	23,91	50,40	42,69	26,10	11,60	15,59	19,61	11,51	9,10	14,09	13,10	20,30	21,50
1996	29,51	26,90	36,70	23,60	16,50	15,40	12,60	10,90	14,09	9,49	21,50	20,20	19,78
1997	80,23	30,21	45,73	24,39	16,98	22,37	13,45	10,28	9,06	12,22	16,88	40,30	26,84
1998	33,74	44,51	29,92	19,50	21,84	13,01	9,03	10,38	5,91	12,04	18,06	27,60	20,46
1999	63,66	30,83	39,75	19,82	12,58	11,15	8,81	6,71	9,12	5,82	7,15	14,50	19,16
2000	53,36	74,45	65,33	29,56	17,52	13,63	11,97	9,72	15,66	7,74	19,71	23,68	28,53
2001	14,75	12,90	18,95	12,76	8,78	6,82	5,21	4,75	4,67	8,53	9,22	15,22	10,21
2002	73,40	60,75	36,72	18,91	14,67	11,74	10,69	9,71	9,97	8,28	19,75	43,44	26,50
2003	86,69	61,99	50,38	31,36	25,35	18,56	15,60	14,93	15,69	15,23	41,03	40,47	34,77
2004	28,42	39,15	27,73	31,95	21,11	20,13	16,15	12,10	8,04	13,57	21,99	37,97	23,19
2005	42,92	38,60	26,89	21,62	19,34	17,94	14,87	13,48	12,98	8,13	21,23	36,16	22,85
Mínima	8,40	9,60	11,01	6,99	5,10	4,80	3,69	3,60	3,00	2,50	4,00	5,30	2,50
Média	35,63	38,89	34,55	24,89	17,46	14,12	11,72	9,67	9,15	11,62	17,48	25,85	20,95
Máxima	86,69	74,45	76,20	63,50	33,81	30,70	26,99	22,80	24,41	29,60	59,20	53,10	86,69

QUADRO 1.4

RIO PIEDADE EM PONTE RIO PIEDADE (AD = 1.727 KM2)SÉRIE DE VAZÕES MÉDIAS MENSAIS - PERÍODO 1.942-2.005

Ano	Jan	Fev	Mar	Abr	Mai	Jun	Jul	Ago	Set	Out	Nov	Dez	Média
1942	17.40	24.60	36.70	24.69	15.81	10.51	7.49	5.41	5.91	5.30	8.71	22.41	15.41
1943	57.11	52.40	46.40	23.10	14.59	11.90	8.30	6.21	5.10	15.40	22.80	19.61	23.58
1944	17.70	25.91	33.40	22.19	11.29	8.30	6.21	4.60	3.69	8.71	16.00	15.90	14.49
1945	15.00	48.60	37.40	31.29	16.90	12.29	8.90	6.21	4.69	15.31	29.10	40.30	22.17
1946	45.00	36.70	52.70	29.21	19.50	15.50	16.59	10.60	8.60	15.40	15.31	22.91	24.00
1947	41.69	43.19	61.50	28.80	22.00	16.90	14.59	12.10	15.90	17.31	13.70	48.49	28.01
1948	36.40	54.90	43.69	27.40	19.61	15.70	13.40	11.01	8.99	10.51	29.40	22.60	24.47
1949	32.40	54.90	35.70	20.00	22.80	14.01	10.90	7.90	5.99	23.80	14.20	22.60	22.10
1950	25.10	47.49	44.41	23.00	16.40	13.01	9.71	6.80	5.69	9.30	32.51	31.79	22.10
1951	52.60	56.20	50.70	26.10	19.61	15.90	12.01	9.30	7.30	10.10	11.40	15.40	23.88
1952	29.90	35.50	42.91	20.30	12.01	10.79	8.60	6.90	5.91	11.79	13.81	12.01	17.54
1953	10.01	11.90	20.70	16.40	9.90	7.60	6.80	5.30	6.40	12.29	9.30	17.70	11.19
1954	9.40	21.69	11.29	10.79	11.01	6.80	5.10	3.69	3.00	2.50	5.69	7.60	8.21
1955	23.19	13.60	11.79	10.79	5.80	4.80	3.69	6.80	4.00	5.00	4.00	20.70	9.51
1956	19.30	15.81	23.91	11.51	11.90	16.50	8.80	7.80	6.30	5.69	9.90	14.70	12.68
1957	25.91	26.99	22.80	31.29	18.50	13.10	11.20	7.60	8.80	4.60	9.79	16.90	16.46
1958	43.00	57.20	44.69	35.59	30.40	21.80	20.20	12.90	14.09	14.81	13.90	29.21	28.15
1959	50.01	37.09	39.11	17.59	13.29	11.51	11.60	11.20	9.79	7.21	11.60	20.80	20.07
1960	29.60	47.21	25.91	16.31	13.40	12.79	8.80	6.10	4.60	12.01	27.10	41.41	20.44
1961	67.49	68.80	59.11	30.70	29.60	20.20	16.70	14.31	12.10	11.20	16.90	15.90	30.25
1962	38.39	53.40	36.09	22.60	19.30	16.90	13.01	11.10	10.51	17.00	12.01	48.60	24.91
1963	41.00	40.00	22.80	18.31	14.50	12.60	11.60	10.21	8.40	6.80	9.10	5.30	16.72
1964	22.00	65.00	15.50	14.09	12.10	8.49	7.99	6.10	5.10	13.70	17.20	34.50	18.48
1965	37.89	41.11	41.61	24.30	19.39	15.00	13.40	10.40	8.80	15.09	18.70	25.10	22.57
1966	25.80	39.50	38.89	24.10	22.00	15.20	12.70	10.10	9.10	15.00	18.31	22.69	21.12
1967	28.40	35.00	28.30	21.91	16.81	13.90	10.90	9.10	10.51	11.01	18.80	28.49	19.43
1968	26.49	36.90	32.51	21.39	16.31	12.79	11.10	9.79	8.90	13.20	16.09	35.90	20.11
1969	32.70	28.10	18.31	17.20	11.79	9.60	8.49	6.99	6.21	11.10	23.91	15.59	15.83
1970	26.80	36.50	23.69	16.90	11.70	9.71	8.49	6.99	7.90	9.40	9.79	9.40	14.77
1971	8.40	9.60	11.01	6.99	5.10	5.19	3.91	3.60	3.10	4.69	8.49	22.91	7.75
1972	13.51	20.61	15.09	9.79	7.40	5.91	6.80	5.10	5.41	15.90	20.89	20.30	12.23
1973	25.71	29.79	38.70	26.10	16.09	12.90	10.60	8.60	8.10	12.51	20.80	23.41	19.44
1974	24.10	16.90	31.79	26.49	16.00	13.29	10.51	9.21	6.99	10.70	10.40	22.69	16.59
1975	27.21	19.50	16.81	20.89	12.20	9.49	10.10	7.21	5.60	9.10	18.39	26.71	15.27
1976	19.39	33.01	25.30	22.11	13.60	11.60	9.60	8.99	11.29	16.50	19.39	38.39	19.10
1977	40.20	29.10	22.30	23.60	17.09	14.31	10.90	8.99	9.60	11.01	25.41	31.79	20.36
1978	49.90	25.19	23.60	20.50	16.31	15.90	12.10	10.51	9.71	16.59	33.60	38.00	22.66
1979	40.00	44.00	30.01	25.00	23.69	20.80	18.50	14.81	20.20	13.60	21.69	24.80	24.76
1980	46.80	42.30	27.30	32.10	25.60	21.61	18.89	15.90	16.31	17.00	24.30	33.01	26.76
1981	42.50	25.71	28.10	19.00	17.00	15.90	13.51	12.10	9.90	19.39	23.50	31.51	21.51
1982	51.51	42.19	45.10	40.39	31.70	28.21	23.91	21.20	18.20	21.11	22.00	38.89	32.03
1983	74.81	69.79	76.20	48.80	33.81	30.70	26.99	22.80	24.41	29.60	32.60	53.10	43.63
1984	40.50	36.09	28.99	29.10	23.60	19.20	17.70	18.61	18.50	16.00	24.50	30.70	25.29
1985	52.20	48.90	54.70	39.89	26.49	22.69	21.00	18.61	17.81	17.09	20.11	23.30	30.23
1986	36.59	35.70	36.09	22.00	21.61	12.51	12.79	13.10	8.30	10.01	9.60	34.59	21.07
1987	41.91	51.20	47.99	27.40	22.50	15.59	11.70	9.21	8.49	7.90	23.91	34.31	25.18
1988	31.10	66.71	36.50	41.00	23.50	17.20	12.29	9.71	7.49	15.50	20.89	29.30	25.93
1989	34.20	56.90	40.39	21.00	15.81	13.01	10.79	12.60	11.29	7.60	12.79	27.10	21.96
1990	30.60	16.31	19.11	22.19	15.09	9.40	8.40	7.71	10.10	8.99	7.60	13.20	14.06
1991	27.90	51.20	57.50	63.50	20.00	18.50	14.81	10.10	8.71	10.90	12.79	26.71	26.89
1992	52.40	72.01	45.99	34.90	23.80	17.20	16.31	13.01	16.50	21.50	59.20	37.31	34.18
1993	27.60	54.31	39.89	45.30	22.60	25.30	16.81	14.20	15.81	18.39	20.50	28.10	27.40
1994	60.20	26.90	45.99	28.49	21.91	15.81	13.90	12.79	10.90	12.01	15.59	32.60	24.76
1995	23.91	50.40	42.69	26.10	11.60	15.59	19.61	11.51	9.10	14.09	13.10	20.30	21.50
1996	29.51	26.90	36.70	23.60	16.50	15.40	12.60	10.90	14.09	9.49	21.50	20.20	19.78
1997	80.23	30.21	45.73	24.39	16.98	22.37	13.45	10.28	9.06	12.22	16.88	40.30	26.84
1998	33.74	44.51	29.92	19.50	21.84	13.01	9.03	10.38	5.91	12.04	18.06	27.60	20.46
1999	63.66	30.83	39.75	19.82	12.58	11.15	8.81	6.71	9.12	5.82	7.15	14.50	19.16
2000	53.36	74.45	65.33	29.56	17.52	13.63	11.97	9.72	15.66	7.74	19.71	23.68	28.53
2001	14.75	12.90	18.95	12.76	8.78	6.82	5.21	4.75	4.67	8.53	9.22	15.22	10.21
2002	73.40	60.75	36.72	18.91	14.67	11.74	10.69	9.71	9.97	8.28	19.75	43.44	26.50
2003	86.69	61.99	50.38	31.36	25.35	18.56	15.60	14.93	15.69	15.23	41.03	40.47	34.77
2004	28.42	39.15	27.73	31.95	21.11	20.13	16.15	12.10	8.04	13.57	21.99	37.97	23.19
2005	42.92	38.60	26.89	21.62	19.34	17.94	14.87	13.48	12.98	8.13	21.23	36.16	22.85
Mínima	8.40	9.60	11.01	6.99	5.10	4.80	3.69	3.60	3.00	2.50	4.00	5.30	2.50
Média	36.84	39.86	35.43	24.91	17.77	14.57	12.16	10.10	9.68	12.33	18.40	26.99	21.59
Máxima	86.69	74.45	76.20	63.50	33.81	30.70	26.99	22.80	24.41	29.60	59.20	53.10	86.69

Table 1.5

PIEDADE River at PIEDADE SHS (AD = 967 KM2) MONTHLY AVERAGE FLOW SERIES - PERIOD 1.942-2.005

Ano	Jan	Fev	Mar	Abr	Mai	Jun	Jul	Ago	Set	Out	Nov	Dez	Média
1942	9.75	13.79	20.57	13.84	8.86	5.89	4.2	3.03	3.31	2.97	4.88	12.56	8.64
1943	32.01	29.37	26.01	12.95	8.18	6.67	4.65	3.48	2.86	8.63	12.78	10.99	13.21
1944	9.92	14.52	18.72	12.44	6.33	4.65	3.48	2.58	2.07	4.88	8.97	8.91	8.12
1945	8.41	27.24	20.96	17.54	9.47	6.89	4.99	3.48	2.63	8.58	16.31	22.59	12.42
1946	25.22	20.57	29.54	16.37	10.93	8.69	9.3	5.94	4.82	8.63	8.58	12.84	13.45
1947	23.37	24.21	34.47	16.14	12.33	9.47	8.18	6.78	8.91	9.7	7.68	27.18	15.7
1948	20.4	30.77	24.49	15.36	10.99	8.8	7.51	6.17	5.04	5.89	16.48	12.67	13.71
1949	18.16	30.77	20.01	11.21	12.78	7.85	6.11	4.43	3.36	13.34	7.96	12.67	12.39
1950	14.07	26.62	24.89	12.89	9.19	7.29	5.44	3.81	3.19	5.21	18.22	17.82	12.39
1951	29.48	31.5	28.42	14.63	10.99	8.91	6.73	5.21	4.09	5.66	6.39	8.63	13.39
1952	16.76	19.9	24.05	11.38	6.73	6.05	4.82	3.87	3.31	6.61	7.74	6.73	9.83
1953	5.61	6.67	11.6	9.19	5.55	4.26	3.81	2.97	3.59	6.89	5.21	9.92	6.27
1954	5.27	12.16	6.33	6.05	6.17	3.81	2.86	2.07	1.68	1.4	3.19	4.26	4.61
1955	13	7.62	6.61	6.05	3.25	2.69	2.07	3.81	2.24	2.8	2.24	11.6	5.33
1956	10.82	8.86	13.4	6.45	6.67	9.25	4.93	4.37	3.53	3.19	5.55	8.24	7.1
1957	14.52	15.13	12.78	17.54	10.37	7.34	6.28	4.26	4.93	2.58	5.49	9.47	9.23
1958	24.1	32.06	25.05	19.95	17.04	12.22	11.32	7.23	7.9	8.3	7.79	16.37	15.78
1959	28.03	20.79	21.92	9.86	7.45	6.45	6.5	6.28	5.49	4.04	6.5	11.66	11.25
1960	16.59	26.46	14.52	9.14	7.51	7.17	4.93	3.42	2.58	6.73	15.19	23.21	11.45
1961	37.83	38.56	33.13	17.21	16.59	11.32	9.36	8.02	6.78	6.28	9.47	8.91	16.96
1962	21.52	29.93	20.23	12.67	10.82	9.47	7.29	6.22	5.89	9.53	6.73	27.24	13.96
1963	22.98	22.42	12.78	10.26	8.13	7.06	6.5	5.72	4.71	3.81	5.1	2.97	9.37
1964	12.33	36.43	8.69	7.9	6.78	4.76	4.48	3.42	2.86	7.68	9.64	19.34	10.36
1965	21.24	23.04	23.32	13.62	10.87	8.41	7.51	5.83	4.93	8.46	10.48	14.07	12.65
1966	14.46	22.14	21.8	13.51	12.33	8.52	7.12	5.66	5.1	8.41	10.26	12.72	11.84
1967	15.92	19.62	15.86	12.28	9.42	7.79	6.11	5.1	5.89	6.17	10.54	15.97	10.89
1968	14.85	20.68	18.22	11.99	9.14	7.17	6.22	5.49	4.99	7.4	9.02	20.12	11.28
1969	18.33	15.75	10.26	9.64	6.61	5.38	4.76	3.92	3.48	6.22	13.4	8.74	8.87
1970	15.02	20.46	13.28	9.47	6.56	5.44	4.76	3.92	4.43	5.27	5.49	5.27	8.28
1971	4.71	5.38	6.17	3.92	2.86	2.91	2.19	2.02	1.74	2.63	4.76	12.84	4.34
1972	7.57	11.55	8.46	5.49	4.15	3.31	3.81	2.86	3.03	8.91	11.71	11.38	6.85
1973	14.41	16.7	21.69	14.63	9.02	7.23	5.94	4.82	4.54	7.01	11.66	13.12	10.9
1974	13.51	9.47	17.82	14.85	8.97	7.45	5.89	5.16	3.92	6	5.83	12.72	9.3
1975	15.25	10.93	9.42	11.71	6.84	5.32	5.66	4.04	3.14	5.1	10.31	14.97	8.56
1976	10.87	18.5	14.18	12.39	7.62	6.5	5.38	5.04	6.33	9.25	10.87	21.52	10.71
1977	22.53	16.31	12.5	13.23	9.58	8.02	6.11	5.04	5.38	6.17	14.24	17.82	11.41
1978	27.97	14.12	13.23	11.49	9.14	8.91	6.78	5.89	5.44	9.3	18.83	21.3	12.7
1979	22.42	24.66	16.82	14.01	13.28	11.66	10.37	8.3	11.32	7.62	12.16	13.9	13.88
1980	26.23	23.71	15.3	17.99	14.35	12.11	10.59	8.91	9.14	9.53	13.62	18.5	15
1981	23.82	14.41	15.75	10.65	9.53	8.91	7.57	6.78	5.55	10.87	13.17	17.66	12.06
1982	28.87	23.65	25.28	22.64	17.77	15.81	13.4	11.88	10.2	11.83	12.33	21.8	17.95
1983	41.93	39.12	42.71	27.35	18.95	17.21	15.13	12.78	13.68	16.59	18.27	29.76	24.46
1984	22.7	20.23	16.25	16.31	13.23	10.76	9.92	10.43	10.37	8.97	13.73	17.21	14.18
1985	29.26	27.41	30.66	22.36	14.85	12.72	11.77	10.43	9.98	9.58	11.27	13.06	16.95
1986	20.51	20.01	20.23	12.33	12.11	7.01	7.17	7.34	4.65	5.61	5.38	19.39	11.81
1987	23.49	28.7	26.9	15.36	12.61	8.74	6.56	5.16	4.76	4.43	13.4	19.23	14.11
1988	17.43	37.39	20.46	22.98	13.17	9.64	6.89	5.44	4.2	8.69	11.71	16.42	14.54
1989	19.17	31.89	22.64	11.77	8.86	7.29	6.05	7.06	6.33	4.26	7.17	15.19	12.31
1990	17.15	9.14	10.71	12.44	8.46	5.27	4.71	4.32	5.66	5.04	4.26	7.4	7.88
1991	15.64	28.7	32.23	35.59	11.21	10.37	8.3	5.66	4.88	6.11	7.17	14.97	15.07
1992	29.37	40.36	25.78	19.56	13.34	9.64	9.14	7.29	9.25	12.05	33.18	20.91	19.16
1993	15.47	30.44	22.36	25.39	12.67	14.18	9.42	7.96	8.86	10.31	11.49	15.75	15.36
1994	33.74	15.08	25.78	15.97	12.28	8.86	7.79	7.17	6.11	6.73	8.74	18.27	13.88
1995	13.4	28.25	23.93	14.63	6.5	8.74	10.99	6.45	5.1	7.9	7.34	11.38	12.05
1996	16.54	15.08	20.57	13.23	9.25	8.63	7.06	6.11	7.9	5.32	12.05	11.32	11.09
1997	44.97	16.93	25.63	13.67	9.52	12.54	7.54	5.76	5.08	6.85	9.46	22.59	15.05
1998	18.91	24.95	16.77	10.93	12.24	7.29	5.06	5.82	3.31	6.75	10.12	15.47	11.47
1999	35.68	17.28	22.28	11.11	7.05	6.25	4.94	3.76	5.11	3.26	4.01	8.13	10.74
2000	29.91	41.73	36.62	16.57	9.82	7.64	6.71	5.45	8.78	4.34	11.05	13.27	15.99
2001	8.27	7.23	10.62	7.15	4.92	3.82	2.92	2.66	2.62	4.78	5.17	8.53	5.72
2002	41.14	34.05	20.58	10.6	8.22	6.58	5.99	5.44	5.59	4.64	11.07	24.35	14.85
2003	48.59	34.74	28.24	17.58	14.21	10.40	8.75	8.37	8.80	8.54	23.00	22.69	19.49
2004	15.93	21.94	15.54	17.91	11.83	11.28	9.05	6.78	4.51	7.61	12.32	21.28	13.00
2005	24.06	21.64	15.07	12.12	10.84	10.06	8.34	7.55	7.28	4.56	11.90	20.27	12.81
Mínima	4.71	5.38	6.17	3.92	2.86	2.69	2.07	2.02	1.68	1.40	2.24	2.97	1.40
Média	20.65	22.34	19.86	13.96	9.96	8.17	6.81	5.66	5.42	6.91	10.31	15.13	12.10
Máxima	48.59	41.73	42.71	35.59	18.95	17.21	15.13	12.78	13.68	16.59	33.18	29.76	48.59

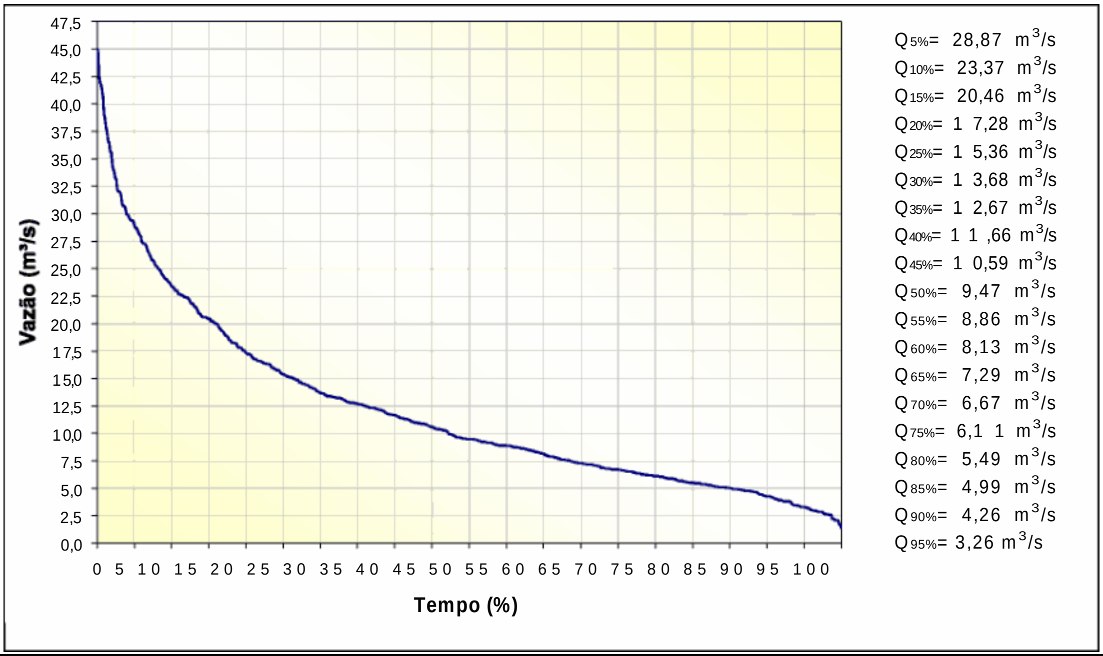

Figure 1.1. Piedade River Permanence Curve at the PIEDADE SHS

1.3 Project Floods

The flood study presented in the original Basic Project did not undergo any significant alterations based on the updated hydrological data, therefore this consolidation uses Table 1.6, summarizing the project and diversion floods as well as other Piedade SHS location characteristics.

Table 1.6
Spillway Project and Diversion Floods

Área de Drenagem (km^2)	Q_{MLT} (m^3/s)	Cheia de Desvio no Período de Estiagem - Junho a Setembro (m^3/s)	Cheia de Desvio (m^3/s)	Cheia de Projeto (m^3/s)
967	12,10	19	67	121

1.4 Reservoir Silting and Working Life

In light of the general characteristics of the project, with a lateral water channel and small flooded area (and volume), the reservoir silting surveys were simplified, however they were complied based on the recommendations in “Practical Hydrosedimentology” (Carvalho, N.O., 1994).

In order to estimate the specific minimum production of material in suspension, given the absence of direct measurements, as a benchmark we adopted the information from “Diagnosis of Sedimentary Conditions in the Main Brazilian Rivers” (CPRM/Eletrobrás, 1.992). It was therefore found, based on characteristics of the hydrosedimentology zoning, that the Piedade river basin presents and average level of erosion, based on the Wishmeier erosion coefficient of the soil with specific solids discharge at around 50 to 100 t/km^2/year. Based on on-site observations in the area upstream from the relevant section, we found that despite anthropic activity, vegetation coverage and the use of appropriate soil handling and occupation techniques have minimized the erosion process. We therefore decided that a level of 50 t/km^2/year would be appropriate to represent the annual average solid load flowing towards the dam sections.

In order to evaluate silting volume, we need to transform the solids discharge calculated in t/year into m^3/year, which only requires finding out the specific weight of the solid material will be deposited in the reservoir. Because of a lack of more detailed information regarding this material, the method proposed by Lane and Koelzer was used, which is based on portions of sand, silt and clay comprising sediment as well as the compactness and/or density level of these materials, which are evaluated based on the length of time they spend in the reservoirs and submerged (at various levels). In order to simplify this process and adopting the guidance in "Practical Hydrosedimentology", we decided to adopt the apparent specific weight corresponding to 100 years.

The formula proposed by Lane and Koelzer to calculate the specific weight of each of the sediment components is as follows:

$$P = Po + B \times \log T, \text{ where:}$$

P = specific weight after T years, in kgf/m^3 Po = initial specific weight in kgf/m^3;
T = permanence, in years, and
B = coefficient (from the table).

As data on the composition of the transported material is not available, we adopted the assumption of 30% silt, 30% clay and 40% sand, values which can be inferred based on field investigations and geological -- geotechnical studies carried out.

For these three types of materials, according to the table prepared by Lane and Koelzer for a situation where plant operation normally maintains sediment submerged, the values for P_o and B were obtained and are shown in table 1.7:

Table 1.7
Values for P_O E
B

Material	*Po* (kgf/m^3)	*B*
Areia	1.490	0
Silte	1.041	91,3
Argila	481	256,3

Based on these values, the following equation is used to calculate the specific weight:

- $P = 0.40 \times (1{,}490) + 0.30 \times (1{,}041 + 91.3 \times \log T) + 0.30 \times (481 + 256.3 \times \log T)$
- $P = 1{,}052.6 + 104.28 \times \log T$

Using the annual average load of total solids transported by the Piedade River, we obtained the corresponding volumes for a permanence period of 100 years, reaching a value of 1261 kgf/m^3. Table 1.8 was drawn up based on this value and considering the specific load of 50 t/km^2/year.

Table 1.8
Calculation of Annual Sediment Load

AD (km^2)	Carga Sólida Anual – Dst (t/ano)	Volume de Sedimentos (10^6 m^3/ano)
967	48.400	0,038

We now have to add the retention percentage, defined as the ratio between sediment deposited and total sediment flow, in order to estimate the percentage of sediment retained in the reservoir. This evaluation is carried out by applying the empirical method specified by Gunnar Brune, which presents a curved graph obtained from surveys of areas reservoirs, where retention efficiency is a function of the reservoirs capacity at maximum normal N.A. (Vta) and annual average flow volume (Vaf). Based on the data from the five projects, we calculated the Vta/Vaf ratios and using the Brune retention curve method, we obtained the retention percentages shown in Table 1.9.

Table 1.9
Retention Efficiency

Volume do Reservatório no NA máx normal – Vta (10^6 m^3)	Q_{MLT} (m^3/s)	Volume Afluente Anual – Vaf (10^6 m^3)	Vta/Vaf	Er – Retenção %
17,52	12,1	375,54	0,047	10

Finally, in order to evaluate the working life of the reservoirs, simply divides the available volume up to the base of the water channel by the volume of flow sediment, affected by the retention index, stating the number of years as shown below. The annual volume of sediment was multiplied by 1.5 to incorporate a possible increase in sediment production over time, which means that this is a very conservative measurements.

$$n = (Vol.\ Disp)/(1{,}5 \text{ x } Vol.\ Sed. \text{ x } Er)\text{, where:}$$

Vol. Disp is the available volume (10^6 m^3) to the base of the water channel, obtained in the height-volume curve;

Vol. Sed.is the annual affluent volume of sediment (10^6 m^3/year);

Er is the retention efficiency (%)

Table 1.10 presents the results obtained, an analysis of which shows that the reservoirs has a working life of around 100 years, even based on the most conservative assumptions we have adopted.

Table 1.10
Silting Time

Cota do Fundo do Canal de Adução (m)	Volume Disponível até a Cota do Fundo do Canal de Adução (10^6 m^3)	Volume de Sedimentos Afluente Anual (10^6 m^3/ano)	Tempo de Assoreamento (anos)
646	12,03	0,038	316

1.5 Reservoir Filling

According to the works timetable, January was selected to close off the river and start filling the reservoir. Based on the historical average flow for the month of January, according to table 1.5, which is 20.7 m^3/s, the environment flow rate of 0.65 m^3/s and the height -- volume curve for the reservoir, the resulting reservoir filling time is 10.1 days. However, when based on average long-term flow rates the reservoir will take a17.7 days to fill.

2 GENERAL METHODOLOGY

This survey was based on information contained in the Environmental Impact Study (EIA) at Piedade SHS (CEMA, 2001), Additional EIA Information (LIMIAR, 2003), LP Conditions (LIMIAR, 2004), Environmental Control Plan for the Piedade SHS (LIMIAR, 2004) and Characteristics of the new project for Piedade SHS (RA Engenharia, 2007).

In order to verify whether the information available in the aforementioned documents is applicable to the new engineering project, an on-site survey was conducted by a multidisciplinary technical team in March 2007.

During the visit to Piedade SHS, priority was given to inspecting new areas directly affected by the project, especially the dam and reservoir at Piedade SHS. Available project data was compiled in addition information on the area in which Piedade SHS is located, updating information as required.

The project layout changes did not undermine the environmental impact evaluation produced by CEMA (2001) and other studies concluded during the project environmental licensing stages. Therefore, only new environmental impacts arising from amendments to the project are evaluated in this document, in order to fully align the study to the new Piedade SHS characteristics.

2.1 DEFINING STUDY AREAS

The areas studied for the Piedade SHS Incremental Impact Study were divided into: Directly
Affected Area – ADA;
Surrounding Area – AE;
Sphere of Influence – AI.

The following definitions of each of these areas which, based on the specific issues investigated, difference in the Natural Environment, comprising the Physical and Biotic Environments, and the Socioeconomic Environment.

2.2 Natural Environment *1*
Sphere of Influence

In the natural environment, the Sphere of Influence (AI) was defined as the watercourse micro-basins which directly contribute to the Piedade river in the project region. These include, for example, the Boa Vista, Cachoeirinha and Valinhos streams.

In terms of water quality, the AI was considered to be the drainage basin upstream from the future dam, because of its direct influence on the quality of reservoir water, in addition to the entire section with reduced flow rate and a section of the river in the reconstituted flow rate section.

As a Hydroelectric Power Station can interfere with fish movements (causing effects upstream and downstream from the plant) the AI took into account the entire Piedade river basin when considering fish.

2.2.2 Surrounding Area

In the Physical and Biotic Environments, the Surrounding Area (AE) extended to the first peaks of bank slopes along the future reservoirs and the dam and auxiliary structures, representing a surface level which has a close relationship with the project. Therefore, the AE boundary varies in distance from the Piedade river within the project area according to the natural characteristics of local topography.

2.2.3 Directly Affected Area

The Directly Affected Area (ADA) covers all the locations which will be directly affected by the project, including the following main areas:

- The dam construction area;
- The area to be occupied by the reservoir in the future: including the section of land to be flooded and the natural river bed;
- The area which will be occupied by construction sites;
- The area which will be occupied by the power station;
- The area to be occupied by the substation;
- Leased land area;
- Stone storage area (quarry);
- Access routes that will be flooded by the reservoir and relocated;
- The area which will be occupied by the water channel system;

Permanent Preservation Area – APP: Based on the characteristics of the projects and the area in which it is located the APP corresponds to a strip of land 30 m wide around the future reservoirs. Please note that the width of the APP may change when preparing the Reservoir Master Plan, complying with CONAMA Resolution No. 302, dated March 20, 2002 and IEF Directive No. 054, dated April 14, 2004.

Specifically in terms of aquatic ecosystems, the ADA refers to the Piedade river section located between the beginning of the future reservoirs backwater area and part of the reconstituted flow section. This definition takes into account the section of the river where its dynamic will be effectively modified, based on transformation of the upstream section from the dam into a lake or semi-lake system.

2.3 Social and Economic Environment

2.3.1 Area of Influence

The AI socioeconomic environment was defined as the municipal region of Monte Alegre de Minas, a city within whose territory this project will be deployed.

The AI boundaries refer to the municipal region as a political and administrative unit, a definition which is linked to the effects of the project will have on social and economic factors, including jobs, income and tax revenues.

Attached to this document is drawing MIN-LMA-001 which represents the boundaries of the Monte Alegre de Minas municipal region.

2 3.2 Surrounding Area

The AE includes the urban area of the municipal region of Monte Alegre de Minas. The social and economic ties of the ADA population, according to new field studies carried out, are basically linked to the urban area of the municipal region, which offers basic goods and services to fulfill the needs of this population.

2.3.3 Directly Affected Area

The project Directly Affected Area (ADA) is defined by the group of rural properties, all within the municipal region of Monte Alegre de Minas, along the banks of the Piedade river, which will be directly affected by the installation of various project structures, including the dam, water channel, power station and reservoirs, as well as support works, such as construction sites, waste sites, leased land, access ways and service routes, among others, as well as the commercial establishments located on the banks of the Piedade river in the reduced flow section.

Drawing PIE-PRO-002, attached to this document, contains the property registered in the Piedade SHS ADA.

3 Physical Environment
3.1 Climate
3.1.1 Methodology

The methodology used to study the climate involved the following steps:

- Collating the prevailing thermal, rainfall and relative humidity conditions in the geographic region, including the project Area of Influence;
- Use of secondary data as the climate study requires a substantial dataset and wide ranging sampling networks, which lie outside the environmental objectives of this study.

Therefore, the analysis of weather characteristics in the Piedade river basin was carried out based on existing data from the Uberaba weather station, code number 83577, monitored by INMET.

3.1.2 AI and ADA Diagnosis

"The climate of the southeast region is the most diverse in terms of temperature, as well as spatial distribution of rainfall. In order to understand the climate processes in this region, we initially need to understand a variety of factors, some statistical and others dynamic. They all act simultaneously and are constantly interacting, but will be described below individually (IBGE, 1996)".

Statistical Factors

Position

In this factor, two important aspects must be highlighted which are the latitude and the position on the western shore of the Atlantic Ocean. Therefore, the southeast region is located between the 14th and 25th southern parallels, therefore almost all of its land mass is located within the tropical zone.

Mountainous Topography

The relief in the southeastern region offers the biggest morphological contrasts in Brazil. This topographic characteristic favors rainfall as it increases air turbulence because of orographic wind patterns especially unsettled currents of wind.

Dynamic Factors

These factors represent:

- Semi-fixed anticyclone in the South Atlantic;
- Unsettled wind currents from the S;
- Unsettled wind currents from the W;
- Unsettled wind currents from the E;

Figure 3.1 shows the action of unsubtle wind currents in the state of Minas Gerais.

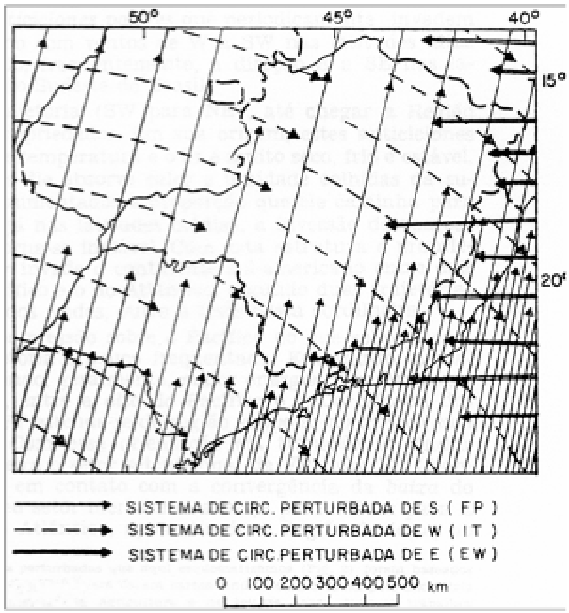

Figure 3.1: *Action of unsettled wind currents in the state of Minas Gerais*

The mass of tropical Atlantic air of is created by the East and North-East winds, arising from high subtropical pressure, in other words the semi-fixed anticyclone in the South Atlantic, or variable winds from occasional high-pressure spots in the interior. It has more or less high temperatures, based on intense solar radiation in the tropical latitudes and strong specific humidity, the result of intense maritime evaporation (Nimer, 1977).

However, because of the subsequent thermal inversion, humidity is limited to the surface which makes it homogeneous and stable. However, despite the thermal inversion, the effects of this anticyclone maintain stable and sunny weather, only affected by the arrival of turbulent wind currents.

The turbulent wind currents from the south or the Atlantic polar mass come from the icy surface of the polar region, comprising the Antarctic content and the fixed ice sheet This zone creates polar winds which periodically reach the state of Minas Gerais, coming from the South, accompanied by frontal instabilities causing swift falls in temperature (Nimer, 1977).

The turbulent currents from the West occur in the middle of spring and autumn, generating wind from the West which comes in a long tropical instability lines which are also known as barometric depressions. They seemed to originate from the wave movement along the polar front when it comes into contact with the hot air in the tropical zone. These fronts cause the so-called summer rains which generally fall at the end of the afternoon or in the early morning (Nimer, 1977).

The turbulent wind currents from the East run from East to West, eliminating the opera thermal inversion, allowing the air when the two horizontal layers of the trade winds to mix giving rise to more or less widespread rainfall (Nimer). They are most often active in winter and subsequently in autumn however they are rare in the spring and summer.

Local Weather

Based on its attitude, the climate in the Piedade River region, according to the Köppen classification, is AW, representing high temperatures and concentrating the majority of the rainfall in the summer.

According to data obtained from the Uberaba station, total annual rainfall is 1590 8.3 mm, 83% of those falling in the months from October to March. The quarter with the highest level of rainfall includes the months of December, January and February representing 48% of rainfall, and the driest quarter includes the months of June, July and August, with only 3% of annual precipitation.

Data obtained from the rainfall station in Monte Alegre de Minas confirms this high level of rainfall during the summer but presents total annual precipitation of 1311 mm, which means that the area surrounding Piedade SHS is subject to lower rainfall levels than those obtained from the Uberaba Station.

Rainfall is most frequent in the months of November, December and January and the months of least rainfall are June and July.

Average annual temperatures of 28.1°C at the Uberaba station, with the period December/January/February the hottest quarter, recording average temperatures between 23.4 and 23.6°C, and the coldest period is between May and July with average monthly temperatures between 18.5 and 20.1°C.

The project location area has average annual temperatures between 22 and 23°C, slightly higher than the values obtained from the Uberaba station. Maximum annual temperatures on site are between 29 and 30°C and minimum annual temperatures are between 16 and 17°C.

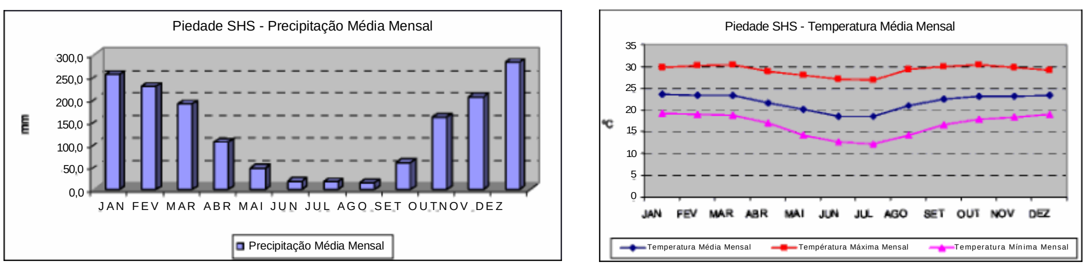

Figure 3.2 Monthly average rainfall and temperature from the Uberaba weather station – Code 83577

We should also mention relative humidity, potential evaporation and transpiration and water surplus/shortfall in the project area according to the State Climate Atlas for

Minas Gerais State. Relative humidity in the project area presents average annual values between 70 and 75%, with averages in excess of 80% between December and March and lower than 65% in the months of August and September.

In terms of potential evaporation, annual averages in the project area between 1000 and 1100 mm, with the greatest losses in the months of November, December and January, when average values exceed 100 mm. In the months of June and July, evaporation is on average between 50 and 60 mm. Water surpluses are prevalent between October and April, with water shortfalls in the other five months (May to September).

In general, the regional climate can be considered stable and uniform because of the predominantly tropical climate. Furthermore, it does not present general, intense and persistent cyclonic phenomena or their effects (tropical cyclones, extra tropical cyclones and occlusions). The region is only subject to the effects of a few climate phenomena, which are strictly localized and short lived, such as convection-orgraphic thunderstorms which are common and frequent in the rainy season. The generalized and migratory phenomena from other latitudes affecting the region are the cold fronts which come from the south and the lines of instability from the West.

3.2 Hydrography

3.2.1 Methodology

The methodology used to study the hydrographic involved the following steps:

- Bibliographic research, in order to obtain information on the River basin, using secondary data;
- Interpreting the results obtained.

3.2.2 AI and AE Diagnosis

The Paranaiba river basin extends through three states: Minas Gerais, Goiás and Mato Grosso do Sul. The draining area in the Minas section of the basin is approximately 32.1% of the total area. Alongside the Grande river, they form the torrential Paraná river. The Parnaiba river runs longitudinally for around 1,120 km, approximately 680 km being used as the frontier between the states of Minas Gerais, Goiás and Mato Grosso do Sul".

The Piedade river drainage basin is wholly within the territory of Minas Gerais. It comprises the Pouso Alegre stream which, after collecting the waters from the Andorinha stream, becomes the Piedade river. From this point, there are various tributaries over 120 km including the Bebedouro river and the Valinhos stream, both on the left, and the Pântano brook and Passa Três stream on the left. The drainage basin area is 1861 km^2.

The stretch with the biggest slopes stretches around 30 km from the Bebedouro stream, located in the middle stretch of the basin, and the height difference is around 210 m. The valley is surrounded with sloping embankments, which continually change the direction of the river.

The Piedade river already has one hydroelectric project: The SHS Santa Luzia, recently rehabilitated by CEMIG, with an output of 0.45 MW located on a lower section of the river.

The structural control of the drainage area can be seen in the straight segments of the rivers, the quick curves and the general occurrence of white water and waterfalls.

3.3 Geology

3.3.1 Methodology

The methodology used for the geology study attempted to describe the relief and morphology of the Piedade SHS sphere of influence. We attempted to show the risk of instability in the natural environment along the banks of the future dam, as well as areas that could suffer changes because of plant construction and operation.

Below is a presentation of the methodology used in order to reach the proposed objectives, in successive and complementary stages:

a) Survey, analysis and compilation of bibliography, maps and aerial photographs;

b) On-site work:

- Geological characteristics;
- Morphological evaluation of the area;
- Photographic record.

c) Process and interpret the data obtained;

- Preparing an environmental diagnosis;

d) Write and illustrate the final report.

3.3.2 AI Diagnosis

- Stratigraphy and Lithology

Regional geology is represented by a Pre-Cambrian bedrock, São Bento Group, Bauru Group and Lateritic-Detritus Cover, summarized below.

The Pre-Cambrian Bedrock, present mainly in the northeast and east of the region, is represented by the Araxá Group (Arx), which belongs to the Brasilia Range. This group presents a metamorphized volcano sedimentary stack, with green shale facies and amphibole facies. It is comprised of granite and graphite mica schists with interspersed layers of quartzite, ortho-amphiboles, acid metavulcanites, gneisses and ferrous formations. Dating indicates a Superior Proterozoic age. In the Araxá Group there are small post-tectonic intrusive granite bodies, syntectonic granitoids and complex polydiapiric granitoids (ã1) related to the presence of casseterite.

In the Minas Triangle region, the São Bento Group is only represented by the General Range Formation (JKsg) as a foundation in all locations for use to build the hydroelectric power station components. The bed of the Piedade river in this section of the Piedade SHS runs directly on the rocky bed composed of basalts in this rock formation.

The General Range Formation comprises mainly a group of outpourings mainly made of basalt, interspersed with intertrappean rocks represented by fine sandstone. Most of the intracontinental basin volcanic phenomena are between 140 and 100 million years old.

The Bauru Group overrides the erosion in the General Range Formation and, in this study, is subdivided into two formations, Adamantine at the base and Marilia at the top, both from the Cretaceous age.

The Adamantine Formation (Ka) is located mainly to the south of the Piedade River. It contains fine to very fine cream, grey-brown and grey-green sandstones, as well as cream-purple siltites and claystone. It has flat-parallel and crossed, small to medium stratification with conglomeratic and carbonatic levels. The trend to concretion and presence of clay balls are common in this unit, which may also be silicified. The disintegration of these rocks creates large and deep sandy areas.

The Marilia Formation (Km), located mainly to the north of the Piedade river, can be subdivided into two members in this region: The Galga Range Member (base) and Ponte Alta Member (top). The former contains sandstones and immature conglomeratic sandstones, with a pallid yellow to reddish hue, located in lenticular strata, with frequent crossed stratification with small or medium tabulation or ribbing. The Ponte Alta Member contains immature sandstones and conglomerate and laminate lenses, all strongly cemented with carbonate, grey in color and generally uniform (solid). The Marilia Formation is around 200 m thick and in exposed areas has steep and well-defined escarpments.

Layers of Tertiary Lateritic-Detritus and Quaternary Non-Differentiated Covers (TQdl) cover the Bauru Group on the tops of hills to the east and south-east of the project area, more common on flat surfaces above 800 m. These layers are currently pedogenized in predominantly red latosols, with a clay texture and horizontal limonite concretions. Under this we can see sandy, sand-clay and clay sediments, with rare layers of conglomerates.

Tectonics

Deforming tectonic activity in the Bauru Basin was considered insignificant for a long time. Apart from a lack of more refined structural analyses, another two factors can explain this approach: Low rock cohesion, supposedly absorbing or dissipating deformation effects, making it hard to register, and the type of tectonic evolution in the basin, mainly based on subsidence lenses, without major vertical movement.

In addition to common fracturing, on occasion we can find faults in the neocretaceous sedimentary cover. In the regional substrate, formed by the older units of the Paraná Basin, we can see three important structural directions associated with faults: NW, NE and EW. In structural geological surveys, groups of different directions have been noted showing brittle structures related to different stratification units: NW, ENE and NE fractures in basalts in the General Range Formation, NW and NNW in the Superior Cretaceous rocks and normal faults with cracks running for tens of meters in the NW direction, in paleozoic units. In general the main directions are observed in all units. Apparently, the different directions are related to the different structural domains and not specific geological units.

3.3.3 Legal Status of Minerals

Following consultation with the National Department of Mineral Production – DNPM, in March 2007, there was no evidence of any mining in the Piedade SHS Surrounding Area and Directly Affected Area.

3.4 Geomorphology

3.4.1 Methodology

The methodology used for the geomorphology study attempted to describe the relief and morphology of the Piedade SHS sphere of influence, surrounding and directly affected areas. We attempted to show the risk of instability in the natural environment along the banks of the future dam, as well as areas that could suffer changes because of plant construction and operation.

Below is a presentation of the methodology used in order to reach the proposed objectives, in successive and complementary stages:

a) Survey, analysis and compilation of bibliography, maps and aerial photographs;

b) On-site work:

- Geomorphological characteristics;
- Photographic record.

c) Process and interpret the data obtained;

- Preparing an environmental diagnosis;
- Mitigating or offsetting measures proposed.
- Proposal to implement, evaluate and monitor measures.

d) Write and illustrate the final report.

3.4.2 AI Diagnosis

Piedade SHS is located in a region known for its relief as "Northern Plain of the Paraná Basin", characterized by its great length (North of the State of Sao Paulo, Minas Triangle and Southern Goiás). The plains adjoin in the northeast with the “Lower Goiania Plain” and the Alto-Tocantins-Paranaiba Plain”. In the north, it reaches the “Guiamaráes Plain” (Cliffs) and part of the Araguiaua Depression (MT/MS) and the Peripheral Depression (SP).

The Northern Plain of the Paraná Basin has two different topographic areas: On higher, between 650 and 1000 m, and another lower, between 350 and 650 m in altitude.

The higher section is dispersed in an irregular manner in the middle of the lower section. Its largest and most connected area is in the north of the plains. The other areas are smaller and are intermittent, varying in size. One of the areas, of greatest interest to the project, is the Minas Triangle, drained by the Uberabinha, Piedade and Tijuco rivers. In this higher section, the relief is mainly dissected into wide, tabular shapes, with subordinated smaller spaces.

Along the edge of the foregoing areas there are structural or erosive escarpments, although mainly an area of Bauru Group sandstones, the escarpments show the following layering from the base to the top: Araxá Group pre-Cambrian rock (predominantly mica schists and quartzite), intertrappean basalts and sandstones for the General Range Formation and Cretaceous sandstones for the Bauru Group.

3.4.3 AE and ADA Diagnosis

The Directly Affected Area is defined by straight lines of the Piedade river bed, noting a certain adaptation of the river course either by the lithology and repeated basalt outcrops or by structural alignment perpendicular to its flow.

The rocky substrate is mainly comprised of solid and altered basalt rocks, structured in horizontal, tabular outcrops. The aggressive erosion makes the river narrower depending on how easy or difficult it is to excavate the successive outcrops, performing waterfalls as it finds difficulty excavating the upper outcrop compared with the lower one. This dynamic erosion is the principal mechanism of regional morphology.

The local relief is generally separated into tabular tops, convex and sloping shapes with average slopes of between 15 and 30%.

In the backwater of the future Piedade SHS reservoirs family is more open and the slopes adjacent to the river banks are not so steep and alluvial terraces are covered by riparian forest. From the waterfall located on the property of Mr. João Vicente de Vasconcelos, the Piedade river becomes narrower and the sides present average slopes on both banks. The alluvial terraces are present at the foot of the slopes and are used as cattle pasture.

Along the first part of the reduced flow section the slopes are not steep and culminate in the alluvial terraces, facilitating cattle access to the river. This section extends to de waterfall located on the property of Mr. Roosevelt Guimarães, known as the Usina Velha waterfall. From this point up to the power station, we find that the slopes become steeper, narrowing the river bed.


Photo 3.1 Piedade River in the backwater of the future reservoir. Observe the riparian forest on both sides and white water

Photo 3.2 Low, undulating incline on the right bank of the river, in the backwater area of the future reservoir

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Photo 3.3 Aerial view of the future location of Piedade SHS. On both sides of the river, the incline become steeper and at the foot of the inclines we can see the alluvial terraces.

Photo 3.4 Aerial view of the future reservoir for Piedade SHS. Note the average incline of the gradient and below the alluvial terraces on both sides of the river.


Photo 3.5 In the foreground, the gradient on the right bank and in the background the gradient for the left bank of the Piedade River, close to the future power station. Below, the alluvial terrace on the right bank of the river

Photo 3.6 Incline of the right bank gradient of the Piedade river close to the future power station.

The structural control of the drainage area can be seen in the straight segments of the rivers and the general occurrence of white water and waterfalls.

Photo 3.7 Piedade River waterfall in the area of the future reservoir.

Photo 3.8 White water on the Piedade river in the reduced flow section.

The focus point of the erosion are compatible with the inclines along the slopes, represented by mass movement, laminar erosion and linear erosion, the latter represented by furrows and ravines. This natural propensity for erosion and subsequent silting of the Piedade river valley is accentuated by intensive deforestation in the area, leading to a gradual substitution of the natural vegetation by farming and grazing areas.

Photo 3.9 Furrow erosion on the left bank of the river, in the area of the future reservoir.

Photo 3.10 Furrow erosion on the left bank of the river, in the area of the future reservoir.

PHOTO 3.11. Erosion in a furrow on the Piedade river in the future reservoir area.

PHOTO 3.12. Laminar erosion on the right bank of the Piedade river in the future reservoir area

PHOTO 3.13. Laminar erosion on the right bank of the Piedade river in the future reservoir area.

PHOTO 3.14. Mass movement on the right bank of the Piedade river in the area of the future reservoir

Photo 3.15 Mass movement on the right bank of the river, in the area of the future reservoir.

Photo 3.16 Mass movement on the right bank of the river, in the area of the future reservoir.

PHOTO 3.17. Laminar erosion on the right bank of the Piedade river in the future reservoir area.

PHOTO 3.18. Laminar and ravine erosion on the right bank of the Piedade river in the future reservoir area.

Photo 3.19 Laminar erosion on the right bank of the Piedade river, in the area of the future reservoir.

Photo 3.20 Laminar erosion on the right bank of the Piedade river, in the area of the future reservoir.

Photo 3.21 Laminar erosion on the left bank of the Piedade river, in the area of the future reservoir.

Photo 3.22 Laminar erosion on the right bank of the Piedade river, in the area of the future reservoir

PHOTO 3.23: Laminar and furrow erosion on the left bank of the Piedade river in the future reservoir area.

PHOTO 3.24: Laminar and furrow erosion on the left bank of the Piedade river in the future reservoir area.

Photo 3.25 Laminar and furrow erosion on the left bank of the Piedade river, in the area of the future reservoir.

Photo 3.26 Mass movement and laminar erosion on the left bank of the Piedade river, in the area of the future reservoir.

Photo 3.27 Mass movement and laminar erosion on the left bank of the Piedade river, in the area of the future reservoir.

Photo 3.28 Mass movement and laminar erosion on the left bank of the Piedade river, in the area of the future reservoir.

PHOTO 3.29: Mass movement and laminar erosion on the left bank of the Piedade river, in the area of the future reservoir.

PHOTO 3.30: Laminar and furrow erosion on the left bank of the Piedade river in the future reservoir area.

Photo 3.31 Mass movement and laminar erosion on the left bank of the Piedade river, in the area of the future reservoir.

Photo 3.32 Laminar erosion on the left bank of the Piedade river, in the area of the future reservoir.

Photo 3.33 Mass movement and laminar erosion on the left bank of the Piedade river, in the area of the future reservoir.

Photo 3.34 Mass movement and laminar erosion on the left bank of the Piedade river, in the area of the future reservoir.

Photo 3.35 Ravine located on the right bank of the Piedade river, in the reduced flow section. Note the presence of Jaraguá grass.

Photo 3.36 Laminar erosion caused by cattle trampling on the right bank of the Piedade river, in the low flow section. Note the beginning of furrow formation.

Drawing PIE-GEM-001 is attached to this document.

3.5 Pedology

3.5.1 Methodology

The methodology used for the geology study attempted to describe the relief and morphology of the Piedade SHS sphere of influence, surrounding and directly affected areas. We attempted to show the risk of instability in the natural environment along the banks of the future dam, as well as areas that could suffer changes because of plant construction and operation.

Below is a presentation of the methodology used in order to reach the proposed objectives, in successive and complementary stages:

a) On-site work:

b) Process and interpret the data obtained;

- Pedological description of the area
- Photographic record.

d) Write and illustrate the final report.

- Preparing an environmental diagnosis;
- Mitigating or offsetting measures proposed.
- Proposal to implement, evaluate and monitor measures.

In the pathology evaluation, the soil found was classified according to the Brazilian Soil Classification System (Embrapa, 1999) up to the second level category.

3.6 AI Diagnosis

3.6.1 Description of Soil Classes, Grouped in the 1st Level Category (Orders)

The pedology in the AI found the following classes of soil at the first level category (orders): Latosols, Ultisols and Neosols described below:

- ULTISOLS

The soil is made of mineral material whose differential characteristics are clay with low activity and B texture horizons (Bt), immediately below any type of surface horizon, except histic horizon.

Part of the soils in this class show an evident increase in the clay content, with or without an increase in the B horizon below the profile. The transition between A and Bt Horizons is usually clear, abrupt or gradual.

The texture ranges from sandy to clay in the A horizon and from average to very clayey in the Bt horizon, always with increased clay from the former to the latter. They are strong to moderately acidic and with a high or base saturation, and predominantly kaolin.

This class includes soils that classified as Red-Yellow Podsolic (with low activity clay, red earth similarly structured, dark brown earth similarly structured, either eutrophic, dystrophic or neutral) and more recently, the Dark Red Podsolic with B texture and Yellow Podsolic.

- LATOSOLS

Latosols are very deep with Horizon sequence A, B and C with gradual and diffuse transitions and accentuated drainage. In terms of environmental dynamic, drainage means the speed and extent with which water is removed from the soil, mainly through surface runoff and flowing towards underground currents. The latter covers internal drainage and refers to soil permeability, which is influenced by the texture, structure and the characteristics of the pedology profile. In soil with accentuated drainage, the water is removed rapidly throughout the entire profile. They present average or light texture in all horizons, uniform colors and no mottling. These are cohesive soils and therefore more resistant to erosion. However, we must also consider the external or surface drainage which is substantially influenced by the topography and type of soil usage, even soils with the same incline can present major differences, related to their physical characteristics.

- NEOSOL

A group of soils with little evolution, undergoing formation, either because of reduced action from pedogenetic processes or characteristics inherent to the base material, or even because of the relief, which can stop or limit evolution of these soils. Some have a B horizon, with weak color, structure or accumulation of secondary minerals and/or colloids, not meeting any type of B horizon diagnosis.

In general they are comprised of mineral or organic material at least 30 cm thick, with an absence of glei horizon and vertical horizon, immediately below the A horizon. There is no plinthic horizon within 40 cm or within 200 cm of the surface when immediately below A or E horizons or when preceded by horizons will abundant pallid, varied or mottled colors. This class includes the soils which were recognized as Litosols and Alluvial Soils, among others.

3.6.2 AE and ADA Diagnosis

The soils found in the ADAE were Latosols and Neosols, classified according to the Brazilian Soil Classification System (Embrapa, 1999) up to the second level category.

- RED LATOSOLS Red soils within the first
100 cm of the B horizon.

- LITOLIC NEOSOLS

Histic soils with horizon A or O, less than 40 cm thick, directly on top of rock or material with 90% volume made of rock fragments more than 2 mm long. Includes horizon B when formation is starting.

- FLUVIAL NEOSOL

Characterized by stratified layers with no pedological relationship among them, shown by irregular decrease in depth of organic carbon (within 200 cm of the surface of the soil) and/or stratified layers in 25% or more of the soil volume (within 200 cm of the soil surface).

Photo 3.37 Slight incline with the presence of pineapple farming in Red Latosol, in the low flow section.

Photo 3.38 Piedade river with the presence of Fluval Neosol on the right bank.

Photo 3.39 Litolic Neosol in the future Piedade SHS reservoir area, covered with pasture.

Drawing PIE-GEM-001 is attached to this document and shows the soil distribution.

3.7 WATER QUALITY

3.7.1 INTRODUCTION

Campaigns

The Water Quality diagnosis for the Piedade river, in the sphere of influence created by the project, was carried out using four sampling campaigns covering one hydrological cycle.

The first field campaign was carried out between 9 and 12 December 2003. Samples were collected on the 10^{th} at points PIE-01, PIE-02 e PIE-04, and on the 11^{th} at PIE-03. While sampling, the weather was good, with rainfall less than 72 hours previously.

The first field campaign was carried out between 9 and 12 December 2003. The weather conditions on the preceding days were unstable, rainfall in the preceding 48 hours. On the sampling day, April 20, temperatures varied between 27 and 33°C. The river water volume was high, because of the rainfall which continued in the region. At the end of the afternoon, after collection, there was heavy rainfall in the region.

The third field campaign was carried out between September 28 and 29th 2004. The weather conditions on the previous days were stable, and according to local information, it had not rained in the region for more than 30 days. On the sample day (29/9), temperatures varied between 30 and 35ºC.

The fourth and last field campaign took place between January 18 and 20, 2005, with collection carried out on the 19th. The weather conditions on the preceding days were unstable, with a lot of rainfall on the day before sampling. Temperatures varied between 23 and 25°C.

Sampling Points

The description and location (UTM coordinates) of the water quality sampling points in the four campaigns are presented in table 3.1. Drawing PIE-PAA-001, attached, presents the location of the monitoring points within the previous and current context, in other words within the two layouts.

Table 3.1
Description and location of the four campaign sampling points

Ponto de amostragem	Descrição	Coordenadas UTM		
		Dez/03	Abr/04	Set/04 e Jan/05
PIE-01	Rio Piedade, a montante do remanso do futuro reservatório da PCH Piedade Novo arranjo: Rio Piedade, no futuro reservatório da PCH Piedade	7932304 N, 711297 E	7932320 N, 711214 E	7932144 N, 711869 E
PIE-02	Rio Piedade, imediatamente a montante do futuro eixo da barragem, no futuro lago a ser formado Novo arranjo: Rio Piedade, no futuro trecho de vazão reduzida	7932895 N, 708326 E	7932937 N, 708290 E	7932917 N, 708280 E
PIE-03	Rio Piedade, no futuro trecho de vazão reduzida	7934613 N, 705813 E	7932950 N, 707794 E	7933238 N, 707558 E
PIE-04	Rio Piedade, a jusante da futura casa de força	7938362 N, 701403 E	7938354 N, 701413 E	7938354 N, 701413 E

Table 3.2 contains a description of the river banks at the sampling points, as well as the water flow.

Collection points PIE-01 and PIE-03 are difficult to access, passing through dirty pasture, plantation and fairly dense forest. Collection point PIE-01 presents a predominance of grasses and plantations. On the left-hand bank the riparian forest has been preserved for about 15 m. Collection points PIE-02 and PIE-03 located close to the main building on Mr. Roosevelt's property. The collection points are well preserved, with the presence of well tended riparian forest. The PIE-04 collection point is located downstream from the future power station, under a wooden bridge.

Table 3.2
Sampling point characteristics

Ponto	Características das margens			Vazão	Observação
	Topografia	Vegetação predominante	Sedimento		
PIE-01	Suave	Gramíneas/Árvores esparsas	Argiloso	Corredeira	Plantação de mandioca na margem direita e mata ciliar na esquerda. Rio com 10 m de largura
PIE-02	Suave	Gramíneas/Mata esparsa	Arenoso	Corredeira	Pasto na margem direita e mata ciliar na esquerda
PIE-03	Suave	Mata Densa	Arenoso	Corredeira	Vegetação bem preservada nas duas margens
PIE-04	Suave	Árvores esparsas	Argiloso	Corredeira	Mata ciliar bem preservada

Parameters Defined

For the first (December 2003) and third (September 2004) campaigns, the following parameters defined:

- Physical And Chemical Properties: Total acidity in CaCO3, total alkalinity in CaCO3, lead, chlorides (only in the third campaign), copper, electrical conductivity, color, biochemical oxygen demand

(DBO$_{5\ dias)}$, chemical demand for oxygen (DQO), total hardness in $CaCO_3$, phenols, soluble iron, total iron, total phosphate, mercury, nitrate, nitride, ammonia nitrogen, total nitrogen, oils and fats, orthophosphates, dissolved oxygen, pH, total dissolved solids, solids in suspension, sedimentary solids, total solids, water and air temperature, turbidity and zinc.

- Bacteriology and Hydrobiology: Qualitative and quantitative fecal coliforms, total coliforms, phytoplankton, zoobenthics and zooplankton.

Additionally, the December 2003 campaign analyzed the presence of organic chlorates and organophosphorus because these are compounds which can be carried to the river by rain, if being used on plantations, and can be observed in the smell of the water.

For the second (April 2004) and fourth (January 2005) campaigns, the following parameters were defined:

- Physical And Chemical Properties: Total acidity in $CaCO_3$, total alkalinity in $CaCO_3$, chlorides, electrical conductivity, color, biochemical oxygen demand (DBO$_{5\ days)}$, chemical demand for oxygen (DQO), total hardness in $CaCO_3$, soluble iron, total iron, total phosphate, nitrate, nitride, ammonia nitrogen, total nitrogen, oils and fats, orthophosphates, dissolved oxygen, pH, total dissolved solids, solids in suspension, sedimentary solids, total solids, water and air temperature and turbidity.
- Bacteriology and Hydrobiology: Qualitative and quantitative fecal coliforms, total coliforms, phytoplankton, zoobenthics and zooplankton.

Sampling and Analysis Specifications

Physical, chemical and bacteriological: Surface sampling. References for the analysis methods: Standard Methods for the Examination of Water and Wastewater (APHA, 1998) e Manual of Analytical Methods for the Analysis of Pesticide Residues in Human and Environmental Samples, U.S. EPA. The Sampling and Analysis of Water for Pesticides (Section-10).

Phytoplankton: In the quality of sample, a 25 µm mesh net was placed against the current 15 minutes, and the quality of sampling 1 L of “natural” water was collected 20 cm from the surface. References for the analysis methods: Standard Methods for the Examination of Water and Wastewater (APHA, 1995) – 10.200 C; 10.200 F (Utermohl chamber counting) and methodology of accounting cyanobacteria in cells/mL (Jardim *et al*, 2002).

Zooplankton: In the quality of sample, a 68 µm mesh net was placed against the current 15 minutes, and the quality of sampling 200 L of “natural” water was filtered through a 68 µm mesh net. References for the analysis methods: Standard Methods for the Examination of Water and Wastewater (APHA, 1995) – 10.200 C; 10.200 F (Utermohl chamber counting).

Zoobenthic: 1st sample – quantitative sampling was carried out using a ladle and the dipping method and qualitative sampling use the net, applying the kicking method. Sampling area: 0.018 m^2. Other samples – the qualitative and quantitative sampling was carried out using the kick sampling method. Samples were carried out on the main substrates in the collection area. References for the analysis methods:

Standard Methods for the Examination of Water and Wastewater (APHA, 1995) – 10.500

The first campaign samples were sent for analysis at the Limnos Hidrobiologia e Limnologia Ltda laboratory and the others were sent to the Visão Ambiental Ltda laboratory. The results are attached.

3.8 Data Analysis Methodology

The Piedade river is an affluent of the Paranaiba river which alongside the Grande river is one of the tributaries of the Parana river. The Piedade river drainage basin, measuring 1861 square kilometers, is wholly within the territory of Minas Gerais.

The results were evaluated based on the main natural and anthropic variables detected in this subbasement, compared with the standards established by federal legislation, CONAMA Resolution number 337, dated March 2005, for results subject to legislated levels. Where the resolution fails to define conditions or quality standards, we adopted the limits established in COPAM Directive 10/86.

As the sub basin of the Piedade River was not studied to analyze the compliance of its waters, the resolution establishes that:

> "Art**.** 42. While the respective classifications are not approved, fresh water shall be considered class two, briny and seawater class one, except when the current quality conditions are better, which result in application of the correspondingly higher class."

Within this context, the waters of the Piedade river were evaluated according to the class 2 classification limits. The standards and/or conditions of water quality class two, according to current environmental legislation, are included in the results table (Table 3.1 to Table 3.5).

Article 2 of the resolution states that " *XXXVII – virtually absent: that cannot be perceived by vision, smell or taste"* and in article 39 that *"the relevant environmental organs, when required, shall define the pollution values which will be considered virtually absent"*. As COPAM does not establish limits for virtually absent pollutants, with regard to oils and fats, in this study all values equal to or lower than 0.5 milligrams/liter were considered virtually absent.

Results analysis also use the water quality index (IQA) developed by the National Sanitation Foundation (USA), based on an opinion poll that involved 142 environmental professionals. Water quality, indicated by the IQA, on a scale of 0 to 100, can be classified in ranges as follows:

- 0 ≤ IQA < 25: very poor water;
- 25 ≤ IQA < 50: poor water;
- 50 ≤ IQA < 70: average water;
- 70 ≤ IQA < 90: good water;
- 90 ≤ IQA < 100: excellent water.

The phyto and zooplankton communities were evaluated for their abundance, density and diversity, also studying the presence of taxonomic groups which indicate water quality. The zoobenthic community was evaluated for the taxonomic number and individual number present in the samples. These parameters for the three communities were related to physical, chemical and hydrological variables in an attempt to better understand how this ecosystem functions.

3. 8. 1 RESULTS AND DISCUSSIONS

Physical, chemical and bacteriological properties:

River water quality is often associated with the composition, usage and occupation of drainage basin land, because it is affected by surface run-off resulting from atmospheric precipitation. Therefore, the physical, chemical and bacteriological results may be related to specific regional issues, described briefly below. Know that the first (December 2003) and the fourth (January 2005) campaigns were conducted during the rainy period, while the others, carried out in April and September 2004, were in periods of transition between the dry end the drought season respectively.

In the project region there are mainly dystrophic Red Latosols and eutrophic Litolic Soils.

The eutrophic Litolic Soil, present mainly on the banks of the river, is shallow. As we move further away from the river the soil becomes deeper and its classification changes gradually towards dystrophic Red Latosol.

The areas covered with dystrophic Red Latosols and eutrophic Litolic Soils may have a sandy endplate texture to clay and silky texture, are red in color with pebbles up to blocks of quartz and basalt. Basalt decomposition produces a reddish clay which creates fertile soil (red land).

On the Piedade River, in the area which will be affected by the project, before the waterfall section, on the banks of the river on the banks of its main tributary is there is dystrophic Red Latosol which is characterized as a mineral, non-hydromorphic soil with Fe_2O_3 in excess of 18%.

In escarpment areas and areas with steep inclines or relief we find soil classified as eutrophic Litolic Soil, which represents mineral, shallow and very undeveloped soil with depths of around 20 cm and texture varying from sandy to clay with or without larger fragments (gravel, pebbles and boulders).

The main activity in the ADA is cattle farming which is carried out in several different ways. The predominance of cattle farming is cleared reflected in the structure of land usage. Pastureland dominates. Crops are represented by temporary and permanent farms, especially those involving pineapple, banana, corn and manioc.

In terms of the use of inputs, according to updated details on affected properties, soil correction techniques were recorded at four farms, fertilizers at nine and the use of seeds and seedlings on eight properties. However, the use of pesticides is not widespread, and was only declared by one interviewee.

The physical, chemical and bacteriological results of the four campaigns carried out in the Piedade SHS area of influence are presented in the following table. The outlying results are highlighted.

Table 3.1
Physical, chemical and bacteriological results, December 2003.

PARÂMETROS	**UNIDADES**	**LIMITES ***	**RESULTADOS**			
			PIE-01	**PIE-02**	**PIE-03**	**PIE-04**
Acidez	mg/L $CaCO_3$	---	1,99	2,99	1,99	3,98
Alcalinidade total	mg/L $CaCO_3$	---	29,0	33,0	36,0	33,0
Chumbo total	mg/L Pb	0,01	< 0,02	< 0,02	< 0,02	< 0,02
Cobre total	mg/L Cu	0,02**	< 0,01	< 0,01	< 0,01	< 0,01
Condutividade elétrica	µS/cm	---	24	24,8	27,2	25,6
Cor aparente	mg/L Pt	75	15	15	15	20
Demanda bioquímica de oxigênio	mg/L O_2	5	1,51	1,43	1,75	1,45
Demanda química de oxigênio	mg/L O_2	---	< 5,00	< 5,00	< 5,00	< 5,00
Dureza total	mg/L $CaCO_3$	---	13	13	15	14
Fenóis	mg/L C_6H_5OH	0,003	< 0,001	0,005	0,001	0,005
Ferro solúvel (dissolvido)	mg/L Fe	0,3	< 0,01	0,290	0,303	0,288
Ferro total	mg/L Fe	---	2,102	2,481	2,588	3,467
Fósforo total	mg/L P	0,1	0,035	0,031	0,031	0,043
Mercúrio total	mg/L Hg	0,0002	< 0,0001	< 0,0001	< 0,0001	< 0,0001
Nitrato	mg/L N	10	0,2	0,2	0,3	0,4
Nitrito	mg/L N	1,0	< 0,005	< 0,005	< 0,005	0,005
Nitrogênio amoniacal (total)	mg/L N	***	0,25	0,36	0,39	0,47
Nitrogênio total	mg/L N	---	0,7	0,6	0,7	0,9
Odor	---	VA	Ausente	Ausente	Ausente	Ausente
Óleos e graxas totais	mg/L	VA	< 1	< 1	< 1	< 1
Ortofosfatos	mg/L P	---	0,023	0,021	0,032	0,029
Oxigênio dissolvido	mg/L O_2	> 5,0	7,21	7,21	7,21	7,00
pH in natura	---	6,0 - 9,0	7,21	7,85	7,87	7,60
Sólidos dissolvidos totais	mg/L	500	19	25	32	38
Sólidos sedimentáveis	mL/L	---	< 0,20	< 0,20	< 0,20	< 0,20
Sólidos suspensos totais	mg/L	---	13	11	15	18
Sólidos totais	mg/L	---	32	36	47	56
Temperatura da água	°C	---	22,0	23,0	23,0	23,0
Temperatura do ar	°C	---	23,0	26,0	26,0	27,0
Turbidez	FTU	100	6,7	7,1	7,2	7,5
Zinco total	mg/L Zn	0,18	< 0,01	0,017	< 0,01	0,014
Coliformes fecais	org/100 mL	1000	250	240	200	60
Coliformes totais	org/100 mL	5000**	21600	19200	24000	89000

*Key: * Standards pursuant to CONAMA Resolution No. 357/05, for class 2 water. ** Standards pursuant to COPAM Decision No. 10/86, for class 2 water. ***Total ammonia nitrogen: 3.7mg/L N. for pH $\leq$ 7.5; 2.0 mg/L N. for 7.5 < pH $\leq$ 8.0; 1.0 mg/L N. for 8.0 < pH $\leq$ 8.5; 0.5 mg/L N. for pH > 8.5. VA = virtually absent.*

Table 3.2
Organochloride and organophosphate results, December 2003.

PARÂMETROS	**VALOR MÁXIMO ***	**RESULTADOS (.g/L)**			
		PIE-01	**PIE-02**	**PIE-03**	**PIE-044**
Organochlorides					
Aldrin	Aldrin + Dieldrin: 0,005 .g/L	< 0,002	< 0,002	< 0,002	< 0,002
OP DDE	DDT (p,p'-DDT + p,p'-DDE + p,p'-DDD): 0,002 .g/L	< 0,80	< 0,80	< 0,80	< 0,80
PP DDE		< 0,80	< 0,80	< 0,80	< 0,80
OP DDD		< 0,80	< 0,80	< 0,80	< 0,80
PP DDD		< 0,80	< 0,80	< 0,80	< 0,80
OP DDT		< 0,002	< 0,002	< 0,002	< 0,002
PP DDT		< 0,002	< 0,002	< 0,002	< 0,002
Mirex	Dodecacloro pentaciclodecano: 0,001 .g/L	< 0,001	< 0,001	< 0,001	< 0,001
Gama BHC	Hexaclorobenzeno: 0,0065 .g/L	< 0,002	< 0,002	< 0,002	< 0,002
Delta BHC		< 0,002	< 0,002	< 0,002	< 0,002
Heptacloro epóxido	Heptacloro epóxido + Heptacloro: 0,01 .g/L	< 0,001	< 0,001	< 0,001	< 0,001
Dieldrin	Aldrin + Dieldrin 0,005 .g/L	< 0,002	< 0,002	< 0,002	< 0,002
Endrin	0,004 .g/L	< 0,004	< 0,004	< 0,004	< 0,004
Endosulfan I	Endossulfan (a + 13 + sulfato): 0,056 .g/L	< 0,056	< 0,056	< 0,056	< 0,056
Endosulfan II		< 0,056	< 0,056	< 0,056	< 0,056
Endosulfan SO_4^{-2}		< 0,056	< 0,056	< 0,056	< 0,056
Metoxicloro	0,03 .g/L	< 0,30	< 0,30	< 0,30	< 0,30
Organophosphates					
Paration Metílico	Paration: 0,04 .g/L	< 0,04	< 0,04	< 0,04	< 0,04
Paration Etílico		< 0,04	< 0,04	< 0,04	< 0,04
Malation	0,1 .g/L	< 0,1	< 0,1	< 0,1	< 0,1
Phorate	Organosfosforados e carbamatos totais: 10 .g/L**	< 0,20	< 0,20	< 0,20	< 0,20
Diazinon		< 0,20	< 0,20	< 0,20	< 0,20
Ethion		< 0,20	< 0,20	< 0,20	< 0,20

*Key: * Standards pursuant to CONAMA Resolution No. 357/05, for class 2 water. ** Standards pursuant to COPAM Decision No. 10/86, for class 2 water.*

As mentioned previously, in the first campaign, carried out during the rainy season, organochlorides and organophosphates. None of the samples found concentrations in excess of those established by environmental legislation. Notes that the analysis method detection limits for certain compounds exceeds the water quality standard in Resolution 357/05.

Table 3.3
Physical, chemical and bacteriological results, April 2004.

PARÂMETROS	UNIDADES	LIMITES*	RESULTADOS			
			PIE-01	PIE-02	PIE-03	PIE-04
Acidez	mg/L $CaCO_3$	---	2,0	2,0	2,5	2,5
Alcalinidade total	mg/L $CaCO_3$	---	20,0	21,0	22,0	20,0
Cloretos	mg/L Cl^-	250	1,0	1,1	1,2	1,2
Condutividade elétrica	µS/cm	---	40	39	41	42
Cor	Unid. Hazen	75	149	154	143	146
Demanda bioquímica de oxigênio	mg/L O_2	5	0,1	0,1	0,1	0,3
Demanda química de oxigênio	mg/L O_2	---	< 5,0	< 5,0	< 5,0	6,0
Dureza total	mg/L $CaCO_3$	---	20,0	22,0	24,0	22,0
Ferro solúvel (dissolvido)	mg/L Fe	0,3	0,11	0,02	0,03	0,16
Ferro total	mg/L Fe	---	1,97	1,87	1,39	1,90
Fosfato total (fósfoto total)	mg/L P	0,1	0,01	0,02	0,01	0,09
Nitrato	mg/L N	10	0,1	0,1	0,1	0,2
Nitrito	mg/L N	1,0	< 0,001	< 0,001	< 0,001	< 0,001
Nitrogênio amoniacal (total)	mg/L N	---	0,45	0,14	0,53	0,58
Nitrogênio total	mg/L N	---	0,6	0,3	0,7	0,8
Óleos e graxas	mg/L	VA	0,3	< 0,1	0,6	0,4
Ortofosfatos	mg/L P	---	0,01	0,01	0,01	0,01
Oxigênio dissolvido	mg/L O_2	> 5,0	6,62	7,58	7,04	7,51
pH in natura	---	6,0 - 9,0	7,95	7,74	8,07	7,96
Sólidos dissolvidos totais	mg/L	500	15	15	17	17
Sólidos sedimentáveis	mL/L	---	< 0,1	< 0,1	< 0,1	< 0,1
Sólidos suspensos totais	mg/L	---	12	15	13	12
Sólidos totais	mg/L	---	27	30	30	29
Temperatura da água	°C	---	24,72	23,37	23,72	24,43
Temperatura do ar	°C	---	30	30	30	30
Turbidez	UNT	100	8	9	8	8
Coliformes fecais	NMP/100 mL	1000	230	300	230	1700
Coliformes totais	NMP/100 mL	5000**	9000	5000	16000	16000

*Key: * Standards pursuant to CONAMA Resolution No. 357/05, for class 2 water. ** Standards pursuant to COPAM Decision No. 10/86, for class 2 water. ***Total ammonia nitrogen: 3.7mg/L N. for pH ≤ 7.5; 2.0 mg/L N. for 7.5 < pH ≤ 8.0; 1.0 mg/L N. for 8.0 < pH ≤ 8.5; 0.5 mg/L N. for pH > 8.5. VA = virtually absent.*

Table 3.4
Physical, chemical and bacteriological results, September 2004.

PARÂMETROS	UNIDADES	LIMITES *	RESULTADOS			
			PIE-01	PIE-02	PIE-03	PIE-04
Acidez	mg/L $CaCO_3$	---	1,0	1,5	2,0	2,0
Alcalinidade total	mg/L $CaCO_3$	---	26,0	21,0	22,0	23,0
Chumbo total	mg/L Pb	0,01	< 0,01	< 0,01	< 0,01	< 0,01
Cloretos	mg/L Cl^-	250	0,1	0,2	0,2	0,2
Cobre total	mg/L Cu	0,02**	0,03	0,02	0,02	0,03
Condutividade elétrica	µS/cm	---	45	44	45	45
Cor	Unid. Hazen	75	35	33	31	35
Demanda bioquímica de oxigênio	mg/L O_2	5	1,0	0,2	0,6	0,1
Demanda química de oxigênio	mg/L O_2	---	< 5	< 5	< 5	< 5
Dureza total	mg/L $CaCO_3$	---	20,0	30,0	24,0	28,0
Fenóis	mg/L	0,003	< 0,001	< 0,001	< 0,001	< 0,001
Ferro solúvel (dissolvido)	mg/L Fe	0,3	< 0,01	< 0,01	< 0,01	< 0,01
Ferro total	mg/L Fe	---	0,48	0,43	0,42	0,26
Fosfato total (fósfoto total)	mg/L P	0,1	0,01	0,01	0,02	0,01
Mercúrio total	mg/L Hg	0,0002	< 0,0002	< 0,0002	< 0,0002	< 0,0002
Nitrogênio amoniacal (total)	mg/L N	---	< 0,01	0,01	0,04	0,04
Nitrogênio total	mg/L N	---	0,1	0,2	0,2	0,2
Nitratos	mg/L N	10	0,1	0,2	0,1	0,1
Nitritos	mg/L N	1,0	< 0,001	< 0,001	< 0,001	< 0,001
Óleos e graxas	mg/L	VA	0,7	1,1	1,4	0,8
Ortofosfato	mg/L P	---	< 0,01	< 0,01	< 0,01	< 0,01
Oxigênio dissolvido	mg/L O_2	> 5,0	7,61	7,20	8,38	8,01
pH	---	6,0 - 9,0	7,51	7,10	7,17	7,35
Sólidos dissolvidos totais	mg/L	500	16	19	19	14
Sólidos suspensos totais	mg/L	---	1	1	1	1
Sólidos sedimentáveis	mL/L	---	< 0,1	< 0,1	< 0,1	< 0,1
Sólidos totais	mg/L	---	17	20	20	15
Temperatura da água	°C	---	21,21	20,44	20,40	20,72
Temperatura do ar	°C	---	34	29	30	33
Turbidez	UNT	100	< 1	< 1	< 1	< 1
Zinco total	mg/L Zn	0,18	0,05	0,08	0,07	0,05
Coliformes fecais	NMP/100 mL	1000	40	110	170	1700
Coliformes totais	NMP/100 mL	5000**	170	1300	1600	5000

*Key: * Standards pursuant to CONAMA Resolution No. 357/05, for class 2 water. ** Standards pursuant to COPAM Decision No. 10/86, for class 2 water. ***Total ammonia nitrogen: 3.7mg/L N. for pH ≤ 7.5; 2.0 mg/L N. for 7.5 < pH ≤ 8.0; 1.0 mg/L N. for 8.0 < pH ≤ 8.5; 0.5 mg/L N. for pH > 8.5. VA = virtually absent.*

Table 3.5
Physical, chemical and bacteriological results, January 2005.

PARÂMETROS	UNIDADES	LIMITES*	RESULTADOS			
			PIE-01	PIE-02	PIE-03	PIE-04
Acidez	mg/L $CaCO_3$	---	6,0	6,5	7,5	5,0
Alcalinidade total	mg/L $CaCO_3$	---	22,0	24,0	36,0	29,0
Cloretos	mg/L Cl^-	250	1,9	1,5	1,7	1,5
Condutividade elétrica	µS/cm	---	35	35	35	35
Cor	Unid. Hazen	75	223	206	210	217
Demanda bioquímica de oxigênio	mg/L O_2	5	< 0,1	0,1	1,2	1,5
Demanda química de oxigênio	mg/L O_2	---	21	17	24	20
Dureza total	mg/L $CaCO_3$	---	14,0	36,0	26,0	38,0
Ferro solúvel (dissolvido)	mg/L Fe	0,3	0,13	0,31	0,19	0,25
Ferro total	mg/L Fe	---	1,98	1,86	1,85	1,65
Fosfato total (fósfoto total)	mg/L P	0,1	< 0,01	0,02	0,02	0,04
Nitrato	mg/L N	10	0,2	0,2	0,2	0,1
Nitrito	mg/L N	1,0	< 0,01	< 0,01	< 0,01	< 0,01
Nitrogênio amoniacal (total)	mg/L N	---	0,4	0,43	0,62	0,4
Nitrogênio total	mg/L N	---	0,7	0,7	1	0,7
Óleos e graxas	mg/L	VA***	2,7	2,0	2,3	1,9
Ortofosfatos	mg/L P	---	< 0,01	0,01	0,01	0,02
Oxigênio dissolvido	mg/L O_2	> 5,0	7,40	7,80	7,40	7,12
pH in natura	---	6,0 - 9,0	7,40	7,39	7,41	7,60
Sólidos dissolvidos totais	mg/L	500	13	13	26	24
Sólidos sedimentáveis	mL/L	---	0,1	0,1	0,1	0,1
Sólidos suspensos totais	mg/L	---	10	10	14	12
Sólidos totais	mg/L	---	23	23	40	36
Temperatura da água	°C	---	24,56	24,30	24,31	24,75
Temperatura do ar	°C	---	24	24	23	23
Turbidez	UNT	100	8	7	10	9
Coliformes fecais	NMP/100 mL	1000	80	2400	300	500
Coliformes totais	NMP/100 mL	5000**	400	16000	2200	3000

*Key: * Standards pursuant to CONAMA Resolution No. 357/05, for class 2 water. ** Standards pursuant to COPAM Decision No. 10/86, for class 2 water. ***Total ammonia nitrogen: 3.7mg/L N. for pH ≤ 7.5; 2.0 mg/L N. for 7.5 < pH ≤ 8.0; 1.0 mg/L N. for 8.0 < pH ≤ 8.5; 0.5 mg/L N. for pH > 8.5. VA = virtually absent.*

The waters of the Piedade river were found to be well oxygenated, bland, with pH always base, although some samples were very close to neutral. Alkalinity, in this case caused by bicarbonate, varied between 20 and 36 mg per liter CaCO3 and was basically uniform throughout the campaigns. The highest values were registered during the rainy season. System acidity, carbon-based, was very low, which indicates the low capacity for offering.

Turbidity was very low, with values below 10 UNT, as well as total solids concentration. In all of the samples, the portion of dissolved solids is equal to or higher than 50% of the solids present in the water. Electrical conductivity on the Piedade River was low, always below 45 µS/cm, corroborating the results of dissolved solids.

We found that the color of the Piedade river was outside the standards for class 2 waters in the April 2004 January 2005 campaigns As presented above, the soil in this region is red in color therefore the results obtained in April could indicate continued influence of rainfall and ferrous compounds present in the water. In fact, during the dry period the color did not exceed 35 Hazen units.

In January, the river color was notably higher, with values of around 200 Hazen units, which confirms the influence of rainfall on water quality.

The levels of soluble eye and found can be associated with the types of rocks and soils diagnosed for the River hydrographic basin, where we found a clear correlation between rocky substrate, relief and soil coverage. in December, soluble iron concentration at PIE-03 was 0.003 mg per liter Fe above the permitted level and in January, 0.01 mg per liter at PIE-02. In the dry season, the levels of dissolved iron were lower than the analysis method detection limit, therefore we can infer that they arrive at the river carried by the rains and are not directly placed into the river.

The DBO values were always below 1.75 mg per liter O2, demonstrating the good water quality for this parameter. DQO was only higher in January, in other words during the high rainfall period and when a large quantity of material is carried to the watercourse.

The influence of the rain on the nutrient concentration can be seen in the data analysis. The Piedade river, in general, has a low level of nutrients such as phosphorus and nitrogen.

Total phosphorus concentrations are within the new standard for class two bodies of water, although we must bear in mind that the river will be dammed and that standards will be more restrictive. Orthophosphate concentrations were, except for the samples collected in December, equal to or lower than 0.01 mg per liter P. Notes the soluble phosphorus is directly available for biological metabolism without need for conversion into simpler forms.

The standard of total phosphate for the watercourse was considered an intermediary environment, in other words a residual time of between two and 40 days, and up to 0.05 milligrams per liter P. For this project, we found that all of the samples of the points which will become lentic met the standard.

In terms of nitrogen, we found that all of the samples, especially total ammonia nitrogen, were within the water quality standard in CONAMA Resolution 307/05.

According to the new legislation, phenol concentration exceeded standards at PIE-02 and PIE-04 during the December 2003 rainy period and could have entered the body of water through sanitary effluent and vegetable decomposition in the soil and water, mainly wood. In the dry season, phenols present very low levels, always below the method detection limit.

In terms of substances that could potentially damage the environment and the biota, mercury and lead were within permitted limits, with values below the analysis method detection limit. The new legislation, CONAMA resolution 357/05, establishes a water quality standard with a maximum concentration of dissolved copper and no longer total copper. Based on this and according to the fact that the analysis were carried out before this resolution came into effect, the results were compared with DN COPAM 10/86 standards. Total copper concentration exceeded the limit in the aforementioned legislation at PIE-01 and PIE-04 during the dry period. We can therefore infer that copper does not reach the waters of the river because of the action of rainfall. The concentration of total zinc, in the rainy and dry seasons, was lower than the quarter quality standard.

In this study, concentrations of oils and fats below or equal to 0.5 mg/L are considered virtually absent. In the second campaign, only PIE-03 presented concentrations in this parameter above permitted levels. In the two following campaigns, during the dry and rainy season respectively, the entire section monitored was found to be contaminated by oils and fats.

The bacteriological quality was satisfactory in the majority of samples. At PIE-04, densities of fecal coliforms were recorded above 1000 NMP/100mL on two occasions, April and September 2004. However, this point is located downstream from the power station, where the water will flow. In January, PIE-02 presented the highest concentration of fecal coliforms registered during monitoring (2400 NMP/100mL).

As with copper, the CONAMA Resolution does not stipulate a maximum value for total coliform concentration in water. According to DN COPAM 10/86, for samples presented unsatisfactory concentrations: PIE-01, PIE-03 and PIE-04 in April and PIE-02 in January.

The results obtained may be related to land occupation and usage, after finding that the main activity within the ADA is farming of different varieties.

he Water Quality Index – IQA reflects interference of sanitary sewage and other organic materials, nutrients and solids present in the water course. Figure 3.3 shows the water quality situation using the IQA environmental index, calculated for the Piedade rigorous stretching the area directly affected by Piedade SHS.

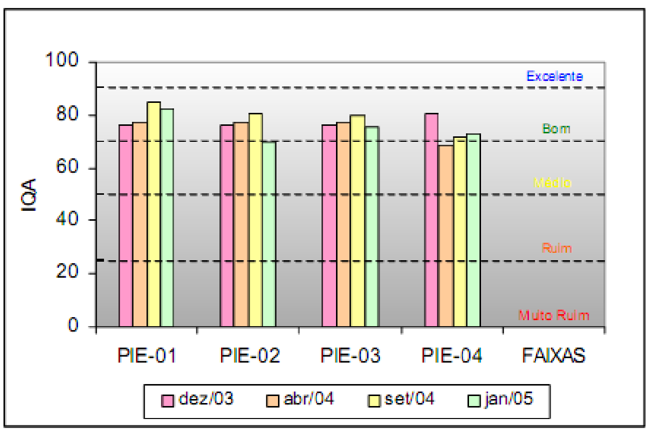


Figure 3.3 Water quality index - PIEDADE SHS.

In analyzing the graph, we can see that the waters of the River Piedade along the SHS section are of good quality during the first rainy season sampled (December/03), despite the water being slightly enriched with phosphorous. Notes that the water quality was uniform throughout the stretch monitored, varying from 76 to 80. In January 2005, the level was a little lower at most points, classifying the water as average quality at PIE-02 (69.7). The point located furthest upstream at the highest quality because of the low level of fecal coliforms on greater oxygenation of the water.

During what are considered transition periods, although the month of September can be considered a dry period, because there was no rain prior to the collection date, the river waters present good quality along practically the entire SHS ADA stretch.

In April, PIE-04, downstream from the future power station, presented average quality water because of fecal coliform counts of 1700 NMP/100 mL. Note that the water quality was uniform throughout the stretch monitored, with a small variation downstream. In the dry period, water quality at PIE-02 and PIE-03 was very similar, and the river presented a slight fall in quality between upstream and downstream.

PIE-04, downstream from the future power station, had a lower average quality level (73.5) although it is still classified as good quality. Periods with lower flows were most critical, especially because of fecal coliform counts.

Phytoplankton

Selected In terms of the phytoplankton community (figure 3.4) we can say that a low number of species were found; the maximum abundance was only 15 species at PIE-03 in September 2004. Algae density was also low, except in the September/2004 campaign, when PIE-01, PIE-02 and PIE-04 reached density is equal to or higher than 80 ind/mL. In the other campaigns, the highest value was just 44 ind/mL at PIE-03, during the April/04 campaign.

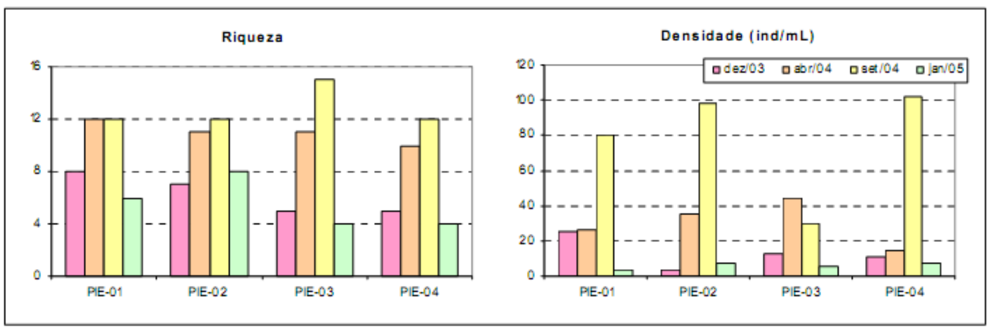


Figure 3.4 Abundance and density of the phytoplankton community in the Piedade river during the hydrological cycle between December 2003 and January 2005.

As a result, community diversity was also lower than expected for this environment, with density at various points lower than 1, which is characteristic in environments that have suffered a strong impact (figure 3.5).

These low diversity values, calculated using the Shannon Weaver species diversity index (1949), were found mainly in campaign points in December 2003 and at all campaign points in January 2005, contrasting with both campaigns in the dry period (April/04 and September/04), when practically every collection point for diversity level in excess of 1, remaining within the typical range of environments suffering moderate impacts.

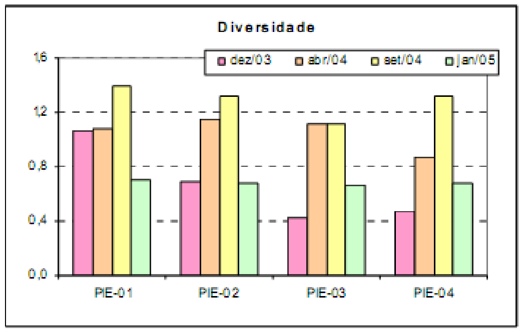


Figure 3.5 Abundance and density of the phytoplankton community in the Piedade river during the hydrological cycle between december 2003 and january 2005.

In December 2003, only three taxonomies were found in the quantitative samples: cyanobacteria of the genus *Lyngbya* sp., diatoms of the Pennales order and an unidentified phytoflagellate. In all three cases, density was low, with a maximum 11 ind/mL for phytoflagellates. In qualitative samples, there were other phytoplankton groups such as Volvocales, Euglena and the genuses *Cosmarium* and *Gonatozygon.*

In April 2004, five taxonomies were found within the division of the cyanophycea, although two of these occurred only in the qualitative samples. The others remained at low densities to the extent that they cause no concern from a sanitary standpoint. CONAMA resolution 357/05 allows for a cyanobacteria density of up to 50,000 cells/mL in class to watercourses. At the full collection points, the algae *Cryptomonas* sp. (Pyrrophyta divisions) was a numerically dominant species, with densities occurring between eight and 18 ind/mL, followed by the cyanophycea Nostocaceae.

In September/2004, diamotic alga was much more extensive than the other types in the waters of the River Piedade. Especially the genuses *Cyclotella* sp.; *Fragilaria* sp.; *Gomphonema* sp.; *Navicula* sp.; *Surirella* sp. and *Synedra* sp.; with densities of at least 20 ind/mL at some sampling points. In addition to the diatoms, cyanophycea *Pseudanabaena* sp. Also occurred in the quantitative samples at PIE-02, at a density of 180 cell/mL. Only these two species of chlorophycea were detected in the quantitative samples: *Crucigenia tetrapedia* at PIE-01 and *Monoraphidium* sp. at PIE-03.

The low abundance and density in the January 2005 campaign were probably accentuated by the rainfall. Only three types could be found in the quantitative samples: *Cryptomonas* sp. (Pyrrophyta divisions), whose density varied at the four points between two and three ind/mL, ad diatoms *Eunotia* sp. and *Ephitemia* sp. The highest density was registered for *Eunotia* sp., 5 ind/mL at PIE-04.

The phytoplankton community in the system is highly susceptible to seasonal environmental variations, shown by alterations in the community structure. These alterations, however, take place as expected, in other words during the intense rainy period there is a further reduction in abundance and scarcity and consequently diversity, which is natural in tropical water habitats.

Zooplankton

Contrary to phytoplankton, the parameters for this community did not follow the normally expected seasonal influences so closely. There was no clear change in the density values between December 2003 and April 2004 (figure 3.6); from then on throughout the dry period, density values increased expressively in September 2004. With the arrival of another rainy period in January 2005, density dropped significantly at two points (PIE-01 and PIE-02) and remained practically constant at the other two.

Diversity, calculated using the Shannon Weaver species diversity index (1949) was the most constant parameter over time. The maximum value (2.55; PIE-03) and the minimum value (1.33; PIE-02) were recorded in January 2005. In most of the samples diversity was equal to or greater than 2.

In the first two campaigns, we found that the waters in the river Piedade had lower densities of zooplankton. PIE-01 and PIE-02 presented an abundance considered scarce and the other two, very scarce, inferior to 1.0 org/l.

However, diversity in April was always higher than diversity in December, because of the number of species present (greater abundance).

In December, the rotifers Bdelloidea were present at every point at relatively high densities. These organisms were numerically dominant at PIE-02 and PIE-04. At PIE-01, there was a participation of micro-crustaceans in the community, reaching a density of 0,408 org/L. In the following campaign, the protozoa will not only more abundant they were also numerically dominant, representing around 70% of the entire community at all four points. In contrast, the micro-crustaceans were few and far between, registering only two taxonomies (*Alona* sp. and Nauplius Cyclopoida), both with a maximum density of 0.1 org/L, at PIE-01.

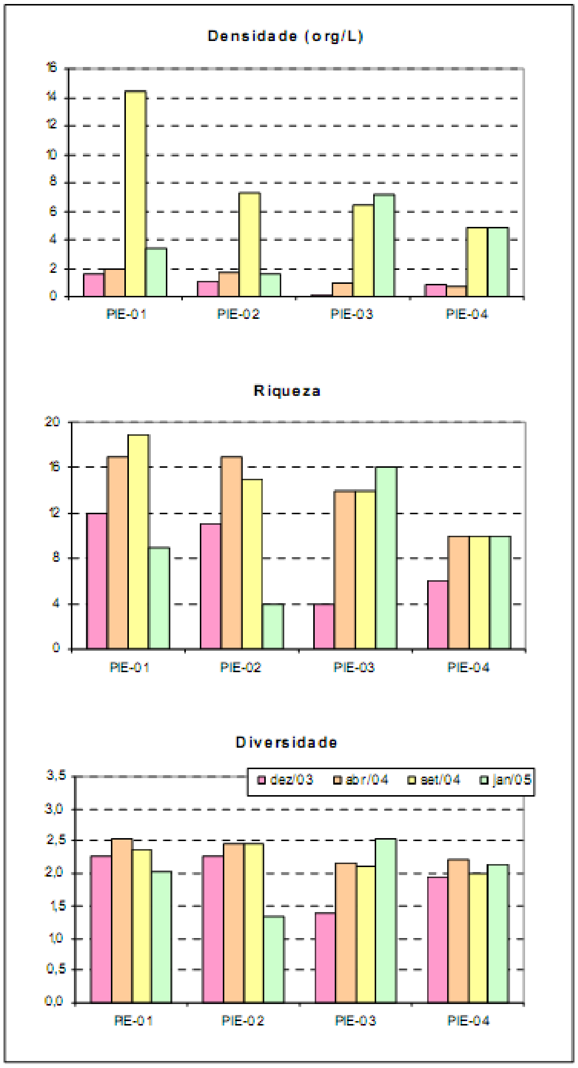


Figure 3.6 Diversity, abundance and density of the zooplankton community in the Piedade river during the hydrological cycle between December 2003 and January 2005.

Keen September 2004, the rotifer species *Lecane lunaris* was numerically more dominant at three points. The exception was PIE-02 where the organism with the highest density was the protozoa *Arcella vulgaris*. Crustaceans were not very representative in this campaign and were absent in the samples from PIE-02 and PIE-04. PIE-01 registered the greatest abundance in the system, 19 taxonomies, especially because of the large number of species of protozoa. At the same point, we also recorded the highest density of total organisms, 14.46 org/L, of which a little over half were protozoa.

In the January campaign, the greatest abundance of zooplankton as well as the highest density was found at PIE-03. Protozoa were the most abundant organisms, especially *Centropyxis aculeata* which was the dominant species at PIE-01 and *Difflugia lobostoma* which was the dominant species at the other three points. Each point recorded representatives from the crustacean class, although they were not very abundant The presence of Bdelloidea was not recorded among rotifers, although it had been very abundant during the previous rainy season.

Benthic community

The zoobenthic community is capable of integrating and reflecting the state of conversational degradation of an ecosystem and organisms which are very sensitive to the effects of even an older or relatively non-serious impact. This is because benthic organisms not only detect physical and chemical alterations in the water but they are also affected by modifications to the structure of their habitat, for example removal of native vegetation from the river banks, deposits of fine sediment on the substrate, less shade along the river banks, the introduction of exotic species etc.

In general terms, we can characterize good quality water environments as those with a large variety of organisms in abundance numbers which are well balanced between species, representing high levels of diversity. Environment is not highly influenced by human activity, we can find organisms with very different lifestyles (sedentary, swimmers, aquatic plants miners etc) and various types of feeding. When there is in fact from human activity, the abundance and diversity of river life tends to fall and the most sensitive species at the first to disappear. In highly degraded environment, with very low water quality, the number of species is small, mainly presenting a single type of animal.

In the December 2003 campaign, the abundance of zoobenthic organisms was especially high at PIE-04, where 14 types were found. The lowest abundance was at PIE-03 with just seven types, although this is a reasonable number considering that the campaign represents the rainy season (table 3.6).

Earthworms (Annelidae), believed to indicate polluted water because they are extremely tolerant of environmental degradation, was the dominant organisms at PIE-01 and PIE-03. The two other points were also dominated numerically by indicators of poor water quality, but in this case the most abundant organisms were immature forms of diptera from the Chironomidae family.

However, we also found some organisms believed to indicate good quality water, because they are extremely sensitive to changes in environment quality. This was the case with ephemeroptera of the genus Baetis, present at all four points from dragon-flies the Libellulidae, Gomphidae and Calopterygidae families (the latter present only at PIE-04) and the caddis fly from the Glossosomatidae family alongside the stonefly from the Perlidae family at PIE-04.

In April/2004, the zoobenthic community showed slightly greater abundance to collection points along the Piedade river (PIE-01 and PIE-03). The lowest abundance was at PIE-02, where only five types were registered (table 2.6). Even at this point, there was a notable presence of organisms indicating good water quality, such as the Marilia genus caddis fly and the mayfly of the genus Thraulodes. The latter was also present at PIE-04. Despite the level of these organisms along the section analyzed, we should point out the high dominance of a single type that PIE-01 and PIE-04, where the lovers of the diptera from the Chironomidae family, which indicate poor environmental quality, represented over 50% of the entire community and were present in great abundance (117 larva at PIE-01 and 91 at PIE-04).

TABLE 3.6
Zoobenthic organism community parameters in the Piedade river waters

CAMPANHA	PONTO	AMOSTRA	TIPO DE SUBSTRATO	Nº DE TAXA		Nº DE INDIVÍDUOS *	
Dezembro/03	PIE-01	1	---	8	8	473	473
	PIE-02	1	---	8	8	322	322
	PIE-03	1	---	7	7	303	303
	PIE-04	1	---	14	14	246	246
Abril/04	PIE-01	1	A	12	12	213	213
	PIE-02	1	A	5	5	28	28
	PIE-03	1	A	9	9	72	72
	PIE-04	1	B	7	11	70	127
		2	A	11		57	
Setembro/04	PIE-01	1	A	12	19	213	393
		2	B	8		180	
	PIE-02	1	A	5	12	28	85
		2	B	11		57	
	PIE-03	1	A	9	13	72	154
		2	B	9		82	
	PIE-04	1	B	7	11	70	155
		2	A	11		85	
Janeiro/05	PIE-01	1	B	8	13	20	42
		2	A	5		22	
	PIE-02	1	B	7	14	36	68
		2	A	6		32	
	PIE-03	1	B	5	11	20	52
		2	A	6		32	
	PIE-04	1	B	7	14	72	140
		2	A	8		68	

Note: Type of Substrate: A – Substrate with predominance of Leaves, Branches and Roots. B – Substrate with predominance of Silt/Fine Sand.
** In the December/2003 campaign, the total abundance of organisms was given in ind./m^2; in the others as ind. in the sample.*

In the substrates sampled at the first three points in the sampling networks, upstream and downstream, there was a predominance of leaves, branches and roots (substrate A). PIE-04, located at a wooden bridge, there was additionally a second substrate with a predominance of fine sand and silt (substrate B). Note that there was no presence of any taxonomy in the sand and silt substrate (substrate B) and that the leaf, branch and group substrate was richer but there was no abundance of organisms (substrate A).

Despite representing very diverse habitats, it is not always possible to discriminate different communities in the A and B substrates. The physical proximity of the two substrates and the ability for organisms to move between them means that the fauna between one location and the other overlaps.

The greatest wealth from the September/274 campaign was recorded at PIE-1 (19 types) where the number of individuals was also especially high (292 individuals, of which 187 Chironomidae larva and 52 Hirudinea bloodsuckers) and the lowest at PIE-04 (11 taxonomies). The point with the least abundance was PIE-02 (85 individuals, of which 30 Chironomidae larva). Despite the fact that Chironomidae lava were very abundant at every point, especially PIE-01, there was also an abundance of several Dragonfly species, belonging to the three families. At PIE-02 and PIE-04, mayfly pupae (family Leptophlebiidae, genus *Thraulodes* sp.) and at PIE-02 we also found caddis fly pupae (family Odontoceridae, genus *Marilia* sp.).

Also in September 2004, no consistent pattern was found representing a community in one or other type of substrate, as both the number of taxonomies and individuals was very similar in both. At PIE-02 we found a difference in taxonomy abundance between one type of substrate and the other, with substrate A presenting five taxonomies and substrate

B 11.

When the rains came, the January 2005 campaign showed a zoobenthic organism community which was much less abundant in the previous campaign and with much less significant dominance. The samples from substrate B from all points contain organisms indicating degradation (Oligochaeta and Chironomidae) and they were not found in substrate A. However, substrate B also presented mayfly pupae (Leptophlebiidae family) at every point, showing that the environment has not seriously degraded. The samples from substrate A were comparatively rich in organisms indicating good quality (mayflies from the Baetidae family and dragonflies from the Gomphidae family).

3.9 NATURAL HERITAGE

3.9.1 METHODOLOGY

The evaluation of the Natural Heritage was carried out between August 14 and 18 2006, complying with LI Condition No. 3.5, which states: *"Present additions and alterations to the scope of the Natural Heritage Registration Program guaranteeing a visual record of the ADA prior to any project intervention affecting Heritage, and cartographic and visual records of remaining natural heritage in the municipal region of Monte Alegre de Minas, characterization of its support capabilities as well as the products associated with the service – Book and CD-ROM, which must be distributed to the community and City Hall. Deadline: 30 days."*

In the municipal region we therefore identified and registered nine waterfalls including the two located on the low flow section of Piedade SHS, also interviewing Mrs. Francinete, an employee at the Municipal Culture and Tourism Department in Monte Alegre de Minas, to identify possible areas of natural heritage in the region.

3. 9.2 AI and ADAE Diagnosis

The Constitution of the State of Minas Gerais, Title IV, Chapter I, Section IV, Article 208 (MINAS GERAIS, CONSTITUTION, 1989) defines natural heritage within cultural heritage, as follows:

"The cultural heritage of Minas comprises the material and nonmaterial natural assets, jointly or individually, which make a reference to the identity, actions and memory of different groups forming States Society, which include: ...

...V - urban areas and sites of historical, natural beauty, artistic, archaeological, spelean, palaeontological, ecological and scientific value"

According to UNESCO (1997) "*Natural Heritage refers to the physical, biological or geological formations which are considered exceptional, threatened animal and vegetable habitats and areas with scientific, conservation or aesthetic value."*

Monte Alegre de Minas has great potential for tourism with innumerable waterfalls and watercourses which can be used for rappel and rafting.

Furthermore, according to the employee Francinete, the town hall intends to implement the "*Heads and Memories Project of Monte Alegre de Minas*" which aims to protect local heritage by protecting historical and architectural assets on farms in the municipal region and at the same time implementer tourism to leverage natural resources in Monte Alegre de Minas.

The City Hall has a leisure area known as the Historic Monument to the Lake Heroes where there is a mausoleum and the reservoirs used for bathing by the local population. The location has infrastructures such as benches, tables and mains/women's toilets, and inoperative bar, gym football pitch and car park.

Photo 3.40 Historic Monument to the Laguna Heroes

Photo 3.41 Mausoleum containing the mortal remains of soldiers killed in the Laguna battle

Photo 3.42 Reservoirs used by the local population for leisure purposes located within the Monument area

Photo 3.43 Infrastructure on the banks of the reservoirs within the Monument area

Photo 3.44 Football pitch

Photo 3.45 Car park within the Monument area

The Babilônia river, which flows into the Tijuco river, passes through the Monte Alegre municipal region in southeast and north-west direction and its main natural attractions are the waterfalls at Usina Velha, the Babilônia Bar and a beach area.

The beach area is around 10 km from the city and is often used by the local population, especially on warm days. This is a very shallow stretch of the Babilônia River with a weak current and no visible sources of pollution.

Photo 3.46 Baber's car is parked close to the right bank of the Babilônia river

Photo 3.47 Small beach, located on the Babilônia river, used for leisure purposes by the local population

The Usina Velha waterfall is located on the Babilônia farm, owned by Mr. Carlitão, and was given its name because of the ruins of the old factory that used to stand there. Because it is on private land it is not used by the city population for leisure activities and according to the owner it is only used infrequently for fishing, because bathing is dangerous based on the depth of the river at this point.

Photo 3.48 Usina Velha waterfall located on the Babilônia River

Photo 3.49 Ruins of the former factory, on the Babilônia farm, on the right bank downstream from the waterfall of the same name.

The Pouso Alegre stream, on the boundary between a municipal regions of Monte Alegre de Minas and Tupaciguara, is where we find the Cachoeira dos Costas or Cachoeirinha. Around 35 km from the city of Monte Alegre de Minas, the waterfall is well known by the local population There is a beach on the left-hand side and a hydrometeorological station run by ANA.

Photo 3.50 CACHOEIRA DOS COSTAS OR CACHOEIRINHA, located on the upper course of the Piedade river, on the boundary between a municipal regions of MONTE ALEGRE DE MINAS and TUPACIGUARA.

Photo 3.51 Hydrometeorological station operated by ANA, located on the upper course of the Piedade river, downstream from the Costas waterfall or Cachoeirinha.

The other waterfalls identified, located and registered were on property belonging to Messrs. José Roberto, Ciro, Nogueira and Vasco; in addition to the Lobo and Onça waterfalls all on private property.

Photo 3.52 CACHOEIRA DA SANGRA, located on the property of Mr. JOSÉ ROBERTO BASÍLIO.	Photo 3.53 CACHOEIRA DO VASCO located in the property of Mr. VASCO, on the TIJUCO river, dividing the Municipal regions of MONTE ALEGRE DE MINAS and PRATA.

Photo 3.54 Waterfall located on the Lobo stream

Photo 3.55 Waterfall located on the property of Mr. CIRO, on the PÂNTANO stream.

Photo 3.56 Waterfall located on the Onça stream

Photo 3.57 Waterfall located on the property of Mr. NOGUEIRA.

The Sangra waterfall, located on the Babilônia river, on a farm belonging to Mr. José Roberto Basílio, has often been used for bathing by the people living on the property and the local population. According to reports from the housekeeper, Mrs. Juliana, the pool which was previously used for bathing has sunk and has caused whirlpools, making the place extremely dangerous for bathing.

The Vasco waterfall is located on the Cachoeira farm, on the Tijuco river at the border between the Monte Alegre de Minas and Prata municipal regions. As it is around 45 km from the city, and difficult to access, it is not used by the local population, only by the people who live on the farm who make sporadic use of it.

The waterfall on the Pantano stream, owned by Mr. Ciro, is not often used by the owner and people living on the farm for leisure activities. There is a barbecue area, with some wooden and cement benches as well as a wooden table. According to reports from the housekeeper, third parties appear sporadically on the farm to use the waterfall

The waterfalls on the Lobo and Pantano stream is owned by Dr Nogueira are difficult to access and are not used by people living there or the local population for leisure activities.

The ADA identified and registered five waterfalls which will be affected by the project, three located in the reservoir and 2 on the low flow section.

The waterfalls in the reservoirs are located on the Piedade river and on the unnamed and Boa Vista streams, which feed into the right-hand bank of the Piedade river. These waterfalls are within the normal, forecast N.A. (650 m elevation) and will disappear when the reservoir is formed.

As the located on private property they are not used for leisure activities, even by their owners, because of difficult access, the absence of a pool for bathing and in the case of the Erson Waterfall located on the Piedade river, the rocky outcrops as well as the strong currents make bathing impossible.

Photo 3.58 Waterfall located on the Boa Vista stream, which feeds into the right-hand side of the Piedade river.

Photo 3.59 Waterfall located on the unnamed stream, which feeds into the right-hand side of the Piedade river.

Photo 3.60 Waterfall located on the Piedade river, known as Erson Waterfall.

Photo 3.61 Details of the falls at the Erson Waterfall on the Piedade river.

At the Erson waterfall, the only leisure activity reported was fishing, carried out sporadically by the owner and third parties.

On the low flow section, we registered the current characteristics of the waterfalls on the area owned by Francisco Carlos Vieira and the waterfall known as Usina Velha and Guimarães, located on property owned by Mr. Roosevelt Guimarães. These waterfalls will not be submerged, but there are flows will be reduced, mainly in the dry season.

Photo 3.62. Waterfall located on the Piedade river on the property of Mr. FRANCISCO CARLOS VIEIRA, on the low flow section

Photo 3.63 Usina Velha or Guimarães waterfall located on the Piedade river on the property of Mr. ROOSEVELT GUIMARÃES JR, on the low flow section

On the left-hand bank we identified around 4 springs which will be submerged by the lake created by the Piedade SHS. The sprinter located on the property owned by Mr. João Vicente de Vasconcelos.

Photo 3.64 One of the springs which will be submerged by the future reservoir, located on the left bank of the Piedade River, on the property of Mr. João Vicente de Vasconcelos.

Drawing PIE-PTN-001 is attached with the location of the waterfalls.

3.9.3. ARCHEOLOGICAL HERITAGE

INTRODUCTION

This report intended to carry out a new archaeological survey of the areas which will be affected by construction of the Piedade Small Hydroelectric Power Station. The Piedade SHS is located in the municipal region of Monte Alegre de Minas, in Minas Gerais.

Because of geological issues related to rock fragmentation under the surface of the water channel location, the entire project had to be altered. A new dam and a new water channel will have to be built on another part of the Piedade river valley. The new dam will be built upstream from the previous dam and the easement for the new water channel, also on the right-hand side of the Piedade river, will be further from the riverbank than the previously planned channel. This additional distance from the riverbank substantially reduces possible effects on archaeological sites, however the depletion area of the new dam is much wider than the previous one and in this case, the occurrence of sites is much more likely. Therefore, a new archaeological study is required because the region is rich in archaeological artifacts and sites.

The new dam's flood area is much larger than the previous one because of local topography. The previous dam would hold back the waters in a section where the valley is more restricted, however by altering the project location, the new dam will flood a much larger area, because the topography of the land along the banks of the Piedade river is much flatter and the gradients are much lower.

LEGAL ASPECTS AND GROUNDS

Brazilian legislation establishing the criteria, procedures and authority for archaeological diagnostic, survey, prospecting and protection stages involves several laws, constitutional articles, resolutions and directives. Below we will present only those which refer specifically to cultural and archaeological heritage as required to produce an EIA-RIMA.

The Federal Constitution of October 5, 1998 establishes the concepts of cultural heritage and the need to preserve it in articles 215 and 216, reproduced in part below:

> *Article 216. The cultural heritage of Brazil comprises the material and nonmaterial natural assets, jointly or individually, which make reference to the identity, actions and memory of different groups forming Brazilian Society, which include:*
>
> *I - forms of expression; II - methods of creating, doing and living; III - scientific, artistic and technological creation; IV - works, objects, documents, buildings and other spaces for artistic and cultural manifestations; V - urban areas and sites of historic, natural beauty, artistic, archaeological, palaeontological, ecological and scientific value.*

Law number 3924, dated July 26, 1961, states that all types of archaeological vestige (sites, the remains of cultural material, structures altering the landscape) which represent testimony of past cultures in Brazil are considered heritage sites and are therefore subject to protection.

Environmental evaluations were created in Brazil in law 6398 dated September 31, 1981, which governs National Environmental Policy and created the National Environmental Council (CONAMA). This organization was created with the specific purpose of establishing regulations, criteria and conduct when licensing activities with an effective or potential impact, determining surveys of environmental consequences and alternatives to protect such areas.

The inclusion of an archaeologist in environmental evaluation works was required as of Resolution number 001, issued by CONAMA and signed on February 23rd 1986; it states that archaeological sites must be evaluated alongside subsequent recommendation of mitigating and/or offsetting measures to balance the negative impacts on archaeological heritage.

IPHAN directive number 230, dated December 17, 2002, defines the environmental licensing procedures, detailing the archaeological research stages: Prospecting, protecting, laboratory, preparing and filing reports on projects that could possibly affect archaeological heritage, as partially reproduced below:

Prior a licensing phase (EIA/RIMA)
Article 1 - in this phase, archaeological and no historical contextualization must be conducted in the area influenced by the project, based on an exhaustive study of secondary data and on-site archaeological survey.
Article 2 - when relating to projects affecting areas which are archaeologically unexplored or not very well-known, which failed to provide any inference regarding the effects of the project, and on-site archaeological survey must be conducted covering at least the area of direct influence. The survey shall include all of the significant environmental compartments within the general context of the area to be affected and shall include a prospecting survey beneath the surface.
I - the final and expected result is a report characterizing and evaluating the current situation of architectural heritage in the area studied, which will be named a Diagnosis.
Article 3 - evaluation of projects impacts on the regional archaeological heritage will be carried out based on a detailed diagnosis, analysis of thematic environmental charts (including geology, geomorphology, hydrographics, declivity and vegetation) and on the technical details of the works. Article 4 - based on the diagnosis and evaluation of the impact, the

Prospecting and Protection Programs will be drawn up and aligned with the works timetable and the environmental licensing faces for the project in order to ensure the integrity of cultural heritage in the area.

Therefore, any project which has an direct or indirect impact on cultural (archaeological) assets must be preceded by an archaeological survey and, if required, subsequent protection of such assets. In this specific case, the archaeological survey aims to complement the Environmental Impact Study (EIA) for the area in question.

OBJECTIVES

The objectives of this report are split into three topics:

- Locate and describe the archaeological sites and events which appear within the area directly affected by the new reservoirs and water channel for Piedade SHS.
- Identify the importance and conservation of archaeological sites and events which may be found.
- Propose recommendations to protect or save them, as required.

METHODOLOGICAL PROCEDURES

In order to conduct an archaeological diagnosis of the area in question, we have defined the following methodology:

- A survey of bibliographic sources available for the region, especially archaeological surveys that have already been carried out; the surveys in item 5 prehistoric history of the region.
- An oral survey, when possible, based on interviews with people who know the area in order to gain information on archaeological traces and/or sites and their possible location. Nobody found during the process was able to tell us of any sites in the directly affected area. In fact, observation of sites with chipped stone remains, such as those found in the previous survey, is not obvious to the lay person.
- Systematic survey: a survey on foot of the entire directly affected area, based on cartographic documents, locating appropriate areas for human occupation and observing the presence of archaeological material on the surface. This survey is carried out using maps, GPS (Global Positioning System) digital camera and a notebook. When travelling through the area, special attention was given to locations where the surface is exposed, providing a better view of archaeological material, mainly in eroded areas.

PREHISTORIC PERIOD IN THE REGION

Archaeological surveys began in the Paranaiba river basin in the Minas Triangle, in 1980 with the *Projeto Quebra Anzol* (Broken Hook project). This project, developed by researchers from the Ethnology and Archaeology Museum from the University of São Paulo, was based on a program of prospecting and systematic excavation which resulted in the excavation of six archaeological sites. The sites are on hillsides and a plateau, with rivers and streams at their bases (Alves, 1992).

Important discoveries were made in the valley of the Piedade river, close to the mouth on the Paranaiba river, on the Rezende farm, 3 km from the city of Centralina/MG. At the site, Alves (1992) identified various archaeological structures, including: spots in the soil referring to the floors of prehistoric dwellings, concentrations of stone artifacts, concentrations of ceramic fragments, fires and director burials. This site provided important dates which helped assemble a timeline of human prehistoric occupation of the Piedade river valley.

Table 3.3
Dating the Resende archaeological site:

Zona	Fogueira	Profundidade (cm)	Data (AP)	Laboratório
5	S1	----	1190 +- 60	CENA*
1	1	90/100	4250 +- 50	Gif.-sur-Yvette**
1	2	110/120	4950 +- 70	CENA
2	1	85	5620 +- 70	CENA
2	3	95	6110 +- 70	CENA
2	2	100/105	6950 +- 80	CENA
2	4	125/130	7300 +- 80	CENA

** Centre for Nuclear Energy in Agriculture/University of São Paulo ** Laboratoire de Faibles Radioactivités/Gif-sur-Yvette*

According to Alves (1992:37) the Rezende site was occupied by the first human groups arriving in the Minas Triangle region more than 7000 years ago. The remains from these groups are chipped stone tools, such as arrowheads, scrapers and borers, as well as fires used to prepare food. These groups remained in the region for various millennia, with no significant changes to their social and economic organization.

From the VIII century of Christian era, the region was subject to transformations that completely changed the daily lives of the groups of humans living there. Ceramic production began and everything indicates this happened alongside horticulture (Alves 2000). New artifacts appear for processing plants that can be cultivated, made of basalt rock and produced by polishing, resulting in tools that resisted the laborious and repetitive work of chopping down forests, grindstones and mortars to grind grain, mud is used to make ceramic spindles to spin cotton as well as vessels to cook vegetables such as corn and beans. There is a substantial growth in population which is reflected in the large number of sites which have been identified as being formed by these populations, called ceramic horticulturalists.

The historical data reveals that the region comprising the “lower Tietê river, towards Mato Gross and Goiás”, in other words including the current Minas Triangle, was known by explorers as the "region of the *bilreiros* or *caiapós*" (Taunay 1975). There are innumerable references indicating that the Triangle was an area of influence for the Kayapó do Sul groups. In 1817, Spix (1981:212) mentions the presence of isolated and rebel Kayapós "bands" in the western part of the province of Minas “ on the other side of the San Francisco River". According to Ribeiro (1996:87) “Caiapônia”, the Kayapó do Sul land, belonging to the linguistic family Jê, corresponds to the entire territory currently encompassing southern Goiás, southeast Mato Grosso, the Minas Triangle and northeastern Sao Paulo.

The Triangle region was travelled by explorers coming from the south from the 17th century. The first documented expedition which probably came through the current Triangle territory was the Pero Domingues expedition which, in 1613, left Sao Paulo and arrived at the confluence of the rivers Araguaia and Tocantins. Various other explorers followed them. After gold was discovered in Goiás in the 18th century, the region became a mandatory route for miners and cattle drivers, increasing pressure on local indigenous groups.

Gradually, despite all of their efforts, the Kayapós lost territory, initially to the explorers who went into the backwards in search of slaves in gold and then in the 19th century, to farming expansion in Minas Gerais and São Paulo. Territorial expansion initially began in the current district of Sacramento (Desemboque) located to the south of Araxá. This was the starting point for expeditions which discovered the entire extent of the Farinha Podre (Barbosa, 1971:160-162) jungle. In 1816 this entire region became part of Minas Gerais instead of Goiás following an order issued by D. João, following interference from the inhabitants in São Domingos do Araxá (Barbosa, 1971:523-526). In the 19th century, the Kayapós were prisoners and intruders on what had been their ancestors land. Their decline culminated in the 20th century when the last group recorded included a little over 30 survivors residing along the banks of the Rio Grande in Salto Vermelho/SP.

The history of Monte Alegre de Minas is linked to the expeditionary routes which explored the Minas Triangle giving rise to various population centers from which cities like Araxá, Uberaba, Prata and others grew. In Prata, the São Francisco das Chagas de Monte Alegre settlement appeared. It was emancipated in 1880 and then changed its name to Toribatê. The current name was given in 1948.

The occurrence of this settlement occurred when a large local family, led by Martins Pereira, moved to the region to take possession of unoccupied land in Goiás, at the beginning of the 19th century. Travelling in a caravan, one of the group became seriously ill, forcing a stopover lasting several months where the city of Monte Alegre currently stands. Because of the lack of medicine, the group's leader, a worshipper of São Francisco das Chagas, promised the construction of the chapel. Once the cure was granted, they decided to stay there until the promise had been fulfilled.

Other adventurers arrived and end up building simple farms close to the rivers with good quality water, as did the Martins Pereira family. After building the São Francisco das Chagas chapel, its name was used in connection with the São Francisco das Chagas market.

The families living there married their children to one another and the village group. Until the Paraguayan War and the Laguna Retreat affected the inhabitants in this region, when a column of the Brazilian army arrived to recruit young men to reinforce the National Volunteers in 1865.

After returning from the battles, the heroes of the Laguna company returns to the region of Prata and Monte Alegre, reoccupying the area.

LIMIAR ENGENHARIA AMBIENTAL

SYSTEMATIC SURVEY

Below, we will present to the waypoints in the archaeological survey and the result obtained and then present these points in a table with their respective coordinates.

The on-site portion was carried out in the month of March when two areas related to the Piedade SHS were inspected:

- The area that will be covered by the reservoir of water, covering both sides of the riverside areas. Both sides could be accessed from the bridge over the River Piedade, going downstream.
- The area where the water channel will be built.

Two on-site teams were mobilized for this project, comprising an archaeologist and a few assistants in each team.

Photo 3.65 Member of the team next to a stake showing the depletion boundary (left); view of the pineapple plantation on the opposite side of the river (right).

During the itinerary, various archaeological sites were identified in the directly affected area of the project. The ADA is considered the areas which will be flooded by the dam and the new transect where the new water channel will pass through. Archaeological sites and occurrences located outside these areas fall within the surrounding area (AE) of the development.

Archaeological traces found were marked with flanks to identify locations with the greatest concentration of sites and facilitate observation from the photographs.

15 sites were identified in the directly affected area and all of them have similar characteristics. They are Stone Age sites of pre-ceramic groups occupying the region almost always located next to rocky outcrops. The raw material is mainly comprised of brown and grey blue silicified sandstone however we also encountered flint, chalcedony and hyaline quartz. Most of the stone material found includes chips, cores and reworked artifacts. All of the sites are close to the banks of the River Piedade, and the main differences between the topographic variations, the quantity of material found in the variations in the proportion of raw material.

The flaking technology is very similar and a variety of types of flaking are related to the different quality of raw material. Groups of hunter gatherers chose these locations for their stonework because raw material was present. In other words, the rocky outcrops were used as deposits and the local areas for testing the flaking. Two of the sites also contain the presence of physical structures in the ruins of farms and traces of ceramic, glass and iron objects, related to the historical occupation of the region.

Right Bank – ADA – Depletion Area

1 – Island Site

Stone Age Site

Coordinates UTM 22K 0713761 \ 7931354

Photo 3.66 Few of the site on the right bank of the River Piedade (top right), remains identified as flanks located in a small drainage ditch (top left) brown sandstone core (lower right), and chips of blue sandstone (lower left).

The Island Site is located on the right bank of the River Piedade, upstream from the new dam and around 150 m from the bridge with a highway crosses the river. The topography has a slight gradient towards the river and the archaeological material is in a swathe less than 15 m from the current bank. Around 5 m from the river bank, there is a steep bank approximately 90 cm high, a result of the seasonal water level variation. The erosion caused by the river Piedade on the embankment is broadly evidence of underground archaeological remains. The Island site is around 10 m in diameter.

Vegetation is low-lying and not dense, mainly grasses and small shrubs. No riparian forest was found in this section. The sediment is exposed over most of the site, which made it easier to find the remains. The Stone Age remains were found in the section where the small drainage ditch feet into the River Piedade. The same drainage ditch has a rocky outcrop which was probably used as raw material by the hunter gatherer groups to practice their stone chipping techniques.

The site has Stone Age remains on the surface, but in no greater density. Some stone chips and one core were identified in the area. The raw material observed on the site is silicified sandstone which is brown and grey blue in color. The entire site will be submerged by the SHS.

2 – Barranquinho Site

Stone Age Site

Coordinates UTM 22K 0713596 \ 7931368

Photo 3.67 Remains marked with flags (top left); view of the site on the banks of the Piedade river (top right), sandstone chips (below).

The Barranquinho site is located 170 meters from the island site and as no material was found between them, it was deemed to be a new archaeological site. However, prospecting work under the surface and archaeological protection could accurately identify their boundaries or any connection between them.

This site is very close to the water and has similar characteristics to the Island. The topography presents a smooth incline and the river has eroded the embankment. This is a rocky outcrop and some remains are deposited on it.
The vegetation is comprised of grasses and shrubs. At the location of the remains there is an interruption in the riparian forest, the river probably removed the overhanging forest as it eroded the bank.
The Barranquinho site is about 10 meters in diameter, but holds more material than the Island site. However, the density of visible archaeological material is also low. We found chips and cores of brown and blue-grey sandstone. The entire site is in the depletion area.

3 - Queda d´água Site

Stone Age Site

Coordinates UTM 22K 0713407 \ 7931595

Photo 3.68 View of the site with the waterfall in the background (top left), remains marked with flags (top right), chipped, semi-buried sandstone (bottom left), fragments of plano-convex artifact (lower right);

This is a Stone Age site close to the right bank next to the largest waterfall observed in the area affected by the project along the Piedade river. This site is located in an almost flat area close to the bank, from where we see an abrupt incline. The Queda D'Água site has a radius of approximately 20 meters where we see archaeological material on the surface.

The vegetation is comprised of grasses and along the bank there is an overhanging forest. Where the sediment was exposed, we could see chips and cores of silicified brown and blue sandstone as well as a fragment of a plano-convex artifact. The archaeological artifacts were found inside and outside the ADA. The density of archaeological artifacts is low, not exceeding 60 items.

The Queda DÁgua site also has a rocky outcrop with the presence of basalt and brown sandstone blocks.

Most of the site (80%) will be submerged and the remainder will be located on the side of the dam lake.

4 – Linha d´água Site

Stone Age Site

Coordinates UTM 22K 0713353 \ 7931831

Photo 3.69 Location of the site with visible remains where the sediment is exposed (top left), concentration of remains identified by flags (top right), plano-convex artifacts known as slugs (below).

The Linha D'Agua site has a large number of archaeological sites dispersed over an area 170 meters long by 40 meters wide, parallel to the Piedade river. Some points have a greater material concentration, especially at the extremities. Remains are found from the river bank up to the steep hillside. Site topography is varied, at some points the hillside is abrupt and at others it is less steep.

Vegetation is comprised of grasses and small shrubs and at some points, riparian forest can be seen, with variable thickness.

The remains found were dozens of chips, some reworked, cores and four plano-convex instruments. A brown sandstone outcrop can be seen and around it waste chips. A large chip showed signs of chipping for a perfect fit with the brown sandstone block which was semi-buried, confirming its origin. The raw material observed on the site is silicified sandstone which is brown and grey blue in color.

The site presents a wide variety of archaeological remains, especially finished artifacts known as plano-convex. Most of the site will be flooded by the new SHS waters and only a small part (less than 10%) will remain above water.

5 – Morrote Site

Stone Age Site

Coordinates UTM 22K 0712666 \ 7931721

Photo 3.70 View of the site left of the hill in the center of the image (top left), archaeological remains identified (top right), chalcedony chip (bottom left) and silicified sandstone chip (bottom right).

This site is in the river lowland, alongside a meander and a small rocky, oval hill. The vegetation is comprised of grasses and some mid-size trees. This site is on a rocky outcrop where we can find basalt and sandstone.

This site is small, around 20 meters in diameter, with average density of archaeological material.

The remains are chips and cores, raw material is brown and grey-blue silicified sandstone and chalcedony.

The Morrote site will be completely destroyed by the reservoir. *6 – Meander Site*

Stone Age Site

Coordinates UTM 22K 0711973 \ 7931447

Photo 3.71 Concentration of visible material where there is no low-lying vegetation (top left), archaeological material rolled and polished, amidst accumulated pebbles, next to waterfall (top right), sandstone chip (bottom left) and reworked artifact (lower right).

The site has a high density of archaeological material dispersed over an area of 150 meters following the river, varying in width by up to 15 meters from the bank.
Topography is varied, from almost flat lowland to a hillside of average gradient. Vegetation also varies between grasses and riparian forest. The site also presents rocky outcrops of basalt and sandstone and it is in the outcrop areas the most remains can be found.

The remains are located in denser and more disperse concentrations. There is a high volume of material and hundreds of chips, cores and reworked artifacts.

There was a concentration of chips and artifacts deposited on a pile of pebbles on the river bank, alongside a waterfall; some of these remains showed marks of abrasion. In other words, positive and negative marks of chipping and retouching were polished by the action of the river water. The raw material used to make the instruments is silicified sandstone in brown, blue-grey and green.

The site will be completely destroyed by the development.

7 – Canindé Site

Stone Age Site

Coordinates UTM 22K 0710656 \ 7932447

Photo 3.72 Material dispersion on the site (left), silicified sandstone chip (right).

A small site, around 15 meters in diameter, located in the middle of a mid-gradient slope. It is more than 150 meters from the river and vegetation is low-lying, with grasses and pasture.

Over 20 brown, silicified sandstone chips were found and a white chalcedony chip. The material was concentrated and found in exposed sediment amongst the vegetation. Archaeological material density is low and no more than 50 items, however it will be completely covered by the water line.

Left Bank – ADA – Depletion Area

8 – Ficus Site

Historical Stone Age site

Coordinates UTM 22K 0713700 \ 7931171

Photo 3.73 Few of the site where we can see a line of coconut trees (top left), historical remains with ceramic and brick (top right), concentration of Stone Age material on the banks above a rocky outcrop (bottom left) and a reworked artifact of green silicified sandstone (bottom right).

The site has two distinct areas which shall widely separated in terms of chronology. The first period is characterized by a series of reoccupation despite pre-ceramic groups who left a great quantity of Stone Age remains in the second period is identified as a historical occupation that left ruins of physical farm structures in the remains of everyday objects such as ceramics, glass and iron pans.

The Fícus site is on a hillside with a low gradient and follows the course of the river Piedade. In this area we can find dry and active drainage ditches. The site is large and was estimated at 400 m long by 70 m wide from the bank. Vegetation is low-lying with the presence of grasses and pasture, alongside large shrubs and trees such as the ficus, coconut trees and mango trees. The latter were planted by the occupants of the old farm, which can be detected from the alignment of the coconut trees.

which are perpendicular to the river, parallel to the stone structures. Along certain sections we can see the presence of riparian forest which varies in thickness, and brushwood along certain sections further from the river.

The historical remains are mainly stone containment walls for flooring and platforms, fragments of decorated and decorated ceramics, iron pans, wooden remains used for building, ceramic flooring, bricks, glass; in addition to changes in the landscape such as earthmoving and tree planting. Note that the location also housed a large farm with some housing structures and that there was architectural and landscaping planning.

There are a lot of Stone Age remains located at specific points throughout the area. Hundreds of chips, cores, artifacts, plano-convexes and their raw material was found almost always made of brown, green and grey blue silicified sandstone. There were also chalcedony chips and cores. Alongside the road parallel to the river we found an archaeological layer exposed in the embankment, with a large number of blue-grey sandstone chips.

Most of the site is not in the depletion area (80%) and only part of it will be submerged. Part of the site which will be destroyed should be excavated on the part outside the water should be protected.

9 – Carneiro Site

Historical and Stone Age site.

Coordinates UTM 22K 0713324 \ 7931612

Photo 3.74 View of the historical wall close to the canal where the water activated the flywheel (top left), detail of the iron flywheel for pumping water (top right), concentration of Stone Age remains in the middle of a basalt outcrop (bottom left), plano-convex instrument (bottom right).

The Carneiro site was also occupied during two different periods: first by hunter gatherers and then thousands of years later, by historical occupants.

The site is about 200 m long by 80 m wide. Its topography presents an abrupt incline close to the waterfall which becomes flat as it moves away from river and in the downstream direction, the same incline presents a decreasing gradient.

The historical site presents ruins of housing which are located in the AE, however the water channel to activate the iron flywheel and all the support structure, such as walls and wooden beams, will be in the flooded area.

The Stone Age site has many cores and chips, some reworked instruments and a plano-convex artifact. The raw material is silicified sandstone of various colors and chalcedony. The site has a basalt block outcrop and it is at this point that more Stone Age remains are found. The site has an average density of archaeological material and almost all of it (90%) is below the waterline, the remainder (10%) will be within the area is flooded by the dam lake.

10 – Pedra Verde Site

Ceramic-Stone Age site

Coordinates UTM 22K 0712489 \ 7931487

Photo 3.75 Concentration of material in a drainage ditch with the river Piedade in the background (top left), and decorated ceramic remains (top right), reworked artifact in green silicified sandstone (bottom left), chips of brown sandstone and white chalcedony (bottom right).

The Pedra Vale site is around 90 m long by 20 m wide, following the course of the river. Its topography has an average gradient which becomes steeper as it follows the river downstream. Visitation is overhanging forest which, at some point, joins the brushwood; only at the beginning of the site, in the eastern section, can we see low-lying vegetation and the slope with a low gradient. Ceramic remains were found at this point.

The Stone Age remains are mainly located at two points at either end of the site. Both were revealed by the action of water in drainage ditches. The downstream concentration is located alongside an outcrop of green rock, including silicified sandstone and flint, showing that the deposit was used for flaking the raw material Between these two concentrations are Stone Age remains visible in the embankment, even in the steeper gradient. We found cores, chips and some reworked items. The raw material used was sandstone, and flint.

Near the upstream concentration of Stone Age remains we found fragments of undecorated ceramic apparently coming from the same recipient. These remains indicate the presence or subsequent passage of ceramic groups, however the small volume of fragments makes it difficult to reach a conclusion.

The site will be completely submerged by the development.

11 – Pineapple Site

Stone Age Site

Coordinates 22K 0711784 \ 7932147

Photo 3.76 Expose Stone Age remains exposed on the contour line in the middle of the pineapple farm (left), plano-convex instrument made of silicified sandstone (right).

This site is located 20 m from the left bank of the River Piedade on a pineapple plantation. The topography has a slight gradient towards the river. The contour line, where the land is exposed, we found evidence of silicified sandstone chips, a plano-convex tool and a fragment of ceramic.

The density of archaeological material is slow and is probably less than 40 objects. Note that the compacting on the site is high because of the fact that land is used for planting, therefore the position of the remains has probably been altered. However, the site will be completely destroyed by the development.

12 –Ladeira Site

Stone Age Site

Coordinates UTM 22K 0712391 \ 7931512

Photo 3.77 View of the site in a drainage ditch surrounded by brushwood (left), Chip and reworked artifact made of sandstone (right).

The Stone Age site is located among brushwood, presenting a very steep drainage ditch. The Ladeira site has an estimated area of 40 m in length by 20 m wide, totaling 800 square meters. The largest concentration of archaeological material is 30 m from the left bank of the River where we found chips, cores and reworked objects in flint, silicified sandstone and chalcedony in various colors. There is a high density of archaeological material on the site will be completely covered by the Piedade SHS.

Water Channel - ADA

13 – Dam Site

Stone Age Site

Coordinates UTM 22 0710032 \ 7932624

Photo 3.78 Sampling hole which showed evidence of archaeological material in the water channel (left), sandstone chip (right).

Stone Age site is located where the new water channel will be built and where the developer made a rectangular excavation (9 m by 6 m) 7 meters deep. The topography of the land is on average gradient with low-lying vegetation and occasional medium-sized shrubs and trees. The hole was made near an access highway and is surrounded by barbed wire fence, properly to avoid cattle accidents.

The material was broadly buried and found because of sedimentary movement while excavating the hole. Please note that the excavation moved the remains out of their original context. They were found in an area 10 m around the hole. We identified brown silicified sandstone chips. The site has a low density of archaeological material, but is exactly on the transect of the new water channel.

14 – Estrelinha Site

Stone Age Site

Coordinates UTM 22K 0709428 \ 7932063

Photo 3.79 Stone Age remains identified by yellow flags (left), reworked artifacts made of brown sandstone (right).

Stone Age site on the water channel, located on a mid-level gradient with low-lying vegetation including grass and pasture. Some medium-sized and large trees are present around the site. The Stone Age remains were located because of the cattle trail which cleared the surface vegetation. The site is traversed by the water line and covers an estimated 80 square meters. It is approximately 100 m from the river Piedade.

The remains found mostly sandstone chips, but we also found a silicified grey green sandstone core. The site has a low density of archaeological material.

15 – Buraco Seco Site

Stone Age Site

Coordinates UTM 22K 0706522 \ 7934652

Photo 3.80 Stone Age remains identified by yellow flags (left), white translucid chalcedony chip (right).

Site located in brushwood near the drainage ditch. The slope has a low gradient. The site is about 200 m square, 20 m long and 10 m wide.
We identified reworked and unworked chips of silicified sandstone and chalcedony, and some cores of the same material. The site presents an average density of archaeological material, however the water channel works will have an impact on this site.

3. *3.9.4 Sites in the Surrounding Area - AE*

1 – Cobra Amarelo Site

Ceramic-Stone Age site

Coordinates UTM 22K 0713588 \ 7931449

Photo 3.81 Ceramic remains marked by flanks (left), polished axe blade (right).

Ceramic Stone Age site is located outside of the directly affected area. The slope has a low gradient and is covered by low-lying vegetation and small shrubs.

The archaeological material was found in an area of approximately 6 m in radius, with some thick ceramic fragments without decoration and a polished axe blade. These remains represents a site occupied by ceramic makers are produced not only the ceramic fragments but also the polished Stone Age artifacts. The site location is within the pattern chosen by ceramic makers. The area is almost flat, close to the river, but not along its banks like the pre-ceramic occupants.

The density of archaeological material is slow and this site will not suffer direct impact.

Archaeological Occurrences – OA.

Occurrence 1

Coordinates UTM 22K 0712739 \ 7931926

Brown silicified sandstone core

Occurrence 2

Coordinates UTM 22K 0712646 \ 7931828

Brown silicified sandstone chip

Occurrence 3

Coordinates UTM 22K 0712541 \ 7931827

One core and two brown sandstone chips

Occurrence 4

Coordinates UTM 22K 0712285 \ 7931928

Brown sandstone chip

Occurrence 5

Coordinates UTM 22K 0711197 \ 7932515

Sandstone and chalcedony chips

Occurrence 6

Coordinates UTM 22K 0711528 \ 7932360

Two brown silicified sandstone chips

Occurrence 7

Coordinates UTM 22K 0709222 \ 7932845

Sandstone chip

Occurrence 8

White chalcedony chip

Occurrence 9
Coordinates UTM 22K 0708637 \ 7933088

Two sandstone and two chalcedony chips

Occurrence 10
Coordinates UTM 22K 0710968 \ 7932299
Two brown silicified sandstone chips

Occurrence 11
Coordinates UTM 22K 0711576 \ 7932143
Brown sandstone chip

Occurrence 12
Coordinates UTM 22K 0711952 \ 7931656
Sandstone and chalcedony chips

Occurrence 13
Coordinates UTM 22K 0711214 \ 7932165
Grey sandstone chip

Occurrence 14
Coordinates UTM 22K 0706647 \ 7934535
Brown sandstone chip

Occurrence 15
Coordinates UTM 22K 0706368 \ 7934809
Chalcedony chip

Occurrence 16
Coordinates UTM 22K 0705249 \ 7935342
Three brown silicified sandstone chips

3.9.5 CONCLUSION

The Piedade SHS deployment area is very rich in archaeological sites and remains, especially Stone Age artifacts. Where we find the presence of rocky outcrops in the raw material is good quality for chipping, such as silicified sandstone, we almost always find archaeological remains.

The large number of archaeological sites and occurrences found suggests that the Piedade river valley was occupied and travelled by groups of hunter gatherers who looked for untested raw materials to obtain the tools they needed for their survival, using chipping techniques. 15 archaeological sites were found in the ADA and 01 in the AE. However, we should point out that in many areas we were unable to locate archaeological remains on the surface because of the vegetation, especially pasture. In these locations, we recommend conducting underground sampling to verify the presence or absence of archaeological remains (prospecting for underground survey on both banks and on the new route of the water channel). Underground sampling is also recommended to detect the boundaries of the sites horizontally and vertically.

Historical sites are also present, however the level of the development impact on them is lower, because most of the physical structures and ruins outside the flooded area.

Excavation of all of the sites in the ADA is very important in order to understand the way of life of hunter gatherer groups occupying the region in ancient times.

4 SOCIAL AND ECONOMIC ENVIRONMENT

4.1 Area of Influence and Surroundings

As highlighted in the document containing Additional Information for the Piedade SHS EIA/RIMA, November 2003, the area of influence adopted for the project is the municipal region of Monte Alegre de Minas and the city's Surrounding Area.

In this document, would provide information on the city of Monte Alegre de Minas and, when available on the official websites, this information has been updated.

Monte Alegre de Minas

Population

Presentation of the population dynamics in Monte Alegre de Minas was based on demographic data for the city collected by the IBGE between 1991 and 2000, as well as estimates calculate by the Institute for 2006.

According to census data from the IBGE, presented in table 4.1, between 1991 and 2000, population in the municipal region of Monte Alegre de Minas remained practically stable, adding only 87 inhabitants, which represents an average annual growth rate of 0.06%. The urban population in this period grew 0.77% per annum, while rural population decreased at 0.01% per annum.

Table 4.1
Population evolution– 1991, 2000, 2006*

Location	1991			2000			2006
	Total	Urban	Rural	Total	Urban	Rural	Total
Monte Alegre de Minas	17,919	11,819	6,100	18,006	12,673	5,333	18,070
Minas Gerais	15,731,961	11,766,538	3,955,423	17,891,494	14,671,828	3,219,666	19,237,450

Source: IBGE. Demographic census 2000. Estimate for 2006 (up to July 1).
** The difference between rural and urban for the year 2006 is not available. The information is an estimate.*

In 2000, the municipal population represented 0.10% of the population in the state and, in 2006, 0 .09%. In light of this, we can see that the municipal region of Monte Alegre de Minas has stagnated in terms of the number of inhabitants with virtually zero growth in this period (0.84%).

Between 1991 in 2000, the region had a demographic density of around 6.8 inhabitants per square kilometer, well below the state average. In terms of spatial distribution, there is a prevalence of the urban population, with urbanization in 1991 of 65.9% and in 2000 70.4%, levels well below the state average in these two years. Table 4.2 contains this information.

Table 4.2
Population Indices, MONTE ALEGRE DE MINAS – **1991/2000**

Location	Area (km2)	Demographic Density (D.D.)		Level of Urbanization (LU)	
		1991	2000	1991	2000
Monte Alegre de Minas	2.615,1	6,85	6.88	65,9	70,4
Minas Gerais	582.586	27,0	30,7	74,8	82,0

Source: IBGE, 1991 and 2000.

In terms of population distribution by sex, Table 4.3 shows that in 1991 and in 2000 the male population was slightly superior in this period, representing, respectively, 51.89% and 51.54% of the total population. A similar analysis could not be conducted in the 2000/2006 period because the IBGE did not issue forecasts separated by gender.

Table 4.3
Population Distribution by Sex, MONTE ALEGRE DE MINAS – **1991/2000**

Location	1991			2000		
	Total	Men	Women	Total	Men	Women
Monte Alegre de Minas	17.919	9.298	8.621	18.006	9.281	8.725
Minas Gerais	15.731.961	7.803.384	7.939.768	17.891.494	8.851.587	9.039.907

Source: IBGE, 1991 and 2000.

In terms of age distribution, in table 4.6 we can see a significant portion of the population is of working age.

Table 1.2
Age Range, MONTE ALEGRE DE MINAS – **1991/2000**

	1991		2000	
	Nº	%	Nº	%
Less than 15	5.632	31,4	4.826	26,8
15 to 64 years	11.220	62,6	11.794	65,5
65 or older	1.067	6,0	1.386	7,7
Total	17.919	100	18.006	100
Dependency ratio	-	59,7	-	52,7

SOURCE: Fundação João Pinheiro, 2000.

In terms of the Economically Active Population (EAP), according to the information presented in table 4.7, in 2000, farming activities, the basis of the city's economy, absorbed 42.1% of the EAP. Services represented 33.1% with a significant participation from government administration, according to information from the City Hall.

Table 1.5
Economically Active Population (EAP), MONTE ALEGRE DE MINAS – **1991/2000**

Industries	EAP	
	Nº	%
Farming, vegetation extraction and fishing	3.208	42,1
Industrial	857	11,2
Trade	1.036	13,6
Services	2.522	33,1
TOTAL	7.623	100

Source: IBGE, 2000.

The city also reveals that municipal unemployment is seasonal and, although not want to fight, is low and is directly related to the main crops of municipal farm products, such as pineapple, soybeans, corn, oranges and sugarcane.

The City Hall has been deploying it to it is to generate jobs such as the "Income Generation Centre" which is an incubator for small and medium-size companies, and the Solidarity Project.

Additionally, the Municipal Job Commission asked the SINE to set up a unit in the region. In terms of specialization, courses are mainly offered by EMATER, CDL and the Rural Union.

4.1.1 SOCIAL INFRASTRUCTURE

Housing

Based on the city, we see that in Monte Alegre de Minas there is predominately horizontal, single-family housing, generally built alongside the roads in the urban centre.

In general terms, the housing is well built, although there is some poorer housing normally belonging to the lower-income populations. According to the City Hall, no areas have been invaded and there are no slums in the municipal region which has space for urban expansion.

The City Hall has no official data on the housing deficit, but it has taken action to improve housing by building bathrooms in houses that don't have them.

Table 1.6 shows the number of private houses in Monte Alegre de Minas according to the period between 1991 and 2000.

Table 1.6
Private, permanent homes by location – 1991/2000

Location:	1991		2000	
	No. of homes	%	No. of homes	%
Urban	3.138	65,18	3.835	69,93
Rural	1.676	34,82	1.649	30,07
Total	4.814	100	5.484	100

Source: IBGE, Demographic Census 1991 and 2000.

In terms of the local population dynamics, between 1991 and 2000 we found that the number of homes in a rural area had fallen and there was a consequent increase in the number of urban homes. However, the number of rural homes fell by 27 units, in other words 1.6%, while the urbanized section grew 18.2%, or by 697 new dwellings. In light of this, we can see that the rise in the number of homes was greater than the population growth in this period. Between 1991 and 2000, while population rose the equivalent of 87 new residents, housing growth was much higher. This therefore means that in Monte Alegre de Minas many more inhabitants were acquiring their own dwellings.

Table 1.7 shows the population's access to services and durable goods according to the 2000 Demographic Census.

Table 1.7
Existence of Services and Durable Goods - 2000

Services and durable goods	No. of homes	%
Trash collection	3,935	71.75
Lighting	5,275	96.2
Telephone line installed	1,897	34.6
Microwave oven	301	5.49
Fridge and freezer	4,641	84.62
Washing Machine	770	14.04
Air conditioning	97	1.77
Radio	4,736	86.36
Television	4,910	89.54
Video cassette	1,096	19.99
Computer	193	3.53
Car for private use	2,079	37.9
Total	5,484	100

Source: IBGE, Demographic Census, 2000.

According to the data, practically the entire municipal population (96.2%) has electrical lighting at home. Trash collection is not so prevalent, at 71.75%. Furthermore, a significant proportion of the inhabitants in Monte Alegre de Minas have basic durable goods such as refrigerators or freezers, radios and televisions.

Basic Sanitation

The City Hall is responsible for water supplies. Water is collected from an Artesian well and distributed without going through the water treatment station, as there is none in the city. According to information from the City Hall, this supply system meets around 99% of local demand.

In terms of sewage, this is also an area that the City Hall is responsible for. There Is No Effluent Treatment Station (ETS) in the city and the waste is pumped directly into the water course which runs alongside the city. The City Hall was unable to estimate the current level of sewage collected by the network.

According to the Demographic Census in 2000, the last census year for which this data is available, water supply and sewage services in Monte Alegre de Minas are presented in table 1.8.

Table 1.8
Water Supply and Sewage, MONTE ALEGRE DE MINAS – **1991/2000**

Municipal Region	Water Supply						Sewage								Total number of homes	
	Network		Source Well		Other		Network		Septic Tank		Rudimentary Septic Tank		Other			
	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%
Monte Alegre de Minas	3.829	69,8	1.584	28,9	71	1,3	3.668	66,9	100	1,8	1.189	21,7	527	9,6	5.484	100

Source: IBGE, Demographic Census, 2000.

The city authorities are also responsible for trash collection and sweeping the streets in the city. Trash is collected throughout the city on a daily basis using a single truck. A dumpster is used to collect refuse; the waste is deposited in a landfill. The City Hall is developing a project to implement a controlled landfill with selective waste collection, alongside the Uberlândia Agricultural Technology School.

Table 1.9 shows the evolution and the number of inhabitants in Monte Alegre de Minas with access to basic services.

Table 1.9
Access to Basic Services, MONTE ALEGRE DE MINAS – **1991/2000**

Services	1991	2000
Water Network	79,6	91,9
Waste Collection(1)	83,6	97,6

SOURCE: Fundação João Pinheiro, 1991 and 2000. (1) Only urban areas.

Based on this data, we can see that there have been substantial advances in the numbers of inhabitants with access to the services. In 2000, practically the entire population have access to water supplies and waste collection.

Health

Evaluation of the musical health sector was based on statistical data obtained from the federal government DATASUS website.

The outpatient health care network in Monte Alegre de Minas provides basic and specialized procedures, as shown in Table 4.4.

Table 4.4
Outpatient Health Care
Number and percentage of procedures - 2005

Procedure category	Nº	%
Basic healthcare procedures	129.066	87.2
Nursing/other mid-level healthcare	35.561	24.0
Basic medical activities	21.374	14.4
Basic dental activities	29.604	20.0
Actions carried out by others University Level Professional	5.215	3.5
Basic sanitation procedures	37.312	25.2
Specialized procedures	18.936	12.8
Spec. Health. Proc., Oth. Level. Sup. Phys.	4.605	3.1
Specialized outpatient surgical procedures	185	0.1
Trauma -- orthopedic procedures	8	-
Clinical pathology	9.975	6.7
X-rays	1.484	1.0
Ultrasound	138	0.1
Diagnostics	332	0.2
Physiotherapy (per session)	2.209	1.5
Total	148.002	100

Source: SIA/SUS - 2005

The specialized procedures include physiotherapy sessions, trauma and orthopedics, clinical pathology, x-ray diagnosis, ultrasound exams, diagnostics, all of which are offered within the Monte Alegre de Minas healthcare system. More complex cases are sent to the Uberlândia health service which is a reference centre.

According to the National Register of Health Care Establishments, the Monte Alegre de Minas health care establishments are represented in table 4.5 below

Table 4.5
Healthcare establishments - 2003

Description	Nº
Health center/Basic unit	3
Specialized clinic/Specialized outpatient clinic	1
Single clinic	5
General Hospital	2
Polyclinic	1
Diagnostic and Therapy support unit	1
Mobile Ground unit	1
TOTAL	14

Source: DATASUS, 2003.

Of the fourteen establishments listed above, 11 belong to the city and 3 are private.

In addition to the physical and human health network in the city, Table 4.6 shows the number of medical clinics and dental teams available in the city per 10,000 inhabitants.

Table 4.6
Medical Clinics and Dental Teams
MONTE ALEGRE DE MINAS - 2003

Type	Number:	No. per 10,000 inhab.
Medical clinics	9	5.0
Dental teams	6	3.3

Source: SIA/SUS – 2003

According to the data, there are 9 medical clinics and 6 dental teams in the city. This is equivalent to 5 clinics and 3.3 teams, on average, per 10,000 inhabitants. Healthcare professionals in the city include: 2 pediatricians, 2 gynecologists, 3 general physicians and 1 anesthetist.

In Monte Alegre de Minas, there is only 1 hospital unit, Santa Casa da Misericórida – a philanthropic entity with just 23 beds, according to Table 4.7.

Table 4.7
Number of Hospitals and beds per Specialty
MONTE ALEGRE DE MINAS - 2003

Type	Hospitals	beds						
		Total	Surgical	Obstetric	Clinical	Chronic/FPT	Psychiatric	Pediatric
Philanthropic	1	23	3	10	7	1	1	1

Source: SIA/SUS – 2003

The 23 beds in the hospital attend the entire municipal population, which amounts to 1.3 beds per 10,000 inhabitants. This level is much lower than the national average of 2.6 beds per 10,000 inhabitants.

Table 4.8 shows admittances are mainly clinical (41.8%), obstetric (28%) and surgical (25.5%). The longest average stay (in days) is clinical treatment (3.6 days) as well as deaths related to hospital care exclusively for this specialty.

Table 4.8
Number of Admittances, Average Stay, Deaths by Specialty
MONTE ALEGRE DE MINAS - 2005

Specialty	Admittances	%	Average stay (days)	Deaths
Clinical surgery	172	25.5	1.9	-
Obstetrics	189	28.0	1.4	-
Health Clinic	282	41.8	3.6	12
Pediatric	32	4.7	2.8	-
Total	675	100	2.5	12

Source: SIH/SUS, 2005.

In relation to evolution and appearance of illnesses, especially STDs, Table 4.9 shows the AIDS distribution in the Monte Alegre de Minas region by age between 2000 and 2005.

Table 4.9
Frequency by age by diagnosis year - AIDS
MONTE ALEGRE DE MINAS – 2000-2005

Diagnosis age	<5 years	13-19	20-24	25-29	30-34	35-39	50-59	60 +	Total
2000	0	0	0	1	0	0	0	0	1
2001	0	0	0	0	0	1	0	0	1
2002	1	0	0	0	1	0	0	0	2
2003	0	0	3	0	0	0	1	0	4
2004	0	1	0	0	0	0	0	0	1
2005	0	0	0	0	1	1	0	1	3
Total	1	1	3	1	2	2	1	1	12

Source: DATASUS, 2006.

According to the foregoing data, we can see a rise in diagnoses over the period except in 2004. 2003 had the highest level, 4 cases, followed by 2005, registering 3 cases in the municipal region. Note that the age range most affected by the disease is youngsters between 20 and 24 years of age.

The municipal region is part of the CISAMVAP – Consórcio Intermunicipal de Saúde da Microrregião do Vale do Paranaíba, founded on August 11 1995 and based in Uberlândia.

According to the information collected, only cases requiring special care are sent to Uberlândia. The municipal region has 2 ambulances and mobile ICU unit to transport patients.

Between 1991 and 2000, the infant mortality rate fell 8.48%, from 29.92 (per thousand live births) in 1991 to 27.40 (per thousand live births) in 2000, and life expectancy rose 2.58 years from 67.84 years in 1991 to 70.42 in 2000, showing an improvement in local quality of life (Table 4.10 below).

Table 4.10
Longevity, mortality and fertility indices, 1991 and 2000

Indicators	1991	2000
Mortality to 1 year of age (per 1000 live births)	29,9	27,4
Life expectancy at birth	67,8	70,4
Total Fertility rate (children per woman)	2,9	2,5

SOURCE: Fundação João Pinheiro, 2000.

Table 4.11 shows the level of admittances, mortality rates and deaths per type of disease diagnosed in 2005 in Monte Alegre de Minas,

Table 4.11
Admittances, deaths and mortality by type of disease - 2005

CID Chapter	Admittances	Deaths	Mortality Rate
I. Some infections and parasitic diseases	14	0	0
II. Neoplasia (tumors)	108	0	0
III. Illnesses of the blood, organs and immune system	31	0	0
IV. Nutritional and metabolic nutritional diseases	46	4	8,7
VI. Nervous system diseases	2	2	100
IX. Circulatory diseases	84	2	2,38
X. Respiratory diseases	114	11	9,65
XI. Digestive diseases	141	1	0,71
XII. Skin and subcutaneous diseases	44	1	2,27
XIII. Osteomuscular and joint tissue diseases	7	0	0
XIV. Genital and urinary diseases	60	2	3,33
XV. Pregnancy, birth and puerperium	426	0	0
XVI. Illnesses originating in the perinatal period	39	0	0
XVII. Congenital deformity and chromosome anomalies	8	0	0
XVIII. Clinical and Laboratory symptoms	134	6	4,48
XIX. Poisoning and other external causes	8	0	0
Total	1.266	29	-

Source: DATASUS, 2005.

In 2005, 1266 people were admitted mainly for neoplasia (8.53%), respiratory diseases (9%), digestive diseases (11.13%), abnormal signs and symptoms (10.58%) and mainly pregnancy, birth and puerperium (33.64%).

Regarding deaths, there were 29 in 2005 and the situation compared with admittances varied little. Respiratory diseases, second place in admittance in the region, led deaths in 37.93% of cases. Following this are abnormal signs and symptoms with 20.68% and finally untraditional and metabolic endocrinal diseases with 13.8%.

Analysis of mortality rates draw attention to the number of deaths in nervous system diseases. In 2005, the two cases led to two deaths, representing a 100% mortality rate that year. In second place are respiratory diseases with a 9.65% rate.

Education

The education system in Monte Alegre de Minas currently comprises 17 establishments. Of these, 13 are run by the local government, 3 by the state and 1 privately.

Among municipal schools, 8 are within the city and range from pre-school (05 crèches) up to high school, with just one school. Schools in the rural zone offer only pre-schooling and basic schooling. State and private schools are located in the city and offer basic through high school.

Table 4.12
Number of Establishment by Location and
Administration - 2003

Municipal Region	Teaching system	Location	Number of Establishments						Total
			Crèche	Pre-school	1st to 4th grade	5th to 8th grade	High School	Adolescent and adult education	Nº
Monte Alegre de Minas	State	Urban	-	03	03	02	01	-	03
	Municipal	Urban	05	02	01	01	01	01	03
		Rural	-	04	05	02	-	-	05
	Private	Urban	-	01	01	01	01	-	01

Source: State Education Department 2003.

According to the city government, the school system is sufficient to meet local demand, with no excess demand for places.

Despite the city government taking charge of maintenance at most schools, the state schools offer most places, as shown in table 4.3 below.

Table 4.13
Enrollment distribution, No. of teachers and schools by administration
MONTE ALEGRE DE MINAS - 2006

Administration	Enrollments		Teachers		Establishments	
	Start	End	N°	%	N°	%
State	2.217	2.231	102	43,4	4	33,33
Municipal	1.777	1.760	124	52,76	7	58,33
Special Education	127	127	9	3,83	1	8,33
Total	4.121	4.118	235	100	12	100

Source: City Education, Sports and Leisure Department: 2006

This trend can be explained by the fact that the state schools still offer most basic schooling places which, as stated in the Directives and Bases Law, should be city-run. Following a trend common in other locations around the State, in Monte Alegre de Minas enrollment is concentrated in the basic schooling cycles.

We should point out that despite the state schools representing 54.17% of enrollments in 2006, this figure is not reflected among teachers and schools. The city manages 52.76% of teachers, and 58.33% of schools.

Analysis of 1999 data, compared with 2006 figures, shows that enrollment distribution in the region followed the population changes in recent years.

The number of enrollments has fallen in Monte Alegre de Minas in recent years. In 1999, 5,238 students were enrolled in the Pre-School, Basic and High School systems. Note that the population in this period was 18.380 inhabitants, almost the same as today. In 2006, the municipal system enrolled 4,118 students at the end of the year. The number of municipal teachers also fell from 286 in 1999 to 235 in 2006.

Analysis of educational figures shows a similar scenario among the Monte Alegre de Minas population. Alongside the population, there has been a certain stagnation in the teaching system, with a significant fall this year in the number of enrollments, which can be explained by the change in population age ranges. This means that the population is not growing, and as it ages there are fewer people of school age.

Students in rural areas are transported by the City Hall to urban areas to continue their studies.

Human Development Index - HDI

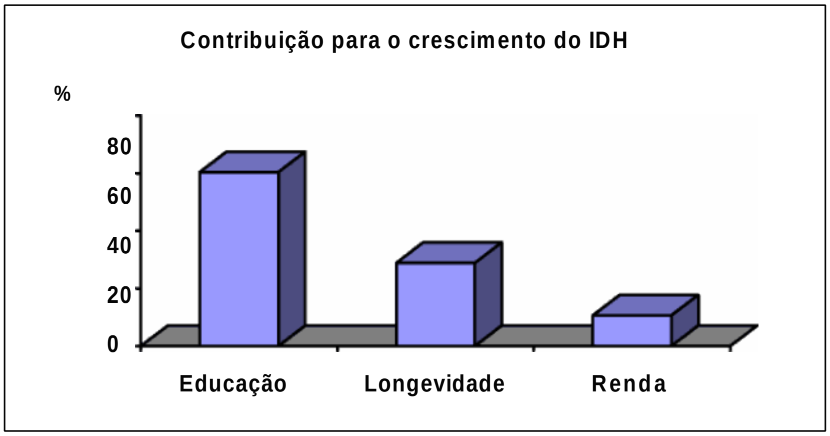
According to the Human Development Atlas in Brazil (HDI-M) 1991-2000, “in the period between 1991-2000, the Municipal Human Development Index (HDI-M) for Monte Alegre de Minas grew 6.90%, from 0.710 in 1991 to 0.759 in 2000.”

Table 4.14
Municipal Human Development Index (IDH-M) -1991 and 2000

Social indicators	1991	2000
Municipal Human Development Index	0,710	0,759
Education	0,755	0,845
Longevity	0,714	0,757
Income	0,660	0,676

SOURCE: Fundação João Pinheiro

The area with greatest contribution to this growth was Education, as shown in the following graph, with 60.4%, followed by longevity, with 28;9% and Income with 10.7%.”



"In this period the human development gap (distance between the municipal HDI and the maximum HDI limit, 1 – HDI) was closed by 16;9%."

"If the HDI-M growth rate is maintained, the region will take 24.8 years to reach São Caetano do Sul (SP), the municipality with the best HDI-M index in Brazil (0.919) and 13.3 years to reach Poços de Caldas (MG), the city with the best State HDI-M (0.841)."

"In 2000, the Municipal Human Development Index for Monte Alegre de Minas is 0.759. According to the PNUD classification, the municipality is among regions deemed average in terms of human development (HID between 0.5 and 0.8)."

"In terms of other Brazilian municipalities, Monte Alegre de Minas is in good standing: It is in 1604th position, with 1603 better (29.1%) and 3903 (70.9%) in an equivalent or worse situation."

"In terms of other state municipalities, Monte Alegre de Minas is in good standing: It is in 215th position, with 214 better (25.1%) and 638 (74.9%) in an equivalent or worse situation."

4.2.1 ECONOMIC INFRASTRUCTURE

A can make infrastructure encompasses aspects linked to electricity, adjudication and transportation and aims to provide a picture of the scope of the services within the area being studied, as an important indicator measuring the economic level and quality of life locally.

Electricity

Electrical services in Monte Alegre de Minas delivered by Companhia Energética do Estado de Minas Gerais (CEMIG), serving various types of consumption are shown in table 4.15, referring to the years 1999 and 2003.

Table 4.15
Electricity Consumption by Class -1999 and 2003

Class		1999	2003
Industrial	Consumption (KWh)	738.421	562.163
	No. of consumers	47	50
Commercial	Consumption (KWh)	2.705.288	2.391.178
	No. of consumers	488	529
Residential	Consumption (KWh)	6.519.148	5.402.238
	No. of consumers	4.074	4.572
Rural	Consumption (KWh)	10.645.486	12.056.923
	No. of consumers	1.097	1.329
Others	Consumption (KWh)	3.108.104	2.990.218
	No. of consumers	79	79
Total	Consumption (KWh)	23.716.447	23.402.720
	No. of consumers	5.785	6.559

Source: CEMIG 1997 and 2001

Based on this data we can see that the most relevant class of consumption in the municipal region is rural. Curiously, this class covers only 20.26% of total consumers in Monte Alegre de Minas, but in terms of consumption it represents more than half of the energy consumed, 51.51%.

In the two years survey, the quantities expressed in table 4.15 indicate a high level of consumption only in the rural class. Any other classes, consumption did not increase.

According to information from the Fundãção João Pinheiro, in 2000, electricity was available to 96.2% of the population.

The municipal region also has public lighting along most streets in the city. Services are considered of good quality.

Communications

CTBC – Companhia Telefônica do Brasil Central is the local telephone utility, offering long-distance and international services. According to city representatives, there are sufficient telephone lines to meet demand. Public services are provided through payphones installed at strategic points throughout the Oban area.

The Empresa Brasileira de Correios e Telégrafos (EBCT) is responsible for sending and receiving correspondence and similar services.

The municipal region has a local radio station and one newspaper.

Transport

The state capital can be accessed along BR-365, a highway, which is taken up to the intersection at the city of Uberlândia. From there, take BR 452 to the Araxá junction, and from here to Belo Horizonte, take BR

The city has a bus station with regular lines to various cities, especially Uberlândia. From here it is possible to take road transport to the other major centers in Minas Gerais and other states.

Monte Alegre de Minas, based on its location alongside the BR-365, also benefits from other bus lines from neighboring municipal regions.

There is no rail or commercial air transport serving the city.

Services and Commerce

Commercial and service activities are adequate to meet the basic demands of the population which goes to Uberlândia for more specialized goods and services. The city has branches of Banco do Brasil, BRADESCO S.A. and Caixa Econômica Federal banks.

Table 4.16 shows the number of companies in each industry and employees. The data is from the CEMPRE (Central Company Register) from the IBGE for 2003.

Table 4.16
General company data according to activity and personnel employed
MONTE ALEGRE DE MINAS - 2003

Activity	Number of units	People employed
Agriculture, fishing, forestry and forest exploration	29	221
Mining industry	1	not available
Transformation industries	46	114
Construction	10	7
Commerce (repairing cars, personal objects and home appliances)	399	790
Housing and food	22	32
Transport, storage and communications	73	80
Financial intermediation	13	45
Real estate and rental activities and services provided to companies	41	99
Public administration, defense and social security	3	559
Education	5	22
Health and social services	8	40
Other collective, social and personal services	104	219

Source: IBGE, Central Company Register, 2003.

4. 1.3 PRODUCTION STRUCTURE

The importance of farming in the Monte Alegre de Minas production base can be seen from the PEA data presented previously.

In fact, the GDP information presented in table 4.17 proves that farming is relevant accounting for over 50% of total income generated, during the period between 1998 and 2002.

Table 4.17
Gross Domestic Product (GDP), at current prices, MONTE ALEGRE DE MINAS 1998-2002

Years	Farming		Industry		Service		Total
	R$	%	R$	%	R$	%	
1998	53.074	59,8	4.312	4,9	31.303	35,3	88.689
1999	56.406	60,5	4.473	4,8	32.324	34,7	93.203
2000	51.264	52,66	7.377	7,57	38.708	39,76	97.349
2001	54.895	51,46	6.625	6,21	45.142	42,32	106.662
2002	72.485	56,43	6.321	4,92	49.636	38,64	128.442

SOURCE: Fundação João Pinheiro, Centre for Statistics and Information (CEI), 2002.

The industrial sector is incipient and city administration highlighted only the presence of one low technology factory producing rum.

In terms of farming, Monte Alegre de Minas is considered the Brazilian capital of pineapple, which is the main product among local crops.

Table 4.18 below present farm production for the year 2002.

Table 4.18
Main products produced - 2002

Product	Harvested area (ha)	Production (t)	Average Yield (kg/ha)
Pineapple (1)	3.000	90.000	30.000
Cotton (seed)	200	480	2.400
Peanuts (unshelled)	600	1.200	2.000
Upland rice	500	900	1.800
Low land rice	200	600	3.000
Banana (2)	187	2.805	15.000
Sugarcane	2.000	140.000	70.000
Coffee	520	936	1.800
Beans (2nd crop)	100	180	1.800
Oranges (1)	1.060	16.960	16.000
Manioc	400	6.400	16.000
Corn	6.000	25.200	4.200
Soybeans	23.200	69.600	3.000
Sorghum (2nd crop)	330	198	600

SOURCE: IBGE, 2006.
(1) Production of 1000 fruit and yield in fruit/hectare
(2) Production of 1000 bunches and yield in bunches/hectare

In terms of cattle farming, beef cattle represent the main activity and are widely farmed. The municipal herd was composed of 137,500 head of cattle in 2000, according to information from the IBGE.

4.2 DIRECTLY AFFECTED AREA

The Directly Affected Area (ADA) according to the original project would affect 15 rural properties (nine on the right bank and six on the left) all located in the municipal region of Monte Alegre de Minas on the banks of the River Piedade, according to table 4.19

Table 4.19

List of ADA Properties for the Piedade SHS – Original Project, 2003

Property number	Under	Structure or element of the project affecting the property
RIGHT BANK		
01MD	Régis Vieira Santos	Reservoir
02MD	Gerson Faria Diniz	Reservoir
03MD	Francisco Carlos Vieira	Reservoir and Dam
04MD	Roosevelt Guimarães Diniz	Water channel
05MD	Leri Parreira Diniz	Water channel
06MD	Dalgiza Teodora dos Reis	Water channel
07MD	Diógenes Coelho Nogueira	Water channel and power house
08MD	Valda	Water channel
09MD	Leonardo Ferreira de Faria	Water channel and water intake
LEFT BANK		
01ME	Antônio Kehdes Sobrinho	Reservoir and Dam
02ME	Áurea Diniz Evangelhista	Low flow section
03ME	Luiz Carlos da Silva	Low flow section
04ME	José Ferreira de Menezes	Low flow section
05ME	José Antônio de Faria	Low flow section
06ME	Jomilton Ferreira de Menezes	Low flow section

Source: EIA/RIMA Additional Information for Piedade SHS, 2003.

Of these, 2 will only be affected by the reservoir, 2 by the reservoir and dam. The remainder, 11 rural properties, all located on the low flow section (LFS), 4 of which will be affected by the water channel, 1 by the water channel and powerhouse and 1 by the water channel and water intake.

Because of the changes to the construction design, the total number of properties affected rose to 21 (13 on the right bank and 8 on the left) as described in table 4.20.

Table 4.20

List of ADA Properties for the Piedade SHS – Current Project, 2007

Property number	Owner	Structure or element of the project affecting the property	Interviewed in 03/2007
RIGHT BANK			
01MD	Juvenil M. Guimarães e Fernando	Reservoir	Y
02MD	Antônio Ferreira Diniz	Reservoir	Y
03MD	Francisco Ferreira Faria	Reservoir	Y
04 MD	Gerson Faria Diniz	Reservoir and Dam	N
05MD	Francisco Carlos Vieira	Water channel	Y
06MD	Robson Pereira Guimarães	Water channel	Y
07 MD	Roosevelt Guimarães Diniz (Estate)	Water channel	Y
08 MD	Leri Parreira Diniz	Water channel	Y
09MD	Dalgiza Teodora dos Reis (Dil Vilela)	Water channel	Y
10 MD	Diógenes Coelho Nogueira	Water channel	Y
11 MD	Valda Pereira de Faria	Water channel	Y
12 MD	Leonardo Ferreira de Faria	Water channel and water intake	Y
13 MD	Vanderlan Pereira de Faria	Water channel and power house	Y

Continued……

Continued... . .

LEFT BANK			
01ME*	João Vicente de Vasconcelos	Reservoir	Y
02ME	Juvenil Martins Guimarães	Reservoir	Y
03ME	Juvenil Guimarães Diniz	Reservoir	Y
04ME	Antônio Kehdes Sobrinho	Reservoir and Dam	N
05ME	Áurea Diniz Evangelhista (1)	Low flow section	N
06ME	José Ferreira de Menezes (1)	Low flow section	N
07 ME	José Antônio de Faria (1)	Low flow section	N
08 ME	Jomilton Ferreira de Menezes (1)	Low flow section	N

Source: Socioeconomic Survey, Limiar Engenharia Ambiental, March/ 2007;
(*) Property 01 ME covers both banks of the river, however only the left bank was considered where the main house is located.;
(1) For LFS properties of the ME, no alterations were forecast to the level and type of interference following project modification which is why they were not included again.

The number of properties followed the same scheme adopted in the IC document for the Piedade SHS EIA/RIMA (from upstream to downstream), in other words, from the reservoirs like to the powerhouse. However, because of the large number of properties affected by the reservoirs, the numbering system used changed substantially.

Note also the increased number of properties affected by the reservoir. Under the current project eight will be affected (four on the right bank and four on the left).

The socioeconomic survey of the new properties affected by the project and/or affected by the new project structures (01 MD, 02 MD, 03 MD, 04 MD, 13 MD and 01 ME, 02 ME, 03 ME, 04 ME) was carried out, as far as possible, in a more detailed fashion, in order to describe the property infrastructure, land and water usage and the quality of life of the resident population.

In relation to the TVR properties on the left (05 ME, 06 ME, 07 ME e 08 ME) no alterations were forecast to the level and type of interference following project modification which is why they were not surveyed again Therefore, new data on these properties will not be included in the survey.

For the other TVR properties on the right bank (06 MD, 07 MD, 08 MD, 09 MD, 10 MD, 11 MD and 12 MD), having already been described in detail in the IC document for the Piedade SHS EIA/RIMA, we tried to elicit the opinion of their owners regarding changes to the water channel layout and possible alterations to the production and socioeconomic conditions on the property.

Table 4.21 contains information on the property areas and the areas required to implement project structures.

Table 4.21
List of Properties by Area – 2007

Property number	Owner	Total area (ha)	Area of Interest (ha)
RIGHT BANK			
01MD	Juvenil M. Guimarães e Fernando	80.0	(2)
02MD	Antônio Ferreira Diniz	145.0	33.94
03MD	Francisco Ferreira Faria	140.0	18.30
04 MD	Gerson Faria Diniz	(2)	(2)
05MD	Francisco Carlos Vieira	242.0 (3)	3.70
06MD	Robson Pereira Guimarães	85.0	3.85
07 MD	Roosevelt Guimarães Diniz (Espólio)	55.0	2.96
08 MD	Leri Parreira Diniz	72.60 (3)	5.95
09MD	Dalgiza Teodora dos Reis (Dil Vilela)	72.60 (3)	2.98
10 MD	Diógenes Coelho Nogueira	99.22 (3)	2.71
11 MD	Valda Pereira de Faria	(2)	0.78
12 MD	Leonardo Ferreira de Faria	62.92 (3)	5.12
13 MD	Vanderlan Pereira de Faria	95.0	4.0
LEFT BANK			
01ME*	João Vicente de Vasconcelos	580.0	25.57
02ME	Juvenil Martins Guimarães	29.0	(2)
03ME	Juvenil Guimarães Diniz	411.0	(2)
04ME	Antônio Kehdes Sobrinho	871.20 (3)	20.26
05ME	Áurea Diniz Evangelhista	(2)	(2)
06ME	José Ferreira de Menezes	11.32 (3)	-
07 ME	José Antônio de Faria	58.08 (3)	-
08 ME	Jomilton Ferreira de Menezes	60.50 (3)	-

Source: Socioeconomic Survey, Limiar Engenharia Ambiental, November/2003 and March/ 2007;
(*) the property extends along both banks of the River Piedade, but the main house is on the left-hand side;
(1) No changes were forecast on these properties with regard to the level and type of interference from the new project, which is why they were not surveyed again;
(2) No information;
(3) Information from the IC document for the Piedade SHS EIA/RIMA, November/2003.

Drawing PIE-PRO-002, attached to this document, contains the properties registered in the Piedade SHS ADA.

4.2.1 Individual Description of Farming Establishments

Right Bank

Reservoirs and Dam Area

Owners: JUVENIL M. GUIMARÃES E FERNANDO

PROPERTY 01 MD: Piedade Farm

The property is located on the right bank of the River Piedade. The Piedade Farm covers an area of approximately 80 ha and was created following purchase of land from the former estate of Mr. Nelson Diniz. The property will be affected only by the reservoir.

The purchasers were Mrs. Juvenil M. Guimarães (owner of another property on the opposite side of the river which will also be affected by the reservoirs) and her brother-in-law Mr. Fernando. The former resides on another property in the ADA, belonging to her father; the latter in a municipal region of Monte Alegre de Minas. There is nobody on the property, either family members or full-time staff. Mr. Juvenil is responsible for the economic activity conducted on the farm

Note that there are no improvements on site or any sanitation infrastructure (water, sewage and energy)

Land usage is predominantly pasture, in line with the main economic activity, cattle farming, as described below:

- Pasture: 70.0 ha
- Forest and brush wood: 10 ha.

No crops are farmed on the property. According to Mr. Juvenil Guimarães, around 50 head of cattle were on the farm at the time of the socioeconomic survey.

The Piedade river is used on the rural property exclusively for animal drinking water.

Mr. Juvenil M. Guimarães was asked about the dam construction and the project's repercussion on his property. He said that construction of the hydroelectric power station is a negative event, because it will use part of his productive land. He also believes the land closest to the riverbed is the best quality and will be covered by the reservoir. Based on this, his cattle farming will suffer.

Despite this negative scenario, if negotiating with the developer, he believes that the best solution will be to negotiate only the area affected by the reservoir.

Owners: ANTÔNIO FERREIRA DINIZ
PROPERTY 02 MD: CACHOEIRINHA Farm

The Cachoeirinha Farm is on the right bank of the Piedade river covering an area of around 145 ha. The property will be affected only by the reservoir.

The property owner lives in Uberlândia, travelling to the farm at the weekends. In the city, Mr. Antonio owns a bread shop and a restaurant which are his main sources of income.

The farm is run by two full-time staff (Mr. Clediomar and Mrs. Aparecida) who live on site and look after the crops, cattle and the home. Temporary staff are hired in March and June, but the number varies depending on their requirements. In addition to these workers, there are three partners (Mr. Sebastião, “Lipe” and “Branco”), who have a half interest with the owner planting soybeans. Mr. Antônio Ferreira, who was interviewed, was unable to say what soybean production was during the last crop.

As pointed out above, the main activities are cattle and crop farming. These are the main areas of land usage as described below:

- Pasture: 64 ha

Temporary crops: 81 ha.

According to information provided by the owner, the soybean and manioc crops are the main activities on the farm. Soybeans account for approximately 60 ha, the largest area. The soybeans are sold to companies in the Minas Triangle region to make oil, while manioc is sold to Ceasa in Uberlândia. Additionally, they have also been cattle farming. The cattle is sold to regional traders.

At the time of the on-site survey, the cattle herds totaled 180 head. Other animals are also bred, to a lesser extent, such as hogs (20 head) and poultry (200). Three horses are on the farm and are used to help carry out everyday activities.

Cattle farming is extensive and no type of pasture has been planted on the farm.

In terms of crop farming, especially soybeans, more sophisticated production techniques are used such as a mechanical tractor to plough the land and plant seeds, as well as a harvester. The crop also benefits from chemical fertilizers.

The Piedade river is used on the property for animal drinking water and leisure purposes (especially weekend fishing).

In terms of infrastructure, the property has: One main house, two outhouses, three pigsties, one chicken house, for material storage warehouses, one corral and one store house.

The main house is only occupied at the weekend by the owner. This is a brick construction with 10 rooms, internal and external finishing and a ceramic floor. Water comes from a spring on the property, the sewage system uses a septic tank and energy is provided from the public electricity network.

The full-time workers (Mr. Clediomar and Mrs. Aparecida) reside in one of the outhouses which is supplied by the same spring, septic tank and electricity network.

Asked about the possibility of building a hydroelectric power station, the owner said he was hearing about it for the first time from the consultancy contracted for the socioeconomic survey.

Because this was news to him, he did not feel secure enough to say whether this was a good or bad thing, although he accepts his property will suffer in terms of production capacity because the area covered by farmland will fall.

If there are any negotiations regarding the land, he demonstrated that he intends to sell only the part affected by the project.

Owner: FRANCISCO FERREIRA FARIA PROPERTY 03
MD: BOA VISTA DO PÂNTANO Farm

The Boa Vista do Pântano Farm is on the right bank of the Piedade river covering an area of around 140.0 ha. The property will be affected only by the reservoir. The property owner lives in Uberlândia, travelling to the farm at the weekends. Mr. Francisco Ferreira Faria's main income is from transporting schoolchildren.

Work on the property is carried out by the interviewee at the weekends. Sometimes, temporary workers are hired, especially in March, for clearing and other services.

Main activities are crop and cattle farming. Land usage is predominantly for pasture:

- Pasture: 115 ha
- Temporary crops: 5 ha
- Forest and brush wood: 20 ha.

As stated by the owner, a small part of his land is used for pineapple farming, sold to traders in Monte Alegre de Minas. The cattle is for breeding and beef, and sold to city traders.

At the time of the on-site survey, the cattle herds totaled 130 head. Three horses are on the farm and are used to help carry out everyday activities.

Cattle farming is carried out on an off-farm basis, however the cattle is vaccinated and wormed.

Farming activities use a mechanical tractor. The pineapple crop requires application of limestone and the use of chemical fertilizers. The land, in the crop area and pasture area, follows the same contour lines.

The Piedade river is used on the property for animal drinking water and leisure purposes (especially weekend fishing). Note that the owner mentioned he intends to increase the pineapple production area next year and if so, he intends to use water from the Piedade river for irrigation.

In terms of infrastructure, the property has: One main house, two outhouses, one pigsty, one chicken house, two corrals, one store house and two milking areas.

The main house is only occupied at the weekend by the owner. This is a brick construction with 07 rooms, internal and external finishing and a cement floor. Water is provided from a spring and are well on the property, while energy is provided by the public utility.

Asked about possible construction of a hydroelectric power station, the owner said he had been approached by representatives from Construtora Gomes Lourenço last year and this person had provided him with preliminary information on changes to the power station project.

Based on this information, Mr. Francisco believes the construction of the power station will be a negative event, because the reservoir will cover part of his most productive land, the low-lying land, closest to the river. Based on this, cattle farming will suffer as all project to expand pineapple farming.

If there is any negotiation regarding the land, he demonstrated that he intends to sell only the part affected by the project.

Owner: GERSON FARIA DINIZ PROPERTY
04 MD: Boa Vista Farm

As highlighted in the IC document for the EIA/RIMA, the Boa Vista Farm is located on the right bank of the Piedade river and will be affected both by the reservoir and the dam. The owner is a bank employee living in the city of Osasco/SP, and the property is managed by his cousin, Mr. Régis Vieira Santos.

Noticeably area of the property was expanded when it incorporated part of the property which belonged to Mr. Régis Vieira Santos.

During the fuel survey, the socio-economic information enabled us to review/update the data because nobody was residing on site. Furthermore, attempts to contact the owner by telephone were unsuccessful.

4.2.2 Downstream Area – Low Flow Section/Adduction Channel/Power Station

As highlighted the beginning of this item describing the ADA properties in this document, the properties 05 MD, 06 MD, 07 MD, 08 MD, 09 MD, 10 MD, 11 MD, 12 MD had already been described in the IC document for the EIA/RIMA at Piedade SHS. Therefore, the main objective was to obtain the opinion of the owners regarding implications of the changes of the water channel route on the production capabilities of the properties and the existing socioeconomic relationships.

We must point out that these owners have renegotiated land with Construtora Gomes Lourenço. Currently, the main concern relates to the solutions which were presented by the company to renegotiate the new areas which will be affected by the new water channel route.

A meeting was held with these owners at the works site for the Piedade SHS on 14/03/2007, when they were presented with questionnaires on their attitude towards the changes in the water channel route.

Photo 4.1 Meeting with the owner of the TVR MD

Photo 4.2 Meeting with the owner of the TVR MD - presenting the new route

Only property 13 MD underwent a more detailed survey because this property was not affected by the original Piedade SHS project.

Owner: FRANCISCO CARLOS VIEIRA PROPERTY 05 MD:

BOA VISTA DO PÂNTANO Farm

The owner, Mr. Francisco Carlos Vieira, has been living in the city of Monte Alegre de Minas with his family where he has a store which, alongside the farm, are his two sources of income.

Mr. Francisco travels at the weekends to the property and with his brother, who resides on a neighboring property, takes care of all the chores. They have no full-time staff. In the months of October to April, they usually hire temporary workers from the region for general services such as fixing fences and clearing the pasture.

In terms of the land negotiation conducted prior to the changes in the project, the interviewee said he received for payment for the sale and used the money to invest in his store and on the property.

He said he was not satisfied, but that he also did not lose out from the negotiation, because he did not intend to sell the entire property. On the other hand, he acknowledges that the Piedade SHS construction will benefit the municipal region.

Regarding changes to the project, the owner said that based on the location of the new channel, Construtora Gomes Lourenço will have to build bridges for cattle and machinery. Furthermore, fences will need to be built so that the cattle do not cross the Piedade river.

Mr. Francisco also mentioned his concern regarding new negotiations for the land which will be used by the water channel, because the land purchased previously represented a larger area and now this area will be much smaller.

Owner: ROBSON PEREIRA GUIMARÃES PROPERTY 06
MD: BOA VISTA DO PÂNTANO Farm

The owner resides on the farm with his family, which is main source of income. He and one other employee carry out all of the farming activities on the property. Once every year they hire around three temporary workers to clear the pasture and fix fences.

Mr. Robson, who was interviewed, said that he had received the payment for the land he had sold and that the money was invested in property. In his opinion, the negotiation was just reasonable.

In terms of changes to the project, he believes that this will not affect him to a great extent if Construtora Gomes Lourenço does not want the land below the channel, acquired during the first negotiation. He would be in favor of exchanging the land purchased for the land that will need to be used by the water channel. However, if Construtora Gomes Lourenço also needs the land below the channel, he said that no further work would be possible on his property.

In addition to this negotiation, they will also need to be some sort of passageway over the water channel (for cattle and machinery) and even drinking areas for the cattle at other locations around the property. He was concerned about the possibility of cattle crossing the Piedade river asking that Construtora Gomes Lourenço build fences along the Piedade river to cut off access.

Owner: ROOSEVELT GUIMARÃES DINIZ (Estate)
PROPERTY 07 MD: BOA VISTA DO PÂNTANO Farm

Based on the latest information obtained on site, the sole beneficiary of the estate of Mr. Roosevelt Guimarães Diniz was his son, Mr. Roosevelt Guimarães Diniz Júnior.

Mr. Roosevelt Jr lives with his family in the city of Monte Alegre de Minas and travels every day to work on the property, which is his main source of income.

On being interviewed, he said that he has no full-time workers and hides a maximum of three temporary employees for two or three months every year for clearing pasture and fixing fences.

When asked whether he had received payment following the land negotiation, he said he had, using the cash on the farm.

He said he was not satisfied with the previous negotiations, but that he also did not lose out from the negotiation, because he did not intend to sell the entire property.

In terms of the project amendments, Mr. Roosevelt Jr. said that the changes were good because the new channel route would affect nonproductive land, but would affect one water source and a small lake. He also said that the solution for the loss of the water would be another water option and he would need a passageway for cattle and machinery over the channel to his more productive farmland, and the need to fence off the Piedade river to stop cattle from crossing.

Mr. Roosevelt Jr also asked us to look into the issue of his father's property, which belonged to Mr. Roosevelt Guimarães, encompassing the Piedade and Boa Vista do Pantano Farms. Gomes Lourenço considered this to be a single farm and in the deeds did not find that the channel would also pass through the Piedade farm.

Today, the owner, Mr. Roosevelt Guimarães, is deceased and his land was split between his children. The Boa Vista do Pântano farm was divided between the children Robson Pereira Diniz (85 ha) and Roosevelt Jr. (12 ha), the remainder was sold to third parties, but will not be affected by the Piedade SHS. Mr. Roosevelt Jr. received the remainder of the estate (23 ha).

Owner: LERI PARREIRA DINIZ
Property 08 MD: Pântano Aguadinha Farm

The owner, Mr. Leri Parreira Diniz, resides at the farmhouse with his wife. Economic activity on the property, along with his pension, are his main source of income.

Farm work is carried out by the owner and members of his family. They have no permanent employees, but usually higher temporary workers once a year for pasture clearing and fence fixing.

Mr. Leri, who was interviewed, said that he had received the payment for the land he had sold and believes that the negotiation had been reasonable. He acknowledges that Construtora Gomes Lourenço paid market values. The cash was invested on the property.

In terms of the project amendments, Mr. Leri said that he was concerned about machine and cattle access to the land which will be below the water channel, adding that there should be individual passages, one for each property. This means he would have his own bridge for cattle and machinery.

Owner: DALGIZA TEODORO DOS REIS (DIL VILELA)
PROPERTY 09 MD: PÂNTANO Farm

The owner, Mrs. Dalgiza Teodora dos Reis, lives in the state of São Paulo, and the property is managed by Mr. Dil Vilela dos Reis, who resides with his family on the property.

According to Mr. Dil, the property represents his main source of income. He said that he has no full-time employees and does not higher temporary workers.

In terms of the sale of the land, Mr. Dil said he had received his payment that negotiation was reasonable, preferred not to say how the money was spent.

Regarding the changes to the project, he said that the new route for the water channel will destroy his cashew trees and a spring and he will need a crossing over the water channel for cattle and wells, as the area below the channel has increased considerably.

Owner: DIÓGENES COELHO NOQUEIRA
PROPERTY 10 MD: MANSSAMBARÁ Farm

The owner, Mr. Diógenes Coelho Noqueira, resides with his family on another rural property outside the project area. The properties are his two main sources of income.

Mr. Diogenes has no full-time staff, but hires one temporary worker for pasture clearing, harvesting, fixing fences, etc.

In terms of the negotiation, he said he received the entire payment for the sale of land and alleged that Construtora Gomes Lourenço "paid a cheap price for land". The cash from the transaction was invested on both properties.

Regarding changes to the project, the owner sent that the new water channel route will go through his best land, part of his banana plantation and a spring. He said that he will therefore need a crossing for cattle and machinery over the water channel.

He highlighted that in the previous agreement, Construtora Gomes Lourenço was supposed to arrange for a well which is now very important, because he will have no water for his cattle. Mr. Diogenes also demonstrated his concern regarding the possibility of cattle crossing the Piedade river. In this case, he asked the construction company to take the necessary measures to ensure that this does not occur.

He also said that he authorised Construtora Gomes Lourenço to open up an access road to the power station on his land, but so far the construction company has taken no steps to legalize the situation.

Owner: VALDA PEREIRA DE FARIA PROPERTY
11 MD: MANSSAMBARÁ Farm

The owner, Mrs. Valda Pereira, lives in the city of Monte Alegre de Minas and the property is managed by her son, Vanderlan Ferreira de Faria, who owns a property in the ADA, where he lives (see MD 13).

Income from the property and a pension are the owner's main source of income.

Mr. Vanderlan, who provided us with information on the property, said that it has no full-time staff. Once a year, he hires a temporary worker to clear the pasture.

He said that he had received the payment for the land he had sold and that the money was invested in property. He said that his mother was happy with the transaction.

In terms of changes to the project, he said that the property needs a crossing over the water channel for cattle and that he had previously agreed a well with Construtora Gomes Lourenço.

Owner: LEONARDO FERREIRA DE FARIA
PROPERTY 12 MD: MASSAMBARÁ Farm

The owner, Mr. Leonardo, resides with his family on another rural property outside the project area. These two properties and his pension are his main source of income.

Farm work is carried out by the owner and members of his family. They have no permanent employees, but usually higher temporary workers once a year for pasture clearing and fence fixing.

The owner said that he had received the payment for the land he had sold and believes that the negotiation had been reasonable. He acknowledges that Construtora Gomes Lourenço paid market values. The cash was invested on the property.

In terms of changes to the project, the owner said that the new water channel route would affect his farmland and two springs would be damaged, expressing his concern with the cattle's access to water and subsequent reduction of the water from his springs. He pointed out that offence would be required to avoid the cattle crossing the river.

Mr. Leonardo said he is aware of the need for a new negotiation because of the land affected and said he will wait for contact from Construtora Gomes Lourenço representatives.

Owner: **VANDERLAN FERREIRA DE FARIA**
PROPERTY 13 MD: Piedade Farm

The Piedade Farm is on the right bank of the Piedade river covering an area of around 95.0 ha. Of this area, approximately 13 ha were recently acquired from his mother, Mrs. Valda Pereira de Faria. This is why the property will be affected by the water channel at two different locations and by the power station.

The owner, Mr. Vanderlan Ferreira de Faria, resides on the property with his wife and he is responsible for farming activity on site. He said that no permanent and/or temporary workers are hired. There are no leases or partnerships for agricultural production on his property.

He mainly farms beef cattle. He also produces milk and sugar cane on a non-commercial basis.

The land on the property is subdivided as follows:

- Pasture: 72.0 ha
- Temporary crops: 2.0 ha
- Forest and brush wood: 21.0 ha.

At the time of the on-site survey, the cattle herds totaled 100 head. Most of the herd is for breeding/beef. The cattle are sold within the municipal region. The owner also reported low-level milk production, around 10 L per day, used for his own consumption and by neighbors.

A mechanical tractor is used to farm sugarcane and apply chemical fertilizer. According to the owner, soil conservation techniques are used all over the property using terraces and pasture rest areas.

The Piedade river is used on the rural property exclusively for animal drinking water.

In terms of infrastructure, the property has: One main house, two pigsties, one chicken house, one material deposit, 1 warehouse, three corrals, one store house and one milking area.

The main house is only occupied at the weekend by the owner. This is a brick construction with 10 rooms, internal and external finishing, ceramic flooring with water from a spring on the property and energy from the local utility company.

Asked about a possible construction of a hydroelectric power station, the owner said he had heard about it in the region.

According to Mr. Francisco, construction of the power station will be a positive event, because this will improve local roads. Regarding possible modifications to his property, he believes that there will be no negative effects provided that during the land negotiation process, his requests are met by the developer.

In terms of the land negotiation, the owner had no opinion.

Left Bank

Reservoirs and Dam Area

Owner: **JOÃO VICENTE DE VASCONCELOS**

PROPERTY 01 ME: Piedade Farm

The Piedade Farm is on the left bank of the Piedade river covering an area of around 580 ha. The main house is on the left bank of the Piedade river and will only be affected by the reservoir.
Of this total, approximately 120 acres have been leased to Mr. Domingos. The lessee plants soybeans and does not reside on the property.

Photo 4.3 Main house on the Piedade Farm

Photo 4.4: Pasture and corral on the Piedade Farm

One of the sons of the owner of the Piedade farm, Mr. Erson de Vasconcelos, lives of the main house on the property with his wife. He is responsible for farm activity on the site. Economic activity on the property, along with his pension, are his main source of income.

The main activity on the property is milk and beef cattle farming.

Taking into account the entire area covered by the property, including the leased area, land usage is divided as follows:

Pasture: 242.0 ha

Temporary crops: 125.0 ha
Forest and brush wood: 213.0 ha.

At the time of the on-site survey, the cattle herds totaled 200 head. The cattle is sold within the municipal region. The interviewee, Mr. Erson, reported a little milk production, around 50 L per day, which is also sold to traders in Monte Alegre de Minas. He also said that some chickens (30) are raised for his own consumption and three horses are on site which are used for everyday activities.

In addition to the soybean plantation on the leased area, a small area is planted with sugarcane. This area, covering around half a hectare, is used to produce inputs to complement cattle feed.

According to the owner, soil conservation techniques are used all over the property using terraces and pasture rest areas.

The Piedade river is used on the rural property for animal drinking water and leisure (fishing).

In terms of infrastructure, the property has: One main house, one outhouse, one pigsty, one chicken house, one corral, one store house and one water tank.

The main house on the property is occupied by Mr. Erson and his wife. This is a brick construction with 07 rooms, internal and external finishing and a cement floor. Water is supplied from an artesian well on the property, electricity from the local utility.

Asked about a possible construction of a hydroelectric power station, the owner said he had heard about it in the region but that nobody from Construtora Gomes Lourenço had approached him.

According to the owner, the hydroelectric power station will have a negative effect. He said that the reservoirs will flood the properties low lying land, which is the most productive area.

In terms of the land negotiation, the owner had no opinion. Additionally, property belonged to his father, Mr. João V. de Vasconcelos, who will be directly involved in the negotiation process.

Owner: JUVENIL MARTINS GUIMARÃES
PROPERTY 02 ME: Piedade Farm

The Piedade Farm is on the left bank of the Piedade river covering an area of around 29.0 ha. The property will be affected only by the reservoir.

The person interviewed, Mr. Juvenil Martins Guimarães, is the owner of this property and one other in partnership with his brother in law, on the other bank. Economic activity on the properties is his main source of income.

Piedade farm was created from a plot of land acquired with his father, Mr. Juvenil Guimarães Diniz. Nobody lives on site and there are no improvements and no sanitation infrastructure (water, sewage) or electricity.

The owner resides on the property with his father, wife and son.

The main activity on the property is beef cattle farming. Mr. Juvenil is the person in charge of working with the animals. Sometimes, in the months of May and June, temporary workers are required to clear the pasture.

The entire property is covered with pasture:

Pasture: 29.0 ha

At the time of the on-site survey, the cattle herds totaled 30 head. The cattle are sold within the municipal region.

The Piedade river is used on the rural property for animal drinking water and leisure (fishing). Note that the cattle also use a small spring on the property as a source of drinking water.

Asked about a possible construction of a hydroelectric power station, the owner said he had heard about it in the region but that nobody from Construtora Gomes Lourenço had approached him.

According to the owner, the hydroelectric power station will have a negative effect. He said that the reservoir will "take over" the best land on his property.

If there is any negotiation regarding the land, he said that he intends to sell only the part affected by the project.

Owner: JUVENIL GUIMARÃES DINIZ

PROPERTY 03 ME: Piedade Farm

The Piedade Farm is on the right bank of the Piedade river covering an area of around 411.0 ha. The property will be affected by the reservoir.

Photo 4.5 Main house on the Piedade farm

Photo 4.6 Machine storage area

The owner, Mr. Juvenil Guimarães Diniz, resides on the property with his wife. His son, Mr. Juvenil Martins Guimarães, also resides on the property with his family. According to the owner, the farm is his main source of income.

The main activity on the property is milk and beef cattle farming and crop farming. These activities are carried out by the owner and his son. In the months of May and June, temporary workers are hired (around 4 every year) to help clear the pasture.

The land on the property is subdivided as follows:

- Pasture: 362.0 ha
- Temporary crops: 20.0 ha
- Forest and brush wood: 29.0 ha.

At the time of the on-site survey, the cattle herds totaled 700 head. Part of the cattle is for slaughter and the other for milk production. The cattle are sold within a municipal region and the daily milk production of around 300 L is sold to Nestlé in Uberlândia. The farm has a mechanical milking system and the cattle are vaccinated against disease and worms.

Two types of crops are present on the property: sorghum, covering 15 ha and pineapples covering 5 ha. The sorghum which is produced is used to feed the cattle and the pineapples are sold to local traders in the city of Monte Alegre de Minas. During planting, the land is ploughed with a mechanical tractor and the crops receive chemical fertilizers. According to the owner, soil conservation techniques are used all over the property using terraces and pasture rest areas.

The Piedade river is used on the property for animal drinking water, crop irrigation and leisure purposes (fishing). Irrigation is carried out using an aspersion system, with a suction pump and 4 inch pipe. The equipment is activated every two weeks between May and October.

In terms of infrastructure, the property has: Two main houses, one pigsty, one corral, one milking house.

The main house is occupied by the owner. This is a brick construction with 10 rooms, internal and external finishing and a ceramic and wood floor. Water comes from a spring on the property, the sewage system uses a septic tank and energy is provided from the local utility.

Asked about a possible construction of a hydroelectric power station, the owner said he had heard about it in the region.

According to the owner, the hydroelectric power station will have positive and negative effects. It will be positive because of the electricity generated a negative because it will flood part of his farming area.

In terms of land negotiation, the owner said he had started discussions with Construtora Gomes Lourenço.

Owner: ANTÔNIO KEHDES SOBRINHO
PROPERTY 04 ME: VALINHO Farm

As highlighted in the IC document for the EIA/RIMA, the Valinho Farm is located on the right bank of the Piedade river and will be affected both by the reservoir and the dam. The owner runs a wholesale company in Uberlândia, where he resides.

During the field survey we were able to review/update the information. Furthermore, attempts to contact the owner by telephone were unsuccessful.

Downstream Area – Low Flow Section

The other TVR properties on the right bank will not survey. This is because modifications to the Piedade SHS project will not interfere with these properties.

4.2.3 Downstream Area – Low Flow Section/Adduction Channel

Owner: FRANCISCO CARLOS VIEIRA PROPERTY 05MD:
BOA VISTA DO PÂNTANO Farm

The owner, resides in the city of Monte Alegre de Minas with his family where he has a store which, alongside the farm, are his two sources of income.

Mr. Francisco travelled to the property every weekend and with his brother, who resides in a neighboring property, is responsible for all of the farm work; there are no full-time employees and between October and April they usually hire temporary workers for general services such as clearing the pasture and fixing fences.

In terms of the land negotiation conducted prior to the changes in the project, the interviewee said he received for payment for the sale and used the money to invest in his store and on the property.

He said he was not satisfied, but that he also did not lose out from the negotiation, because he did not intend to sell the entire property, despite recognizing the benefits arising from construction of the Piedade SHS.

Regarding changes to the project, the owner said that based on the location of the new channel, Construtora Gomes Lourenço will have to build bridges for cattle and machinery. Additionally, fences will need to be built so that the cattle does not cross the Piedade river.

Mr. Francisco also mentioned his concern regarding new negotiations for the land which will be used by the water channel, because the land purchased previously represented a larger area and now this area will be much smaller.

Owner: ROOSEVELT GUIMARÃES DINIZ JR.
PROPERTY 06MD: BOA VISTA DO PÂNTANO Farm

Mr. Roosevelt Jr lives with his family in the city of Monte Alegre de Minas and travels every day to work on the property, which is his main source of income.

On being interviewed, he said that he has no full-time workers and hides a maximum of three temporary employees for two or three months every year for clearing pasture and fixing fences.

When asked whether he had received payment following the land negotiation, he said he had, using the money on the farm.

He said he was not satisfied with the previous negotiations, but that he also did not lose out from the negotiation, because he did not intend to sell the entire property.

In terms of the project amendments, Mr. Roosevelt Jr. said that the changes were good because the new channel route would affect nonproductive land, but would lose one water source and a small lake. He also said that the solution for the loss of the water would be another water option and he would need a passageway for cattle and machinery over the channel to his more productive farmland, and the need to fence off the Piedade river to stop cattle from crossing.

Mr. Roosevelt Jr also asked us to look into the issue of his father's property, which belonged to Mr. Roosevelt Guimarães, encompassing the Piedade and Boa Vista do Pantano Farms. Gomes Lourenço considered this to be a single farm and in the deeds did not find that the channel would also pass through the Piedade farm.

Today, the owner, Mr. Roosevelt Guimarães, is deceased and his land was split between his children.

The Boa Vista do Pântano farm was divided between the children Robson Pereira Diniz (85 ha) and Roosevelt Jr. (12 ha), the remainder was sold to third parties, but will not be affected by the Piedade SHS. Mr. Roosevelt Jr. received the remainder of the estate (23 ha).

Owner: ROBSON PEREIRA DINIZ
PROPERTY 07MD: BOA VISTA DO PÂNTANO Farm

The owner resides with his family on the farm, his main source of income, carrying out all the work on the property with one full-time member of staff. He normally hires around three temporary workers to clear the pasture and fix fences.

He said that he has received for payment for the sale of the land and the cash was invested in property. He believes the negotiation was reasonable, because he wanted a partnership with Construtora Gomes Lourenço.

In terms of changes to the project, he believes that this will not affect him to a great extent if Construtora Gomes Lourenço does not want the land below the channel. However, if Construtora Gomes Lourenço also needs the land below the channel, he said that no further work would be possible on his property.

He said that he would need a passageway over the Channel and drinking areas for cattle and was concerned about the possibility of the cattle crossing the Piedade river requesting that the building company construct a fence along the river while providing an access way so that the cattle could drink.

Owner: LERI PARREIRA DINIZ
PROPERTY 08MD: PÂNTANO DA AGUADINHA Farm

The owner resides with his wife at the main house on the farm, which alongside his pension is his main source of income.

Work on the farm is carried out by the owner and family members, as they have no permanent employees, but usually higher temporary workers once a year for pasture clearing and fence fixing.

The owner said he had received full payment for sale of the land and believes the negotiation was reasonable, alleging that Construtora Gomes Lourenço did not pay market values. And the cash was invested on the property.

In terms of the project amendments, Mr. Leri said that he was concerned about machine and cattle access to the land which will be below the water channel, adding that there should be individual passages, one for each property. This means he would have his own bridge for cattle and machinery.

Owner: DALGIZA TEODORA DOS REIS (DIL VILELA)
PROPERTY 09MD: PÂNTANO Farm

The owner, Mrs. Dalgiza Teodora dos Reis, lives in a state of São Paulo, and the property is managed by Mr. Dil Vilela dos Reis, who resigned with his family on the property.

According to Mr. Dil, the property represents his main source of income. He said that he has no full-time employees and does not hire temporary workers.

In terms of the sale of the land, Mr. Dil said he had received his payment and the negotiation was reasonable, but preferred not to say how the money was spent.

Regarding the changes to the project, he said that the new route for the water channel will destroy his cashew trees and a spring and he will need a crossing over the water channel for cattle alongside wells, as the area below the channel has increased considerably.

Owner: .DIÓGENES COELHO NOGUEIRA
PROPERTY 10MD: MASSAMBARÁ Farm

The owner resides with his family on another rural property outside the project area. These two properties are his main source of income.

Mr. Diogenes has no full-time staff, but hires one temporary worker for pasture clearing, harvesting, fixing fences, etc.

In terms of the negotiation, he said he received the entire payment for the sale of land and alleged that Construtora Gomes Lourenço "paid a cheap price for land". The cash was invested on the property.

Regarding changes to the project, the owner sent that the new water channel route will go through his best land, part of his banana plantation and a spring. He will also need the crossing for cattle and machinery over the Channel and that in the previous agreement, Construtora Gomes Lourenço was supposed to arrange for a well which is now very important, because he will have no water for his cattle. He was also concerned about cattle crossing the Piedade river, requesting further measures be taken by the construction company to avoid this happening.

He also said that he authorised Construtora Gomes Lourenço to open up an access road to the power station on his land, but so far the construction company has taken no steps to legalize the situation.

Owner: **VALDA PEREIRA DE FARIA**
PROPERTY 11MD: BOA VISTA DO PÂNTANO Farm

The owner, Mrs. Valda Pereira, lives in the city of Monte Alegre de Minas and the property is managed by her son, Vanderlan Ferreira de Faria, who owns a property in the ADA, where he lives.

Income from the property and a pension are the owner's main source of income.

Mr. Vanderlan said the property does not have any full-time staff and he usually hires one temporary worker to clear the pasture

He said that he had received the payment for the land he had sold and that the money was invested in property.

In terms of changes to the project, he said that the property needs a crossing over the water channel for cattle and that he had previously agreed a well with Construtora Gomes Lourenço.

Owner: **LEONARDO FERREIRA DE FARIA PROPERTY 12MD:**
MASSAMBARÁ DO PÂNTANO Farm

The owner resides with his family on another rural property outside the project area. These two properties and his pension are his main source of income.

Work on the farm is carried out by the owner and family members, as they have no permanent employees, but usually higher temporary workers between January and April for pasture clearing.

The owner said he had received full payment for sale of the land and believes the negotiation was reasonable, alleging that Construtora Gomes Lourenço did not pay market values. The cash was invested on the property.

In terms of changes to the project, the owner said that the new water channel route would affect his farmland and two springs would be damaged, expressing his concern with the cattle's access to water and subsequent reduction of the water from his springs. He pointed out that offence would be required to avoid the cattle crossing the river.

Mr. Leonardo said he was aware of new negotiations for the new land affected.

5 BIOTIC ENVIRONMENT

5.1 Description of the survey area

The forecast location for construction of the SHS-Piedade is located in the municipal region of Monte Alegre de Minas, in the state of Minas Gerais, near the cities of Centralina and Canápolis. It is located in the southern basin of the Piedade river - basin of the Paranaiba river, a region in the Minas triangle and Alto Paranaiba - in the extreme west of Minas Gerais. (SEPLAN , 1987). Phytogeographically it is in the Cerrado biome (BASTOS FILHO, 1974).

The new reservoir is located in the Cerrado Biome, considered one of the 25 top priority areas worldwide for conservation because of its biological wealth and high anthropic pressure which it is under (Mittermeier *et al.*, 2000). Covering an area of 204,000,000 ha, equivalent to 23% of Brazilian land mass, the Cerrado is considered the savannah with the greatest vegetable by diversity in the world, with the presence of various phytofisionomies, reflecting the substantial diversity of its flora (> 10,000 species of plants, 4400 of which are endemic). The fauna includes 837 species of bird; 67 genuses of mammals, covering 161 species in 19 of which are endemic; 150 species of amphibian, of which 45 are endemic; 120 species of reptiles, of which 45 are endemic (Myers et al., 2000).

The Cerrado landscape is a mosaic of open environments (cleared fields, savannah fields and other variations and cerrado in the strict sense) as well as closed environments (thick forest) occupying plateaus and uplands. They are dry environments with seasonal influences and in the dry season there is desiccation and leaf loss.

According to VELOSO (in IBGE, 1992), the forest formations are very different, representing seasonal forests (deciduous and semi-deciduous), riparian forest and flooded forest. The seasonal, deciduous forests cover sides and tops of hills with litolic soil, with substantial leaf loss in the dry season. Seasonal, semi-deciduous forests present less leaf loss and appear on plains on more fertile soil. The riparian forest cover is fertile soil along the banks of water courses and drainage ditches, forming "corridors" of perennial vegetation. The flooded forests, which are also perennial, can be found at river sources in flatter and more swampy areas.

In recent decades, this biome has been altered by the expansion of agricultural frontiers and illegal extraction of vegetation. In this region, there is a predominance of pasture, pineapple plantations (Ananas sp.) and a narrow strip of riparian forest.

5.2 FLORA

5.2.1 INTRODUCTION

The Piedade SHS reservoir extends 4.42 km from the dam up to the lake, covering anthropized and degraded land. Crop plantations, landslides areas and buildings are common throughout the reservoir area. Drawing PIE-VEG-002 is attached to this document describing the vegetation in the project area.

Table 5.1

Phytofisionomy distribution in the surrounding area and directly affected area (ADAE)

	Surrounding Area (AE) (ha)	Directly Affected Area (ADA) (ha)
Pasture	3008	113
Crops	377	-
Cerrado	105	-
Riparian forest	23	10
Total	3515	123

5.2.2 Methodology

Considering the size of the development, to levels of vegetation coverage were defined as the basis for evaluating the environmental impacts in this area.

Description of vegetation coverage began by determining the phytogeographic domain in which the Area of Influence AI is located. In order to define the phytogeographic domain the basic tool used was mapping and descriptions from the RADAMBRASIL Project (BRASIL, 1983), contained in Folio SE. 22 (Goiânia).

The description of the location was based on observation and data collected in the project location reconnaissance campaign on 25/07/01.

5.2.3 Regional Classification

Macro scale mapping of the RADAMBRASIL Project (BRASIL, 1983) places the project in the Savannah Region (Cerrado *Latu senso*), a biome covering approximately 23% of the Brazilian landmass and presents a diversified and specific flora. There are approximately 6500 vascular plant species (Mendonça *et al.* 1998), the majority endemic to this biome (Myers *et al*., 2000).

This domain presents a mosaic of different types of vegetation, classified as forest formations (riparian forest, riverside forest, deciduous seasonal forests, semi-deciduous seasonal forest and Cerradão), savannahs (Cerrado "sensu stricto", Parque de Cerrado, Palmeiral and Vereda), and rural (Campo Sujo, Campo Rupestre and Campo Limpo), according to the classification proposed by Ribeiro & Walter (1998).

There are few forest formations in the Cerrado and they appear in patches associated with more fertile soils (deciduous seasonal forest, semi-deciduous seasonal forest and Cerradão) and also a long water courses (riparian forest and overhanging forest) (Cruzeiro & Schiavini 2001). Forest formations are very important in the environment and anthropic relations for example in protecting the soil against erosion, regulating the flow of drainage water, maintaining the nutrient cycle, as a source of food and refuge for animals, forming ecological corridors, as a supply of wood, etc. (Cardoso *et al.* 2003). Additionally, they contribute approximately 40% of the flora diversity in the Cerrado (Mendonça *et al.* 1998), a substantial contribution given that they occupy small areas in relation to rural and savannah areas.

The Savannah is defined as xeromorphic vegetation, preferably in a seasonal climate (more or less 6 dry months), covering lixiviated, aluminized soils, occurring throughout the entire Neotropical Zone.

According to the current Brazilian vegetation coverage map, available at the IBGE website (www.ibge.gov.br), the entire Minas Triangle is classified as "Anthropized areas". The background of economic development in the region is marked by the intensive use of land, mainly for crops and cattle (Radambrasil, 1983). As a result, there is little remaining native vegetation and the countryside is basically dominated by vast areas of pasture and crops. The native vegetation still present in the Piedade SHS AI is very fragmented and comprises mainly fragments of Cerrado “sensu stricto”, Cerradão, Semi-Deciduous Seasonal Forest and interrupted and narrow bands of Riverside and Riparian Forest long water courses.

According to the descriptions in Folio SE 22 (Goiânia), guidance from the IBGE (1991) and Scolforo and Tavares (2005), there are four subgroups of formation:

Forested savannah (cerradão)

A formation with a typical and characteristic forestry physiognomy, restricted to lixiviated sandstone areas with deep soil, occurring in eminently seasonal tropical climates. The height of individual trees varies between 7 and 15 m and the trunks are not as twisted and do not have as many branches as cerrado-field trees. Although the crowns of the trees touch, light penetrates inside these forests allowing development of smaller shrubbery, forming a lower strata which is sometimes very dense.

We can differentiate seasonal forests by the abundant present of typical cerrado tree species such as: *Terminalia argentea* (capitão), *Hymenaea courbaril* (jatobá), *Salvertis convallariodora* (pau-decolher), *Bowdichia virgilioides* (sucupira-preta), *Pterodon pubescens* (sucupira-branca), *Dimorphandra mollis* (faveiro), *Qualea grandiflora* (pau-terra-de-folhas-grandes), *Qualea parviflora* (pau-terra-de-folhas-miúdas), *Anadenanthera peregrina* (angico-preto) and *Kielmeyera coriaceae* (pau-santo), *Caryocar Brasiliense* (pequi), *Xylopia aromática* (pimenta-de-macaco), etc.

Figure 5.1 General view of a fragment of the cerradão in the AI, this is one of many fragments that will not be cut down.

- Forested savannah (cerrado-countryside)

The Cerrado countryside, either in the Midwest, where we find its core region, or in any other area where it occurs always presents the same characteristics, in other words low, widely spaced and twisted trees with very irregular crowns, thick bark covering, leathery and generally hairy leaves. A lot of light hits the ground which is sometimes there will covered by tufts of grass and scrubby plants, which throughout the drought present dry branches, leading to fires which may arise from natural or other causes.

The botanical composition, despite similarity with the Forested Savannah (Cerradão), has dominant ecotypes which characterize environments according to the geographic area, in Minas Gerais citing the *Dimorphandra mollis* (faveiro).

This landscape is sometimes interrupted by riverside forests which accompany drainage ditches.

- Park Savannah

This vegetation is characterized by vegetation which is essentially open, formed by a carpet of grass with some trees at an average height of 2 to 3 m almost always of a single type.

The anthropic Park Savannah is found throughout the country and natural only to the Ilha do Marajó, Pantanal Sul-Mato-Grossense and Depressão do Araguaia.

- Grassy-Woody Savannah

In this physiognomy, when naturally occurring, there is a prevalence of grasses interlaced with woody, scrubby plants which occupy extensive areas dominated by hemicryptophites and which, little by little, when controlled by a fire or grazing, substituted by geophyes which can be distinguished by their underground stalks which are therefore more resistant to cattle trampling and fire.

The flora is very diversified, with woody plants most representative of the ecotype: *Andira humilis* (Angelim-do-cerrado), *Cassia* spp (fedegoso-do-cerrado), *Byrsonima* spp (murici-rasteiro), *Bauhinia* spp (unha-de-vaca), *Attalea* spp (palmeirinha-do-cerrado); and the grasses: *Axonopus* spp (grama-do-cerrado), *Andropogon* spp (capim-do-cerrado), *Aristidia pallens* (capim-barba-de-bode), *Echinolaena inflexa*; *Paspalum* spp.

Savannah formations in the region through which the Piedade river passes our accompanied by riverside forests along drainage ditches, beside springs and on wetland. The most common species are Envira (*Xylopia* sp), ucuuba (*Virola* sp), pau-pombo (*Tapirira* sp), jacareúba (*Calophyllum* sp) and the palmeira buriti (*Mauritia* sp).

According to information from Ibama, the Brazilian Cerrado is known as the richest Savannah in the world in terms of biodiversity, as the very rich flora contains more than 10,000 plant species, 4400 of which are endemic.

RIBEIRO (2001) cites a recent flora survey by EMBRAPA-Cerrados in partnership with other research and teaching institutions covering only typical Cerrado vegetation (excluding riverside forest and mesophile forest) involving the Federal District, Minas Gerais, São Paulo, Tocantins, Bahia, Piauí and Maranhão. This survey identified 542 woody species, none of which were present throughout the entire area studied and 140 of which live only in two of the areas studied. The most commentary was the *Qualea grandiflora* known as the pau-terra-defolha-larga, found in 82% of the areas visited.

In the Minas Triangle, most of the natural vegetation has been eliminated by crop farming or replaced by pastures and already presents a substantial degree of degradation. All of this anthropic transformation has changed the physiognomy of the regional Cerrado.

5.2.4 Local Description

Description the vegetation in the reservoirs and water channel.
The vegetation found in the reservoirs can be classified in three distinct phytofisionomies.

Cerrado *stricto sensu*, which is mostly found at a distance of 20 to 100 m from the riverbank, riparian forest, which extends along the river and has small gaps which vary between five and 10 m wide depending on the slope of the land and semi-deciduous seasonal forests, quite different from the others, which is substantially anthropized and appears much less frequently.

The types within the AI are described below, except for the cerradão which was described in the previous section of the document.

Alluvial forests

Forest formations associated with watercourses are divided into two types: Riverside Forests and Riparian Forests. Riverside Forests follows small streams and the vegetation canopy front opposite banks meets, forming a gallery. Riparian Forests occurs along the banks of medium and large rivers and the vegetation is different from Riverside Forests because it is deciduous and the composition of the flora difference. In the Riparian Forests there are different levels of leaf shedding and the Riverside Forest is perennial (Ribeiro e Walter 1998).

- Riparian forest

In the SHS Piedade AI, this biotype is found along the margins of the River Uberabinha, but it has many gaps. Largest sections of the riverbank are not covered by Riparian Forest which has been substituted by pastures.

The fragments visited present a similar structure to that described as Semi-Deciduous Seasonal Forest and is very similar in flora composition. This results in a dominance of trees like *Myracrodruon urundeuva* (aroeira), *Pterodon pubescens* (sucupira-branca), *Trichilia clausseni* (Catiguá) and *Cedrela fissilis* (cedro). Some epiphytes were found in this section formation, such as *Pleopeltis angusta* e *Pteris denticulata* and peperômia (*Peperomia* sp).

Alongside the Uberabinha River, where there is no riparian forest, we found various types of ruderal species which are dominant at these locations. Most common were the lírio-do-brejo (*Hedychium coronarium*) and capim-colonião (*Urochloa maxima*).

Figure 5.2 General view of the fragments of riparian forest in the Piedade SHS ADA.

- Riverside forests

A few fragments of this type of forest were visited and most of the streams in the area do not present to their original vegetation. Riverside forests are characterized as perennial forming enclosed corridors over watercourses. The trees do not reach more than 20 m, and the main species found include *Cecropia pachystachya* (embaúba), *Copaifera langsdorffii* (paud'óleo), *Guarea macrophylla*, *Hedyosmum brasiliense, Miconia* spp., *Sweetia fruticosa* (sucupira-amarela).

Herbaceous plants include *Olyra* spp. (Bambuzinho), *Thelypteris* spp. and *Adiantum* spp. (samambaia). Some pteridophyts (*Pleopeltis angusta* e *Microgramma* sp.) and bromelias (*Aechmea bromeliifolia, Tillandsia stricta*) are found among the epiphytes.

5.2.5 Grazing biotypes

- Pasture

Pasture occupies large areas of the Piedade SHS AI and is a very homogeneous vegetation. These pastures are basically made of a single species of exotic grass (*Urochloa decumbens*), a widely used species in the region. We can occasionally find isolated trees, typical of forests and Cerrado, such as angico (*Anadenanthera colubrina*), a mamica-de-porca (*Zanthoxyllum riedellianum*), o pau d'óleo (*Copaifera langsdorffii*), a peroba (*Aspidosperma cylindrocarpon*) o pau-santo (*Kilmeyera coriacea*) and bacuri (*Attalea phalerata*), which is commonly found alongside mata-paus (*Ficus* spp) and some herbs and invasive shrubs like *Solanum palinacanthum, Waltheria indica, Crotalaria brachystachya* and *Gochnatia polymorpha.*

Figure 5.3 An example of GAMELEIRA (*FICUS ADHATODIFOLIA)* in the middle of a pasture area.

Figure 5.4 Overview of a pasture area containing well spaced trees.

- Crops

Alongside pasture, crops dominate the countryside in the Piedade SHS AI. These are basically annual crops. These are biotypes involving intensive handling and usage, generally without natural vegetation, principally when preparing the soil. From time to time, we found isolated trees in the middle of cultivated areas. The main annual crops in the area soybeans, corn and beans. Permanent or semi permanent crops occupy a small area and are mainly small plantations of coffee, bananas, oranges, etc.

- Regeneration areas (brushwood)

"Regeneration Areas" were considered areas where the original vegetation was removed and is not occupied by pasture or crops and now has brushwood type characteristics. There is little vegetation diversity, and absence of clear strata and a predominance of herbaceous and shrub plants less than 3 m tall. The dominant vegetation is precursors which are easy to disperse and require little in terms of substrate and shade. The main are alecrim (*Baccharis dracunculifolia*) and unha-de-gato (*Acacia* sp.), which may be associated with younger trees from forest species such as sangra-d'água (*Croton urucurana*) and aroeira (*Myracrodruon urundeuva*), and Cerrado species like lobeira (*Solanum lycocarpum*) and pimenta-demacaco (*Xylopia aromatica*).

FIGURE 5.5: Regeneration area with a concentrated population of aroeira (ASTRONIUM FRAXINIFOLIUM)

5.2.6 Reservoir

The dam itself will be built practically in an area of unkempt pastures, with small areas of trees predominantly inhabited by speeches such as Assa-Peixe (*Vermonia Ferrugínea*), Aroeira-vermelha (*Schinus terebinthifolius)*, with the former extending throughout the reservoirs and the latter found mostly in the central region and at the end of the right-hand side of the Piedade river.

Figure 5.6. Aerial view of the left-hand side of where the center of the dam will be.

In this region, there is also riparian vegetation extending 4.42 km, with gaps, up to the reservoirs leak. This vegetation various from five to 10 m wide depending on the slope of the land along the riverbank.

There are also large, native trees, generally isolated in degraded pastures with large spaces between them. Some of the tree species observed include: jacarandás (*Machaerium* spp), pauterra-folha-miúda (*Qualea parviflora*), pau-terra-folha-larga (*Qualea grandiflora*), ipê-caraíba (*Tabebuia caraíba*), jatobá (*Himenaea stigonocarpa*), vinhático (*Plathymenia reticulata*), lixeira (*Curatella americana*), *Annona* spp, patas-de-vaca (*Bauhinia* spp), macaúba (*Acrocomia* sp), aroeira (*Astronium* sp), Gameleira (*Ficus adhatodifolia)*, etc.

At coordinate X:7932529 and Y: 710469, we can see slightly more exuberant forest because of the greater volume of water in the soil from a stream flowing into the Piedade river. In this region, we observed certain species like: ingá (*Inga* spp), palmeira-buriti (*Mauritia flexuosa*), pau-pombo (*Tapirira* sp), copaíba (*Copafera* sp), ucuuba (*Virola* sp), *Xylopia* sp, etc.

Figure 5.7 Riparian forest located along the Boa Vista strain, which flows into the Piedade river

Figure 5.8 View of the interior of the Boa Vista stream

Other affluents can be seen along the Piedade river: Cachoeirinha and another with no name on the right bank and Valinhos and another two on the left. All of these affluents have very well conserved riparian forest. Species like *Campomanesia guaviroba* (Guabiroba), *Croton urucurana* (Sangra-d'água), *Copaifera langsdorffii ,(M*aria-pobre), *Inga sessilis* (Ingá), *Myracrodruon urundeuva* (Aroeira), *Trema micrantha* (Grandiúva), and others are found in these locations.

The vegetation in the middle third of the reservoirs is mostly sparse Cerrado, with trees almost always of the same species, varying between two and 3 m in height and with a diameter of no more than 8 cm when measured at chest height (130 cm), pasture and crops.

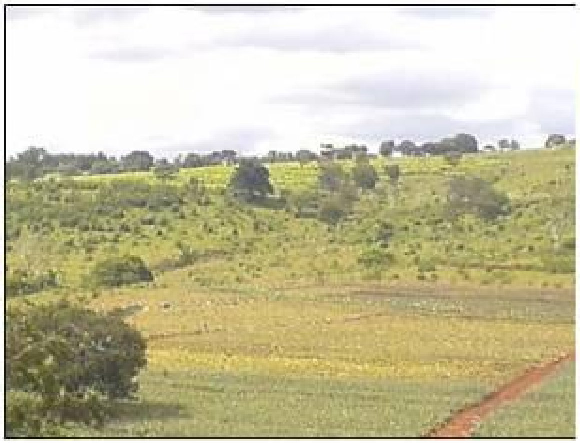


Photo 5.9 Pineapple plantation, very common in the region

Photo 5.10 Scrubby cerrado in the intermediate level of the reservoir, vegetation varying between 2 and 3 meters tall

Figure 5.11 Pasture in the intermediate third of the reservoir, a landscape which repeats throughout the reservoirs.

Figure 5.12 View of pasture along the left hand side of the reservoirs

In the reservoirs lake, at point X: 7931672, Y: 713456, there is a waterfall known as Erson's waterfall which will be totally submerged by the reservoir. There is significant riparian vegetation because of the quantity of water on site in an environment which is very favorable for species like: *Inga sessilis* (Ingá), *Croton urucurana* (Sangra-d'água), *Myracrodruon urundeuva* (Aroeira), *Trema micrantha* (Grandiúva).

5.2.7 Water channel

At this site the landscape is completely anthropízed with tree species spread throughout abundant pasture. Once again, species like assa-peixe (*Vermonia Ferrugínea*), Aroeira-vermelha (*Schinus terebinthifolius),* most common throughout this area.

The SHS water channel will run mainly through pasture areas with some isolated trees, as well as a little secondary vegetation.

The power station and tailrace will mainly intercept Riverside forest whose physiognomy is at a stage of natural regeneration.

Tree species found in Riverside Forests include: ingá (*Inga* spp), palmeira-buriti (*Mauritia flexuosa*), pau-pombo (*Tapirira* sp), copaíba (*Copaifera* sp), ucuuba (*Virola* sp), *Xylopia* sp, etc.

5.2. 8. Final Considerations

The area belonging to be Piedade SHS reservoirs contains mainly riparian forests in a secondary stage of development and covers around 60% of the area surrounding the river, varying between five and 10 m wide, while we can also find fragments of cerradão, which will not be affected by the flooding. Some semi-deciduous forests can be found in areas close to the SHS, however these are not within the AI.

Table 5.2

List of some species encountered in the Piedade SHS area.

SCIENTIFIC NAME	COMMON NAME	BOTANICAL FAMILY
Annona Cacans	Araticum	Anacardiaceae
Astronium fraxynifolium	Gonçalo alves	Anacardiaceae
Bau in some semi-deciduous forests can be found in areas close to the hina sp.	Unha de vaca	Leguminosae
Bowdichia virgilioides	Sucupira Preta	Leguminosae
Byrsonima coccolobifolia	Murici-do-cerrado	Malpighiaceae
Campomanesia guaviroba	Guabiroba	Myrtaceae
Casearia sylvestris	Guaçatunga	Flacourtiacea
Cocos nucifera	Coqueiro	Palmáceae
Cecropia pachystachya	Embaúba	Cecropiaceae
Copaifera langsdorffii	Copaiba	Leguminosea
Coutarea hexandra	Quina	Rubiaceae
Croton urucurana	Sangra d'água	Euphorbiacea
Curatella americana	Sambaíba, Lixeira	Dileniaceae
Didimopanax morototoni	Folheiro branco	Araliacea
Eriotheca gracilipes	Imbiruçu do litoral	Bombacaceae
Erythroxylon sp.	Mercúrio	Erytrhoxylaceae
Eugenia brasiliensis	Grumixama	Myrtaceae
Eugenia leitonii	Araçá piranga	Myrtaceae
Eugenia multicostata	Araçá açu	Myrtaceae
Eugenia pyriformis	Uvaia	Myrtaceae
Eugenia speciosa	Laranjinha do mato	Myrtaceae
Eugenia tomentosa	Cabeludinha	Myrtaceae
Eugenia uniflora	Pitanga	Myrtaceae
Ficus gameleira	Gameleira	Moraceae
Ficus insipida	Figueira do brejo	Moraceae
Hymenaea stigonocarpa	Jatobá	Leguminosae-Caesalpinoideae
Inga uruguensis	Ingazeiro	Leguminosaea – Mimosoideae
Inga vera	Ingá verde	Leguminosae
Lithraea malleoides	Aroeira Brava	Anacardiaceae
Lonchocarpus guilleminianus	Embira de sapo	Fabaceae
Lonchocarpus subglaucescen	Embira	Leguminosae
Magonia pubescens	Tingui	Sapindaceae
Luehea divaricata	Açoita cavalo	Tiliaceae
Omosia Arborea	Olho-de-Cabra	Leguminosae
Qualea Grandiflora	Pau-Terra	Vochysiaceae
Qualea Multiflora	Pau-Terrinha	Vochysiaceae
Platypodium elegans	Jacarandá-do-campo	Fabaceae

Continued…. . .

Continued... . .

SCIENTIFIC NAME	COMMON NAME	BOTANICAL FAMILY
Psidim cattleianum	Araçá amarelo	Myrtaceae
Pterodon emarginatus	Sucupíra Branca	Fabaceae
Rapanea umbellata	Pororoca	Myrtaceae
Schinus terebenthifollius	Aroeira mansa	Anacardiaceae
Tapira guianensis	Tapiriri	Anacardiaceae
Terminalia sp.	Terminalia marfim	Combretaceae
Trema micrantha	grandiúva	Ulmaceae
Vernonia sp.	Assa Peixe	Asteraceae
Virola sebifera	Ucuuba	Miristicaceae
Xylopia sericea	Pimenta de macaco	Annonaceae

5.3 Mammalian Fauna

5.3.1 INTRODUCTION

The biodiversity in areas altered by anthropic interference is constantly under threat. One of the most important factors contributing to the situation may be the economic value tribute to the land at areas covered with natural vegetation generate no financial return for the owners and it is more profitable to convert this land into pasture or plantations, discouraging their protection.

Vegetation is one of the most important characteristics of the habitat for aerial and terrestrial fauna. Changes to the vegetation cover direct effect on the entire food chain, altering the diversity of species because it changes to basic factors: food and shelter (FIRKOWSKI,1990).

More specifically, in terms of this project, fragmentation of regional vegetation (Cerrado, Semi-Deciduous Seasonal Forest, Riparian Forest), caused by past deforestation to make pasture and crop areas, as had serious consequences mainly for mammalian species, especially larger ones, a fact we can see from the total disappearance of some species in certain regions and locations. These factors in conjunction mean that some species of mammals in these biomes are currently on the official list of Brazilian fauna threatened with extinction.

5.3.2 METHODOLOGY

Studies on mammalian fauna in the region for the Piedade SHS project were carried out in July 2001, November 2003 and December 2004.

Surveys were based on indirect evidence (tracks, feces, carcasses and others) and direct evidence (visualization and/or vocalization).

Bibliographic surveys on regional fauna were used to complement data alongside interviews with local inhabitants, selecting the information obtained. This methodology was not quantitative. The interview method, when correctly applied, can be an important tool when building an inventory of species. This method is an essential source of information on mammals which are easily identified by external characteristics like edentates, carnivores, primates, ungulates, etc (VOSS & EMMONS, 1996). In this case, interviews were carried out with people living in the region initially noting the species voluntarily cited by those interviewed.

In the 2004, traps were used to capture live specimens in cages, placed along the transects of the Riparian Forest, in pasture and brushwood (photo 5.1 to photo 5.5). 10 capture stations were created with two traps each, totaling 20 traps, located in:

Pasture region (A1) - pasture area located on the left bank of the Piedade River on the farm belonging to Mr. Roosevelt Guimarães Diniz, whether penstock will be located. 10 capture stations were set up in this area with two traps each, totaling 20 traps.

Pasture region (A1) - area formed by a fragment of riparian Forest located on the left bank of the Piedade River on the farm belonging to Mr. Roosevelt Guimarães Diniz, close to the low flow section. 10 capture stations were set up in this area with two traps each, totaling 20 traps.

Cerrado brushwood (A3) – an area of brushwood located on the left bank of the Piedade River with the presence of cattle in the future region of the reservoirs on the farm belonging to Mr. Francisco Carlos Vieira. 10 capture stations were set up in this area with two traps each, totaling 20 traps.

Pasture region (A1) - area formed by a fragment of riparian Forest located on the left bank of the Piedade River on the farm belonging to Mr. Francisco Carlos Vieira, close to the future dam and reservoir. 10 capture stations were set up in this area with two traps each, totaling 20 traps.

Cerrado brushwood (A1) - brushwood area located on the left bank of the Piedade River on the farm belonging to Mr. Antônio Kheds Sobrinho, close to the lake of the future reservoir. 15 capture stations were set up in this area with two traps each, totaling 30 traps.


Photo 5.1 Pasture - Point A1 | Photo 5.2 Riparian forest - Point A2


Pohot 5.3 Cerrado brushwood - A3 | Photo 5.4 Riparian forest – A4

Photo 5.5 Cerrado brushwood – A5

5 3.3 Environmental Diagnosis

During the surveys carried out at the Piedade SHS to describe the mammalian forma, few small mammal species were found in the region. This low level of diversity may be caused by the fact that the landscape has been substantially altered following the creation of pasture and also crops, more specifically pineapples, commonly found along the Piedade River.

Table 5.3

List of small mammal species encountered in the Piedade SHS area.

Order	Family	Species
MARSUPIALIA	**Família Didelphidae**	***Didelphis albiventris***
RODENTIA	**Família Muridae**	***Oryzomys subflavus*** ***Oligoryzomys sp***

In the Cerrado region various species of medium-sized and large mammals were found such as the tatu peba

Photo 5.6. Captured animal	Photo 5.7: *OLIGORYZOMYS* SP – RATO DO MATO

Photo 5.8: *ORYZOMYS SUBFLAVUS* – RATO DE CANA

Photo 5.9: *DIDELPHIS ALBIVENTRIS* - GAMBÁ

(*Euphractus sexcinctus*), tatu galinha (*Dasypus novencinctus*), in semi-fossorial habitats, jaratataca (*Conepatus semistriatus*), furão (*Conepatus* sp.), cachorro do mato (*Cerdocyon thous*) and tapeti (*Sylvilagus brasiliensis)*. Two species of tamanduá bandeira (*Myrmecophaga tridactyla*) were observed. There were also reports of the tamanduá mirim (*Tamandua tetradactyla*), which is rarer in the region according to local population. There were various reports of the onça parda or sussuarana (*Puma concolor*), which, according to local inhabitants, is frequently seen..

The macaco prego (*Cebus apella*) was one of the most common mammals in the Semi-Deciduous Seasonal Forest areas.

The most frequently seen mammal in riparian forests was the sagui (*Calithrix penicillata*). Many mammals are dependent on this type of vegetation, using it for shelter, food, dispersion, etc. These include the capivara (*Hydrochaeris hydrochaeris*), in semi-aquatic habitats, the mão pelada (*Procyon cancrivorus*), which feeds off crustaceans, amphibians and other aquatic animals, the mutum (*Crax fasciolata*) and tree living species like the macaco-prego (*Cebus apella*) and sagui (*Callithrix penicillata*). The riparian Forest is fundamental for survival of the otter (*Lontra longicaudis*).

In fact, in terms of mammals, a mosaic of existing forest environments least to the existence of many species which live indiscriminately among them, such as the veado catingueiro (*Mazama guazoubira*), coati (*Nasua nasua*), paca (*Agouti paca*), cutia (*Dasyprocta* sp) and others. The cutia was reported as a rare species in the region.

Table 5.4

List of medium-sized and large mammal species encountered in the Piedade SHS area.

Ordem	Família	Espécie	Nome Comum	Local de Ocorrência	Habitat	status	Tipo de Registro
MARSUPIALIA	Didelphidae	*Didelphis albiventris*	Gambá	AI, AE, ADA, FL, I			
XENARTHRA	Mirmecophagidae	*Myrmecophaga tridactyla*	Tamanduá bandeira	AI, AE	C	AM	D
		Tamandua tetradactyla	Tamanduá mirim, Melete	AI		AM	I
	Dasypodidae	*Euphractus sexcinctus*	Tatu peba	AI, AE			D
		Dasypus novemcinctus	Tatu galinha	AI			D
PRIMATES	Callitrichidae	*Callithrix jacchus penicillata*	Sauim, Mico estrela	AI, AE, ADA	FL,	X	D
	Cebidae	*Cebus apella*	Macaco prego	AE, AD	FL,	X	D
CARNIVORA	Canidae	*Chrysocyon brachyurus*	Lobo guará	AI, AE	C	AM	I
		Cerdocyon thous	Cachorro do mato	AI, AE	C		I
		Lycalopex vetulus	Raposa	AI, AE	C	AM	I
	Procyonidae	*Procyon cancrivorus*	Mão pelada, Guaxinim	AE, ADA	FL/DU		V
		Nasua nasua	Coati	AE, ADA	FL	CI	D
	Mustelidae	*Galictis vittata*	Furão	AI	C		I
		Conepatus semistriatus	Jaritataca	AI	C		I
		Lontra longicaudis	Lontra	ADA	DU	AM	
	Felidae	*Felis pardalis*	Jaguatirica	AI	FL	AM	I
		Felis yagouaroundi	Gato mourisco	AI	FL/CA	PA	I
		Felis concolor	Onça vermelha, Sussuarana	AI, AE, ADA	FL/C	AM	I
ARTIODACTYLA	Cervidae	*Mazama guazoubira*	Veado virá, Veado catingueiro	AI, AE, ADA	C	CI	V
RODENTIA	Erithizontidae	*Coendou prehensilis*	Porco espinho	AI	FL		I
	Agoutidae	*Agouti paca*	Paca	AI, AE, ADA	CI/FL	RA	I
	Dasyproctidae	*Dasyprocta sp*	Cutia	AI	CI/FL	RA	I
		Cavia aperea					
	Hydrochaeridae	*Hydrochaeris hydrochaeris*	Capivara	AI, AE, ADA	FL	CI	D
LAGOMORPHA	Leporidae	*Sylvilagus brasiliensis*	Coelho do mato, Tapeti	AI, AE, ADA	FL/C	CI	V

Sighting location: AI: area of influence, AE; surrounding Area – ADA:; directly affected area
Fauna status by category: CI: used for hunting; X: for domestication; AM: Threatened with extinction; RA:rare species (locally)
Prevalence by type of habitat: C: countryside; FL: forest; DU: fresh water (encompassing species with habitats which are strictly aquatic or linked to environment such as swamps and marshes).
The FL/C and C/FL conventions mean the species inhabits two environments, however the former is the preferred habitat. Registration method: I: information; D: direct observation (viewed); V: traces

The lower level of diversity in the future Piedade SHS region was expected, as the area is dominated by anthropized environments. The natural environment has already changed substantially and what remains of the riparian forest may not be sufficient to support a high level of mammal diversity.

5. 3.4. Final Considerations

Throughout the future deployment area of the Piedade SHS we found regions which have been changed substantially by man, which may restrict the occurrence of certain mammal species which require preserved environments for survival. The presence of domestic animals (cattle, horses and dogs) may drive away some wild mammal species. Because of the substantial anthropic pressure historically present in the area, we can say that for local mammalian fauna there will be little change. Many sampled species are very generalized and a highly adaptable in terms of environment, quite capable of adapting to the impact inherent to deployment of the SHS.

5.4 Birdlife

5.4.1

INTRODUCTION

Birds are one of the major fauna groups in impact evaluation surveys, because we are able to obtain large volume of data compared with other vertebrates. They are always present with a large number of species and often many individuals. This makes them easier to identify (most can be identified from visual and/or audible observation) and are well known in terms of taxonomy. They use various terrestrial and aquatic habitats and most are diurnal. Finally, several species are subject to environmental restrictions with habitats requirements that make them good biome indicators.

5.4.2 METHODOLOGY

Studies on birdlife in the region for the Piedade SHS project were carried out in July 2001, and November 2003.

A census technique was used on random transects to create an inventory of the birdlife in the region. This methodology also attempted to register the presence of indicative, rare, threatened, endemic, migratory, domesticated, hunted and other species subject to some type of environmental restriction.

The census was also used to evaluate the variety (list of birds observed) and ecological characterization of the species and their preferred environments/habitat requirements.

The species were observed and identified with the aid of binoculars. Birdcalls were registered using a mini recorder and identification was based on “Ornitologia Brasileira” (SICK, 1997).

5. 4.3 Environmental Diagnosis

During the surveys carried out in the SHS Piedade area, 138 species of bird were registered, distributed among 16 Orders and 36 Families (table 5.5). 32 species are sought out for domestication, which include all of the psitacídeos (parrots, cockatoos, maritacas) as well as many Passeriformes, such as the canário da terra (*Sicalis flaveola*) and the azulão (*Passerina brissonii*).

79 species inhabit countryside landscapes, 32 inhabit forest habitats and 20 species are considered flexible because they inhabit more than one environment simultaneously. 11 species are connected to freshwater environments and may have a more direct link with water, such as the martim pescadores, saracuras, or inhabit hydromorphic areas, such as the tesoura do brejo (*Gubernetes yetapa*) and noivinha (*Arundinicola leucocephala*).

Four species are migratory, citing the falcão de coleira (*Falco femoralis*) and one is endemic to the Cerrado, the gralha do campo (*Cyanocorax cristatellus*). Three species are considered to be threatened with extinction, the canário da terra (*Sicalis flaveola*), the mutum de penacho (*Crax fasciolata*) and the Barranqueiro-deolho-branco (*Automolus leucophthalmus*).

One species presumed to be under threat as the azulão (*Passerina brissonii*). Two species have habitats to waterfalls, the andorinhão de coleira (*Streptoprocne zonaris*) and the taperuçu (*Cypseloides senex*).

Table 5.5

List of bird species encountered in the Piedade SHS area.

Ordem	Família	Espécie	Nome Comum	Local de Ocorrência	Habitat	status
TINAMIFORMES	Tinamidae	*Crypturellus parvirostris*	Inhambu-xororó	AI, AE, ADA	C	CI,
		Crypturellus tataupa	Inhambu-xintã	AI, AE, ADA	C/FL	CI
		Rhynchotus rufescens	Perdiz	AI, AE, ADA	C	CI
		Nothura maculosa	Codorna	AI, AE, ADA	C	CI
CICONIIFORMES	Ardeidae	*Casmerodius albus*	Garça-branca grande	AE, ADA	DU	
		Butorides striatus	Socozinho	AE	DU	
		Bubulcus ibis	Garça vaqueira	AI, AE	C	
		Syrigma sibilatrix	Maria-faceira	AI, AE, ADA	C	
		Pilherodius pileatus	Garça real	ADA	DU	
	Threskiornithidae	*Theristicus caudatus*	Curicaca	AI, AE, ADA	C/FL	
		Mesembrinibis cayennensis	Tapicuru	AE, ADA	FL	
	Cathartidae	*Coragyps atratus*	Urubu-de-cabeça-preta	AI, AE, ADA	C	
		Cathartes aura	Urubu-de-cabeça-vermelha	AI, AE, ADA	C	
FALCONIFORMES	Accipitridae	*Ictinia plumbea*	Gavião-pomba	AI, AE, ADA	C	
		Buteo albicaudatus	Gavião-de-rabo-branco	AI	C	
	Falconidae	*Herpetotheres cachinnans*	Acauã	AE	FL	
		Milvago chimachima	Gavião-carrapateiro	AI, AE, ADA	C	
		Polyborus plancus	Caracará, Carancho	AI, AE, ADA	C	
		Falco femoralis	Falcão-de-coleira	AI, AE	C	
		Falco sparverius	Quiri-quiri	AI, AE, ADA	C	
GALLIFORMES	Cracidae	*Crax fasciolata*	Mutum-de-penacho	AE, ADA	FL	CI, X
GRUIFORMES	Rallidae	*Rallus nigricans*	Saracura sanã	AI, AE	DU	
		Aramides cajanea	Saracura-três-potes	AI, AE	DU	
	Cariamidae	*Cariama cristata*	Seriema	AI, AE, ADA	C	X
CARADRIIFORMES	Charadriidae	*Vanellus chilensis*	Quero-quero	AI, AE, ADA	C	
COLUMBIFORMES	Columbidae	*Columba picazuro*	Pomba-asa-branca	AI, AE, ADA	C	CI
		Columba cayennensis	Pomba-galega	AI, AE, ADA	FL	CI,
		Zenaida auriculata	Pomba-de-bando	AI, AE, ADA	C	CI
		Columbina talpacoti	Rolinha-caldo-de-feijão	AI, AE, ADA	C	
		Scardafella squammata	Fogo-apagou	AI, AE, ADA	C	
		Leptotila verreauxi	Juriti-pupu	AE, ADA	FL	CI
		Leptotila rufaxilla	Juruti-gemedeira	AE, ADA	FL	CI
PSITTACIFORMES	Psittacidae	*Diopsittaca nobilis*	Maracanã-pequena	AI, AE, ADA	C	X
		Aratinga leucophthalmus	Maritaca, Maracanã	AI, AE, ADA	C	X
		Aratinga aurea	Periquito-rei	AI, AE, ADA	C	X
		Forpus xanthopterygius	Tuim-de-asa-azul	AI, AE, ADA	C	X

Continued……

Ordem	Família	Espécie	Nome Comum	Local de Ocorrência	Habitat	status
		Brotogeris chiriri	Periquito-de-encontro-amarelo	AI, AE, ADA	C	X
		Amazona aestiva	Papagaio-verdadeiro	AI, AE, ADA	C	X
		Amazona amazonica	Papagaio-do mangue	AI, AE, ADA	C	X
CUCULIFORMES	Cuculidae	*Coccyzus sp*	Papa-lagarta	ADA	FL	
		Piaya cayana	Alma-de-gato	AE, ADA	FL	
		Crotophaga ani	Anu-preto	AI, AE, ADA	C	
		Guira-guira	Anu-branco	AI, AE, ADA	C	
		Tapera naevia	Saci, Sem -fim	AE	FL	
STRIGIFORMES	Strigidae	*Speotyto cunicularia*	Coruja-do-campo	AI, AE	C	
CAPRIMULGIFORMES	Caprimulgidae	*Nyctidromus albicollis*	Curiango	ADA	FL	
APODIFORMES	Apodidae	*Streptoprocne zonaris*	Andorinhão-de-coleira	ADA	CACH	
		Cypseloides senex	Taperuçu	ADA	CACH	
		Reinarda squamata	Tesourinha	AI, AE, ADA	C/FL	
TROCHILIFORMES	Trochilidae	*Phaetornis pretrei*	Rabo-branco	AE, ADA	FL	
		Amazilia lactea				
		Chlorostilbon aureoventris	Besourinho-bico-vermelho	ADA	C/FL	
CORACIIFORMES	Alcedinidae	*Ceryle torquata*	Martim-pescador-grande	AE, ADA	DU	
		Chloroceryle amazona	Martim-pescador-verde	AE, ADA	DU	
		Chloroceryle americana	Martim-pescador-pequeno	AE, ADA	DU	
PICIFORMES	Galbulidae	*Galbula ruficauda*	Ariramba-da-mata	AI, AE, ADA	FL	
	Bucconidae	*Nystalus chacluru*	João-bobo, Fevereiro	AI, AE	C	
		Monasa nigrifrons	Bico-de-brasa	ADA	FL	
	Ramphastidae	*Pteroglossus aracari*	Araçari-de-bico-branco	AE, ADA	FL	X
		Ramphastus toco	Tucano toco	AI, AE, ADA	FL/C	X
	Picidae	*Picumnus cirratus*	Pica-pau-anão-barrado	AI, AE, ADA	FL/C	
		Colaptes campestris	Pica-pau-do-campo	AI, AE, ADA	C	
		Colaptes melanochloros	Pica-pau-carijó	AE, ADA	FL	
		Dryocopus lineatus	Pica-pau-de-banda-branca	AI, AE, ADA	FL/C	
		Melanerpes candidus	Pica-pau-branco, Bilro	AI, AE	C	
PASSERIFORMES	Thamnophilidae	*Taraba major*	Chorão, Choró-boi	ADA	FL	
		Thamnophilus doliatus	Choca-carijó	AI, AE, ADA	FL	
		Thamnophilus punctatus	Choca, Choró-bate-cabo	AI, AE, ADA	FL	
	Furnariidae	*Furnarius rufus*	João-de-barro	AI, AE, ADA	C	
		Phacellodomus rufifrons	João-graveto	AI, AE, ADA	C	
		Anumbius anumbi	Cochicho	AE, ADA	C	
		Automolus leucophthalmus	Barranqueiro-de-olho-branco	ADA	FL	AM
	Dendrocolaptidae	*Lepidocolaptes angustirostris*	Arapaçu-do-cerrado	AI, AE, ADA	FL/C	

Continued... . .

Ordem	Família	Espécie	Nome Comum	Local de Ocorrência	Habitat	status
		Serpophaga subcristata	Alegrinho	AI, AE, ADA	C	
		Elaenia flavogaster	Guaracava-de-barriga-amarela	AI, AE, ADA	C	
		Camptostoma obsoletum	Risadinha,	AI, AE, ADA	C	
		Tolmomyias sulphurescens	Bico-chato-de-orelha-preta	ADA	FL	
		Todirostrum cinereum	Sebinho-dorso-cinza	ADA	FL	
		Xolmis cinerea	Pombinha-das-almas, Maria-branca	AI, AE, ADA	C	
		Xolmis velata	Mocinha-branca	AI, AE, ADA	C	
		Colonia colonus	Viuvinha	AE, ADA	FL	
		Gubernetes yetapa	Tesoura-do-brejo	AE, ADA	DU	
		Knipolegus lophotes	*Maria-preta-de-penacho*	*AE*	*C*	
		Fluvicola nengeta	*Lavadeira-mascarada*	*AE,*	*C*	
	Tyrannidae	*Arundinicola leucocephala*	*Freirinha*	*AE*	*DU*	
		Machetornis rixosus	*Suiriri-cavaleiro*	*AI, AE, ADA*	*C*	*M*
		Tyrannus savana	Tesourinha	AI, AE, ADA	C	
		Tyrannus melancholicus	Suiriri	AI, AE, ADA	C	
		Tyrannus albogularis	Suiriri-de-garganta-branca	AI, AE, ADA	C	M
		Megarhynchus pitangua	- Bem-te-vi-nenei	AI, AE, ADA	FL/C	
		Myiodynastes maculatus	Bem-te-vi-rajado	AI, AE, ADA	FL	M
		Myiozetetes cayanensis	Mosqueteiro	AE, ADA	FL/C	
		Myiozetetes similis	Bem-te-vi-pequeno	AE, ADA	FL/C	
		Pitangus sulphuratus	Bem-te-vi	AI, AE, ADA	C/FL	
		Myiarchus ferox	Maria-cavaleira	AI, AE, ADA	C	
		Myiarchus tyrannulus	Maria-cavaleira-rabo-castanho	AI, AE, ADA	C	
	Pipridae	*Antilophia galeata*	Tangará-de-crista-vermelha	AE, ADA	FL	X
		Phaeprogne tapera	Taperá	AI, AE, ADA	C	
	Hirundinidae	*Notiochelidon cyanoleuca*	Andorinha-pequena-de-casa	AI, AE, ADA	C	
		Stelgidopterix ruficollis	Andorinha-serradora	AI, AE, ADA	C	
	Corvidae	*Cyanocorax cristatellus*	Gralha-do-campo	AI, AE, ADA	C	EN
		Donacobius atricapillus	Batuquira	AE	DU	
	Troglodytidae	*Thryothorus leucotis*	Garrinchão-de-barriga-vermelha	ADA	FL	
		Troglodytes aedon	Corruíra	AI, AE, ADA	C	
	Sylviidae	*Polioptila dumicola*	Balança-rabo-de-máscara	AI, AE, ADA	C	

Continued……

Ordem	Família	Espécie	Nome Comum	Local de Ocorrência	Habitat	status
		Turdus rufiventris	Sabiá-laranjeira	AI, AE, ADA	C/FL	X
	Turdidae	*Turdus leucomelas*	Sabiá-barranqueiro	AI, AE, ADA	FL/C	X
		Turdus amaurochalinus	Sabiá-poca	AI, AE, ADA	FL/C	X
	Mimidae	*Mimus saturninus*	Sabiá-do-campo	, AI, AE, ADA	C	
		Cyclarhis gujanensis	Pitiguari	AI, AE, ADA	FL	
		Vireo olivaceus	Juruviara	AI, AE, ADA		
		Basileuterus flaveolus	Mariquita-amarela	ADA	FL	
		Basileuterus culicivorus	Pula-pula	AI, AE, ADA	FL	
		Coereba flaveola	Caga-cebo	AI, AE, ADA	C/FL	
		Euphonia chlorotica	Vi-vi	-, AI, AE, ADA	FL/C	X
	Vireonidae	*Tangara cayana*	Sanhaço-cara-suja	AI, AE, ADA	C	X
		Trhaupis sayaca	Sanhaço-do-mamoeiro	AI, AE, ADA	C	X
		Thraupis palmarum	Sanhaço-de-coqueiro	AE, ADA	C	X
		Thraupis sayaca				
		Piranga flava	Sanhaço-de- fogo	AI,	C	X
		Tachyphonus coronatus	Tiê-preto	AE, ADA	FL	
		Nemosia pileata	Fruteiro	AI, AE, ADA	C/Fl	X
		Dacnis cayana	Saí-azul	AI, AE, ADA	C	X
		Tersina viridis	Saí-andorinha	AI, AE, ADA	C/FL	X
		Volatinia jacarina	Tiziu	AI, AE, ADA	C	
		Sporophila nigricollis	Coleiro-baiano	-, AI, AE, ADA	C	X
		Sporophila caerulescens				
		Sicalis flaveola	Canário-da-terra	AE, ADA	C	X, AM
	Emberezinae	*Ammodramus (= Myospiza) humeralis*	Tico-tico-do-campo	AI, AE, ADA	C	
		Zonotrichia capensis	Tico-tico	AI, AE, ADA	C	X
		Emberizoides herbicola	Canário-do-campo	ADA	C	
		Saltator similis	Trinca-ferro	AI, AE, ADA	FL	X
		Saltator atricollis	Batuqueiro	AI, AE, ADA	C	X
		Passerina brissonii	Azulão	AE, ADA	C	X, PA
	Cardinalinae	*Molothrus bonariensis*	Vira-bosta	AI, AE, ADA	C	X
		Cacicus haemorrhous	Guaxe	AE, ADA	FL	X
		Gnorimopsar chopi	Pássaro-preto	AI, AE, ADA	C	X

Sighting location: AI: area of influence, AE; surrounding Area – ADA:; directly affected area
Fauna status by category: CI: used for hunting; X: for domestication; M: migratory; AM: Threatened with extinction; EM: endemic species in Brazil
Prevalence by type of habitat: C: countryside; FL: forest; DU: fresh water (encompassing species with habitats which are strictly aquatic or linked to environment such as swamps and marshes). CACH: Species associated with waterfalls. The FL/C and C/FL conventions mean the species inhabits two environments, however the former is the preferred habitat.

The Cerrado is normally inhabited by birds with generalist habitats. In countryside areas, common species are the seriema (*Cariama cristata*), codorna mineira (*Nothura maculosa*), and perdiz (*Rinchotus rufescens*). The tico-tico rasteiro (*Ammodramus humeralis*) lives in grassy areas.

In sparser Cerrado areas we find the maria-branca (*Xolmis velata*) and para-bala (*Xolmis cinerea*). Where there are termites, we can find the coruja buraqueira (*Athene cunicularia*) and the pica pau do campo (*Colaptes campestris*), which use these locations to build nests.

Low-lying areas are home to species such as the choca bate-cabo (*Tamnophilus punctatus*).

In dense Cerrado there are species such as the bem-te-vi (*Pitangus sulphuratus*), bem-te-vi rajado (*Myiodinastes maculatus*) and saira-mascarada (*Nemosia pileata*).

In treetops we observed predatory species such as the gavião-sovi (*Ictinia plumbea*) (Foto 5.10) and falcão-de-coleira (*Falco femoralis*) and nesting species such as the Maria-faceira (*Syrigma sibilatrix*) and pombas (*Columba* spp.).

Photo 5.10 GAVIÃO SOVI - *ICTINIA PLUMBEA*

Adult, dead or senile trees provide cavities which are home to many species which nest there, like papagaios (*Amazona aestiva, Amazona amazonica*) (Foto 5.11) and the pica pau de banda branca (*Dryocopus lineatus*).

Photo 5.11 PAPAGAIO - *AMAZONA AESTIVA*

The Semi-Deciduous Seasonal Forest provides a wider variety of resources such as flowering and fruit flowers and also insects. These are important environments for species that need larger areas such as the mutum-de-penacho (*Crax fasciolata*), which inhabit areas closer to the ground.

In the middle strata live bird species that feed off insects, such as the pica-pau-anão (*Picumnus cirratus*), pichito (*Basileuterus culicivorus*) and omnivorous species like the guaxe (*Cacicus haemorrhous*). The highest strata is inhabited by birds like the tiê-preto (*Tachyphonus coronatus*).

Deciduous forest can frequently be found on the hillsides adjacent to the Piedade river. One of the most typical types of bird in this environment, which inhabits the lower strata of the forest, is the canário-domato (*Basileuterus flaveolus*). In the middle and high strata there are species of bird including the bem-te-vide-bico-chato (*Megarhynchus pitangua*) and figuinha (*Conirostrum speciosum*). The acauã (*Herpetotheres cachinans*) is a predator which lives among the treetops. It is often present, detected because of its calls.

The riparian forest is also home to species which are typical to this environment as well as species from inside and around other types of forests. The most typical species include bico-de-agulha (*Galbula ruficauda*) (Foto 5.12), the garrinchão-de-barrigavermelha (*Tryotorus leucotis*) and the relógio (*Todirostrum cinereum*).

Photo 5.12 BICO DE AGULHA - *GALBULA RUFICAUDA*

There are few in backwards along the river banks providing nesting conditions for species such as martins pescadores.

The embankments are home to ombrophilous species like the soldadinho (*Antilophia galeata*), or Riverside forest species such as the corocoró (*Mesembrinibis cayennensis*) and saracuras. The andorinha tesourinha (*Reinarda squamata*), are totally dependent on riverside areas with the presence of palm trees.

Date palm trees, which formed cavities, or important for nesting among many species of bird, such as the psitacídeos (papagaios, maritacas, jandaias), pássaros pretos (*Gnorimopsar chopi*), and even living trees where several species nest like the curicaca (*Theristicus caudatus*).

The brushwood is mainly home to more generalised species like the a juriti (*Leptotila* spp.), joão-graveto (*Phacellodomus rufifrons*) and peixe-frito (*Tapera naevia*).

Anthropic areas are represented by pasture, crops and orchards. Here we find species like the codorna-mineira (*Nothura maculosa*), inhambu-xororó (*Crypturellus parvirostris*), tico-ticodo-campo (*Ammodramus humeralis*), pomba verdadeira (*Columba picazzuro*), a pomba galega (*Columba cayennensis*), sanhaçu (*Thraupis sayaca*), saira-de-bico-fino (*Dacnys cayana*), periquitos (*Brotogeris chiriri*, *Forpus xanthopterygius*), avoante (*Zenaida auriculata*), tiziu (*Volatinia jacarina*) and papa-capim (*Sporophila nigricollis*). The garça vaqueira (*Bubulcus ibis*) accompanies the cattle in the pastures.

The riparian forest on the Piedade river covers the section between the dam location extending upstream to the end of the new reservoir. It is linear with a few small areas where the tree canopy has gaps. Although it is narrow, it has a fundamental role in terms of shelter and as a corridor for dispersion of the resident fauna.

Many species are connected to this habitat, like the bico-de-brasa (*Monasa nigrifrons*), reloginho (*Todyrostrum cinereum*) and bico-de-gulha (*Galbula ruficauda*), curicaca (*Theristicus caudatus*), and bem te vi (*Pitangus sulphuratus*).

The waterfalls from the dam and the “Guiamrães” (or Piedade) waterfall are highly important locations for several species such as the martim-pescadores (Alcedinidae) and garça-real (*Pilherodius pileatus*). Two species of andorinhões (*Streptoprocne zonaris* and *Cypseloides senex*), both have a highly specific connection with this habitat because of shelter and nesting, with colonies around the sites.

5. 4.4. Final Considerations

Birdlife species use the riverside forest and large trees in pasture areas around the development area in order to travel. This group of vertebrates will maybe be the least harmed by installation of the Piedade SHS.

5.5 HERPETOFAUNA

5.5.1 INTRODUCTION

Amphibians constitute an animal group with a specific type of biology because, except under certain circumstances, they depend on water to reproduce and for activity during the larval period (Duellman e Trueb, 1986). Adaptations related to life in damp environments, like high skin permeability, make conformable the activity of pollutants in water and the air (Feio *et al*.,1998). Because of this, this animal group deserves special attention in areas which may or will be impacted.

Worldwide, 3500 species of frog are known (Class Amphibia: Order Anura) representing the most widespread group of amphibians. In Brazil, 776 species of amphibian have been registered, one of the highest levels of diversity worldwide, of which around 60% are endemic, in other words they are only present on Brazilian territory (Feio *et al*.,1998).

Brazil has a diverse reptile fauna, with species appearing in several types of vegetation such as the Tropical Forest, Caatinga, Cerrado and swamps, as well as strictly marine environments. For example, around 400 types of lizard are found in Brazil (Rocha, 1994).

Serpents are a group of reptiles with specific characteristics, such as an elongated body without locomotive appendages or scapular waist (Ferrarezzi, 1992). Dodd (1987), reveals that 186 species and subspecies of serpents on Earth are threatened or need some type of control. Wilcox and Murphy (1985) state that the largest threat to serpents is destruction of their habitat which results not only in the physical destruction of the animals but also their ecosystems. As the remaining populations are fragmented, they lose potential genetic diversity.

5.5.2 METHODOLOGY

The campaign to survey herpetofauna was conducted in June 2004 over a period of five days, two of which were taken up by travel and three involved fieldwork.

Seven collection points were selected around the Piedade river environment, according to the potential for finding specimens and ease of access. These points represent different types of formations within the survey area and can be seen on drawing PIE-PAF-001. They are:

- *P1* (*UTM: 7933140 / 22K 0708290)*: Pasture area cut through by a permanent stream with separated fragments of riparian forest. Location close to the future power station on property belonging to Mr. Roosevelt.
- *P2* (*UTM: 7934054 / 22K 0708591*)*:* Green area on a higher portion of the land on the same body of water as P1. Although located on the same body of water is point 1, this can be considered an independent location because it contains a different type of that nation.
- *P3* (*UTM: 7933252 / 22K 0710395*): A dammed stream upstream from the location of the future power station. In this area, the riparian forest also includes palm trees. Location on property belonging to Mr Regis.

- *P4* (*UTM: 7934734 / 22K 0707179*): Area where a small stream has been dammed creating a permanent lake. Location on property belonging to Mr Leri, close to the future low flow section.
- *P5* (*UTM: 7935150 / 22K 0705048*): Small stream in a fragment of forest and an artificial well built from the diverted stream. Location on property belonging to Mr. Leonardo, close to the future power station.
- *P6* (*UTM: 7935105 / 22K 0705105*): Small body of water with a small fragment of forest, creating permanent lakes because of artificial dams. Located on land belonging to Messrs. Dill and Diógenes, close to the future low flow section.

NOTE: Points P1 to P6 located on the right bank of the Piedade river and all the bodies of water mentioned flow into the Piedade river.

- *P7* (*UTM: 7935150 / 22K 0705048*): Area with two streams (flowing into the Piedade river) with altered riparian vegetation with riparian vegetation remaining in some sections. There are also permanent wells in open areas. Located on the left bank of the Piedade river, on property belonging to Mrs. Áurea, an area which will represent the future banks of the reservoir.

Registration of reptile species was carried out during daytime and nighttime with active searches at each sampling point (on land and/or bodies of water) and occasional observations, as well as manual captures using lassoes or garrotes. Amphibian registrations were carried out during nocturnal excursions in the field actively looking for animals, their calls, direct observation and manually capturing some samples. During daytime, wells, flooded areas and bodies of water were checked to collect and observe tadpoles and other evidence of reproduction.

The results of interviews with local inhabitants (when researching the prevalence of serpents, lizards and amphibians and the frequency they could be seen in the region) were considered indicative of the occurrence of species or genuses in the area.

5. 5.3 Environmental Diagnosis

The relevance of species inventory surveys for the Minas Triangle region arises from the very sparse information on local herpetofauna. Therefore, studies of this nature not only provide information for controlling and conservation of herpetofauna in respective project areas but are also able to increase knowledge on important species for conservation purposes in the regional environment.

A total of eight amphibian species and to reptile species were registered through direct observation, collection and/or visualization. Based on interviews with local inhabitants, others species also comprise local herpetofauna.

Table 5.6

List of herpetofauna species encountered in the Piedade SHS area.

Ordem	Família	Espécie	Nome Comum	Local	Tipo de registro
Anura	Bufonidae	*Chaunus* sp.	sapo	P5	Voc
	Hylidae	*Hypsiboas albopunctatus*	Perereca amarela	P1, P2, P4	Voc
		Hypsiboas lundii	Perereca	P4, P5, P6	C
		Dendropsophus minutus	Perereca-de-ampulheta	P2, P4, P5, P6	C
		Pseudis sp	Rã-pé-de-pato	P5	V
		Scinax fuscovarius	Perereca-de-banheiro	P5	C
	Leptodactylidae	*Leptodactylus labyrinthicus*	Rã-pimenta		E
		Odontophrynus sp	Rã	P5, P7	Voc
Squamata	Amphisbaenidae	*Amphisbaenia alba*	Cobra-de-duas-cabeças	P1	C
	Boidae	*Boa constrictor*	Jibóia		E
		Eunectes sp	Sucuri		E
	Colubridae	*Spilotes pullatus*	Caninana		E
		Waglerophis merremii	Caninana		E
	Polychrotidae	*Polychrus acutirostris*	Lagarto		E
	Teiidae	*Ameiva ameiva*	Lagarto-verde		E
		Tupinambis sp	Teiú		E
	Tropiduridae	*Tropidurus cf. torquatus*	Calango	P3, P5, P7	V
	Viperidae	*Bothrops jararacussu*	Jararacussu		E
		Crotalus durissus	Cascavel		E

Voc= Individuals registred by their calls. V= Individuals registred from obersvation. C= Individuals registred by capture.
E= Recorded through interviews

The species found are generally typical in Cerrado areas and are frequently found in open areas (for example: H. *albopunctatus*, *D. minutus* e *Pseudis* sp. e *Scinax fuscovarius*; *Tropidurus cf. torquatus*, *Leptodactylus labyrinthicus*, *Eunectes* sp. e *Crotalus durissus*) or in areas of dense vegetation (ex: *H. lundii*, *Polychrus acutirostris*, *Ameiva ameiva*, *Tupnambis* sp, *Boa constrictor*, *Bothrops jararacussu*). Some of them are widely distributed throughout Brazil like *H. albopunctatus*, *S. fuscovarius*, *D. minutus*, *B. jararacussu*, *A. alba*, *T. cf. torquatus* e *Ameiva ameiva*. However, we must note that the amphibian species *L. labyrinthicus*, popularly known as the Rã-pimenta, is frequently used as a source of protein by rural populations. Therefore, populations of this species, when found, will have been affected by hunting.

We know that the diversity of a species in a specific area is directly linked to environment availability (environmental heterogeneity) (Pianka, 1967). Therefore, it is probable that although the area surrounding the future of Piedade SHS reservoirs has already been changed, the heterogeneous nature of the environments (Cerrado, riparian forest, fragments of forest, pastures) associated with the high structural complexity of certain types of habitats, especially fragments of forest, support a larger number of species than that found in this study.

Various components regulate herpetofauna species activity. However, in tropical and subtropical regions rainfall seems to be the biggest external effect determining species activity (Duellman and Trueb, 1986, Pombal, 1997, Galdino *et al*, 2003). It is believed that the low number of species found may be based on the period the samples were taken, in the middle of the dry season.

5. *5.4. Final Considerations*

Based on the results obtained and taking into account this area has been altered, we believe that the impact from the project will have a minimal impact on local herpetofauna. However, deforestation (partial or total) of fragments of forest will create more uniform habitats, destroying specialist species and favoring ruderal and/or generalist species thereby contributing to a reduction in alpha diversity (Woodruff, 2001). Furthermore, during deforestation and especially during flooding, as the habitats are shrinking there will probably be a dispersion of individual members of local herpetofauna species.

We know that water quality is an important component affecting the composition of amphibian taxonomy (Silvano, 1999). We therefore expect anurofauna to be affected as the reservoir eutrophizes, although few amphibian species use the reservoir for their activities. Reptile species will be little affected by this process because they are more mobile and can therefore look for free-flowing water in the free-flowing stretch of the Piedade river and/or in other higher quality bodies of water.

5.6 Fish Life

5.6.1 Introduction

Reductions in river flow, like the reduction when operating a small hydroelectric power station (SHS), require a certain level of control in the relevant hydrographic basin. The effect of reducing the flow affects many aspects of this ecosystem, including the concentration of pollutants, water temperature and thermal regimes and habitat availability (RICHTER *et al.*, 1996).

Some impact must be considered on the fish. As cited previously, river or flow reduction may increase the concentration of pollutants, increasing their relative toxicity, increasing water temperature, reducing species survival capabilities and reducing habitat availability, reducing the local density of fish populations. Other impacts may arise from alterations to water channel structures, for example, favoring species better adapted to less intense flows, while harming those which need faster flows in other words there may be a change in the structure of the community.

The absence of flooding on a periodic basis may eliminate an environmental "signed" which triggers reproductive behavior in certain species. Increased water visibility because of reduced depth may favor a nonoriginal species, or even predatory species (ALLAN, 1995).

5.6.2 *METHODOLOGY*

Data on fish life is based on the first field campaign carried out in the project area for the Piedade SHS and along the Piedade river water course in January 2007. This data therefore relates to the most updated list of species for Piedade river fish life. During the survey, four sampling points were established along the Piedade river, the area of influence created by the future Piedade SHS add one on the lower course of the Piedade river. Table 5.7.

Sampling point location is presented in drawing PIE-PAF-001.

Table 5.7
Location of qualitative and quantitative sampling points in the area of influence of PIEDADE SHS, RIO DA PRATA, GO.

Points	Location	UTM Coordinate UTM
P 1	Upstream from the future Piedade SHS reservoir	22K 0713707 /7931282
P 2	Area of the future Piedade SHS reservoir	22K 0708848 /7932911
P 3	Low flow section for Piedade SHS	22K 0705252 /7934921
P 4	Downstream from the Piedade SHS powerhouse	22K 0704250 /7934997
P 5	Lower course of the Piedade river	22K 0690230 /7949422


Photo 5.13 P1


Photo 5.14: P2


Photo 5.15: P3


Photo 5.16: P4

Photo 5.17. P5

Qualitative and quantitative sampling

Qualitative sampling was conducted during the day (dragging a 2 mm mesh net and 3, 4 and 6 cm casting nets between opposing knots), and quantitative sampling (using 10 meter gill nets with meshes varying between three and 14 cm between opposing knots). The nets were set up at the end of the afternoon and removed the following morning, remaining in the water for approximately 12 hours. The effort used with the respective mesh size it was recorded for each sampling point (Table 5.8).

Table 5.8
Catch per unit effort (M^2), by mesh size, used at fish life monitoring points for the future PIEDADE SHS, RIO PIEDADE, MG (JANUARY/2007).

Mesh	Fishing effort (m^2)					
(cm)	P1	P2	P3	P4	P5	Total
3	15	15	15	15	15	75
4	15	15	15	15	15	75
5	15	15	15	15	15	75
6	15	15	15	15	15	75
7	15	15	15	15	15	75
8	18	18	18	18	18	90
10	18	18	18	18	18	90
12	18	18	18	18	18	90
14	22	22	22	22	22	110
Total	151	151	151	151	151	755

The fish which were captured were separated by capture location, type of equipment used and were placed in labeled plastic bags indicating their origin and date. Individual fish selected as examples and not destined for dissection were immediately stabilized and maintained in 10% formol and this material will be incorporated into the collection archive which will be created. The fish were then identified (identification confirmation for some species was carried out in the laboratory), taking biometric data such as: Body weight (PC) and total length (CT). On some occasions, before the stabilization process, the fish were photographed.

- Evaluation of reproductive activity

The state of fish gonad maturity was diagnosed macroscopically based on volume, color, blood irrigation, turgidity and visualization of ovocytes and sperm line cells. The gonads were classified on a maturity scale according to BAZZOLI (2004).

1 = undeveloped*, small, translucid ovaries, small volume, containing O1 and O2; thready or frilled and transparent testicles containing only spermatagonia and semnipherous tubes closed.*
2 - initial maturity*, larger ovaries, some ovicyte organs visible tot he naked eye containing 01, 02 and 03, larger and whiter testicles with a small quantity of spermatozoids in the semnipherous tubes in relation to other spermatogenic cells.*
3 – advanced maturity/mature*, ovaries at maximum volume with many ovocytes visible to the naked eye, containing 01, 02, 03 and 04 and turgid testicles, milky white with semnipherous tubules full of spermatozoids.*
4A = partially spent/exhausted*, flaccid ovaries, hemorrhagic, containing 01, 02, 03 and 04 and post=ovulation follicles. Flaccid testicles, hemorrhagic, with appreciable quantities of spermatozoids and open semnipherous tubules.*
4A = totally spent/exhausted*, very flaccid ovaries, hemorrhagic, containing many 01 and 02, various post=ovulation follicles and O3 and O4 in atresia. Small testicles, hemorrhagic, containing only spermatagonia in the wall of the semnipheral tubes with open tube.*

When diagnosis of the reproductive status was doubtful, a fragment of the gonad was fixed in Bouin solution.

- Size and abundance of samples captured

The variation in size of species for the sample period was evaluated by building tables with average, maximum and minimum length and weight of the samples captured.

The relative abundance will be determined by calculating the catch per unit effort (CPUE) defined as the sum of the number (CPUEn) or biomass (CPUEb in kg) of fishing 100 square meters of nets used for 12 hours. This procedure provides quantitative comparisons between species, seasons and period sampled, obtained from the following formula:

$$CPUE_n = \sum_{m=3}^{12} (Nm / EPm) * 100$$

$$CPUE_b = \sum_{m=3}^{12} (Bm / EPm) * 100$$

$CPUE_n$	=	*captura em número por unidade de esforço;*
$CPUEb$	=	*captura em biomassa (peso corporal) por unidade de esforço;*
N_m	=	*número total dos peixes capturados na malha m;*
B_m	=	*biomassa total capturada na malha m;*
Ep_m	=	*esforço de pesca, que representa a área em m^2 das redes de malha m;*
M	=	*tamanho da malha (3, 4, 5, 6, 7, 8, 10 , 12 e 14 cm).*

We therefore obtained the following CPUEs:

CPUE(n, b) malha	=	*CPUE, by number and biomass, by collection point;*
CPUE(n, b) malha	=	*CPUE, by number and biomass, by mesh;*
CPUE(n, b) espécie	=	*CPUE, by number and biomass, by species;*

- Analysis of fish life diversity

In order to calculate the diversity of species we used quantitative data obtained from the fish captured in the gill nets (CPUE). We used the diversity index created by Shannon (Magurran, 1988), described by the equation:

$$H' = -\sum_{i=1}^{S} (pi) * (\log_n pi)$$

S = número total de espécies na amostra;
i = espécie 1, 2, 3 .. .i na amostra;
pi = proporção do número de indivíduos da espécie i na amostra, através da CPUE em número.

- Similarity

The similarity between the sampling points was estimated using the Sorensen (C_n) index for quantitative data, as stated in MAGURRAN (1988):

$$S = 2j / (a + b)$$

S = índice de similaridade;
j = número de espécies comuns nos pontos de amostragem a e b;
a e b = número de espécies exclusivas nos pontos de amostragem a e b.

Based on the methodology in VALENTIN (1995), similarity tables will be constructed based on the values of these indices for the quality of sampling points. These were then used in the analysis of groupings in order to create a densogram, based on the connection with the Unweighted Pair Group Method with Arithmetic Mean (**UPGMA**).

Note: Data on the abundance, wealth, diversity, percentage occurrence, abundance level, frequency of occurrence and reproductive activity will be presented in the final report.

5. 6.3 Environmental Diagnosis

Initially it is important to point out that the conditions of the Piedade River during the field campaign conducted in the month of January 2007 were not favorable for catching fish using either quantitative (gillnets) or qualitative (casting nets, dragnet) equipment. This is mainly because of the waterfalls along the river which almost never have lakes and because of the high volume of water.

60 samples were captured in the qualitative and quantitative samples during the first monitoring campaign in the Piedade SHS influence area and its lower course, in January 2007, comprising eight species, five genuses and five families (Table 5.9).

Table 5.9
list of species captured in the first fish monitoring campaign in the area of influence from the PIEDADE SHS and the lower course of the Piedade River in January 2007.

Espécies	Nome vulgar
ORDEM CHARACIFORMES	
Família Characidae	
Astyanax bimaculatus	Lambari-do-rabo-amarelo
Astyanax fasciatus	Lambari-do-rabo-vermelho
Astyanax sp	Lambari
Família Erythinidae	
Hoplias lacerdae	Trairão
Família Anostomidae	
Leporinus friderici	Piau-três-pintas
Leporinus macrocephalus	Piau
Família Parodontidae	
(espécie identificação)	Canivete
ORDEM SILURIFORMES	
Família Loricariidae	
Hypostomus sp1	Cascudo

Size and abundance of samples captured

The variation in size of species for the sample period was evaluated by building tables with average, maximum and minimum length and weight of the samples captured. The largest sample captured was a trairão, *H. lacerdae*, 58 cm long (ICT) with 4350 g bodyweight (PC) and the smallest was a lambari, *A. bimaculatus* with 7.5 cm (CT) and 8.0 g PC. The most abundant species in number was *Astyanax sp. com* with 26 individuals and by biomass was *H. lacerdae* with 7150 g. The range of total length (CT) and bodyweight (PC) by species and number of individuals captured is presented in table 5.10.

Table 5.10
Number of individuals captured (N), biggest (Max.) and smallest (Min.) samples; average (Med.) for body weight (PC) and total length (CT) for each species captured during January 2007 sampling in the Piedade SHS area of influence and lower course of the Piedade river.

		PC (g)			CT (cm)		
Espécie	N	Max	Min	Med	Max	Min	Med
Astyanax bimaculatus	17	19.0	8.0	12.0	10.5	7.5	8.7
Astyanax fasciatus	2	11.0	10.0	10.5	10.5	9.0	9.8
Astyanax sp	26	16.0	11.0	13.7	12.0	8.5	9.8
Hoplias lacerdae	2	4350.0	2800.0	3575.0	58.0	50.0	54.0
Leporinus friderici	6	204.0	72.0	126.8	25.0	17.0	21.6
Leporinus macrocephalus	2	327.0	98.0	212.5	28.0	20.0	24.0
(espécie identificação)	1	24.0	24.0	24.0	14.0	14.0	14.0
Hypostomus sp1	4	17.0	12.0	14.0	12.0	9.0	10.5

5. 6.4. Final Considerations

Damming a watercourse results in various alterations to the aquatic environment with changes to flow (free-flowing water) and standing (stationary water) characteristics most easily visible. This changes the available habitats, physical and chemical conditions of the water, nutrient cycles, biomass/energy ratios and the dynamic of water biotic communities (Sale, 1985). Based on the magnitude of these alterations we will then see a reduction or elimination of species adapted to free-flowing water.

Alterations and elimination of habitats within the flooded area (reservoirs) is a major factor when building dams.

On the Piedade River, downstream from the power station, the impact on fish will be related mainly to the daily fluctuation in water levels related to the operating regime adopted by Piedade SHS. According to the literature available, swift variations in flow levels are responsible for reducing aquatic communities in free-flowing water environments downstream from dams. The factors responsible for these changes are not clearly understood, but related to changes in the water habitat conditions. Among changes observed at those related to dragging organisms, changes in the recruitment rates and nutritional condition for certain species.

So far, no information has justified deployment of a mechanism to transfer fish from the PHC Piedade dam area. Such a mechanism is therefore likely to be unnecessary. However, the final analysis this issue will be presented at the end of the first fish monitoring phase, as stated previously in this PCA.

6 ENVIRONMENTAL IMPACTS

As stated in this document, the change to the Piedade SHS layout does not invalidate the environmental impacts identified in relation to the project. This chapter will therefore deal only with possible new impacts arising from deployment and operation of Piedade SHS based on alterations to the engineering design.

In order to describe and evaluate possible environmental impacts from PCH Dias deployment in operation, we based our analysis on CONAMA Resolution 01/86.

The potential effects of the impacts were qualified in line with the following criteria:

- Development phase: Planning, Deployment, Reservoir Filling and Operation;
- Effect: Positive or negative;
- Type: Direct or indirect;
- Scope: Local or regional;
- Duration: Short, medium or long term;
- Reversibility: Reversible or irreversible;
- Importance: Important or unimportant;
- Magnitude: Low, medium or high;
- Quantifying the final impact: Significant, moderate, not very significant or insignificant.

6.1 Physical Environment

6.1.1 Loss of Natural Heritage Locally from Filling the Reservoir and TVR Formation

In the new reservoir area, three waterfalls will be affected by the increased water level, two located on the "unnamed" and Boa Vista streams, located on the right bank of the Piedade River and the Erson Waterfall located on the Piedade River, thereby erasing their landscape effects (scenic value). Alongside the waterfalls, 4 springs will also be flooded. This will have a direct, local, long-term, irreversible, important, high magnitude, significant and negative effect.

Downstream from the forecast dam location, the Piedade River creates two waterfalls, one located on property belonging to Mr. Francisco Carols Vieira and another known as Usina Velha or Guimarães Waterfall, located on the property of Mr. Roosevelt Guimarães Jr.

By damning the river to retain the water in the reservoir, the volume of water in the existing waterfalls will be restricted to a volume corresponding to the project low flow, compromising their landscaping effect (scenic value). This will have a direct, local, long-term, irreversible, important, high magnitude, significant and negative effect.

These impacts may be minimized by the "*Natural Heritage Registration Program", "Project to Recover, Rehabilitated Me Vegetate Springs and Watercourses" and "Groundwater Monitoring Program".*

6. 1.2 WATER QUALITY

When a watercourse is dammed the water is held in place for a longer time compared with the free-flowing system. Thomas *et al.* (1997) states that because of this, there are alterations to water temperature, sedimentation levels and circulation of water masses, gas dynamics and nutrient circulation structure of aquatic communities.

These modifications have the most effect on changes to the physical, chemical and biological characteristics of the new water system (Júlio *et al.*, 1997). As a direct consequence, the authors report possible appearance of thermal stratification at during certain seasons and/or times of the day, forming the so-called thermocline, specific vertical gradients in the water column, mainly in terms of dissolved oxygen concentration, resulting in limits on aquatic organism distribution. We can observe the formation of three different longitudinal zones (river, intermediate and lake), resulting from contributions from the water source creating the reservoir. These ranges result in different behavior in relation to factors such as sedimentation rate, concentration and cycling of nutrients, accretion and retention of organic and inorganic material, factors limiting primary production and values of this production (Thomas *et al*., 1997).

Installation of the Piedade SHS will result in creation of a reservoirs the volume of 17,520,000 cubic meters; water surface of 1,499,000 square meters, perimeter of 10400 and 33 m, approximate length of 4420 m, maximum depth of 30 m and average depth of 14.5 m.

Plant reservoir operation will be based on the water level and the length of time that the water remains in the reservoir will be subject to variation in incoming water flows. At a minimum monthly average flows observed from fluviometric data (1.4 m^3/s) this period will be around 145 days; for average long-term flows (11.9 m^3/s), 490 hours or 17 days; and for a maximum average monthly flow (42.7 m^3/s), around 114 hours or five days.

In order to better evaluate potential modifications arising from the Piedade SHS reservoirs, we looked at certain important morphological aspects in the system which will be created. We therefore drew up calculations evaluating susceptibility to stratification and eutrophization, as recommended by Von Sperling (1999) and Håkanson (1981), taking into account a variety of morphometric variables. This was used to generate important information on issues linked to limnological dynamics such as water column stratification, inter-relation between the body of water and surrounding areas and the drainage basin, among others, based on the reservoir format.

According to Von Sperling, correct interpretation of morphometric data from lakes and reservoirs can be a useful tool for controlling bodies of water. However, the author points out that these studies can only be used to determine trends and do not replaced suitable monitoring of water systems. The following indices were therefore adopted: *relative depth, densimetric Froude number, coastal region development index and involvement factor.*

In the methodology adopted for this type of valuation, the following parameters were used. maximum reservoir depth (M), total surface area of the reservoir (m^2), reservoir length (m), reservoir inflows (m^3/s), reservoir volume (m^3), reservoir perimeter (m) and total drainage area of the reservoirs hydrographic basin (m^2).

The first index, relative depth, tells us about the stability in stratification of the water column. The value obtained for the future Piedade SHS reservoir was 2.17%. This value shows that the future reservoir has a slight tendency towards meromixis because of morphological limitations, meaning that the environment will only be able to create vertical movement of water masses if there is sufficient incoming external energy, for example high-intensity wind. We therefore estimated that the liquid mass of the reservoir will be subject to periods of low vertical circulation which may result in a vertical stratification forming different metabolic compartments such as epilimnial, metalimnial and hypolimnial. The absence of oxygen at the bottom of the lake not only reduces biological diversity it also leads to reach soluble isolation of nutrients, especially phosphorus, which makes it available for assimilation by aquatic plants, mainly to the underside formation of eutrophization phenomena.

Calculation of the densimetric Froude number is carried out by evaluating the tendency to mix or stratify water in a reservoir, taking into account key affluent flows in this system. The results obtained showed that at the maximum depth (30 m) the trend revealed by the relative depth of periods of water column stratification in the future reservoir will probably not be restricted only to times of lower flow, because the maximum average flow registered was 0.115 for this index.

The perimeter development index provides the level of the regularity of the coastal region, i.e. the number of ramifications. Reservoirs with an extensive coastal region consequently have a good capacity to assimilate the impact of pollution and especially greater resistance to eutrophization. On the other hand, they have a disadvantage in the indentations where water is retained for a longer period of time, thereby favoring an accumulation of material in shallower areas which are exposed to sunlight radiation and subject to little water movement. All of these conditions support decomposition of organic material and the growth of microalgae.

However it would seem that offsetting these two phenomena, in most cases, are the predominant positive conditions for nutrient assimilation. The value obtained from the perimeter development index, 2.39, indicates the low number of reservoir bank ramifications. This means that the inter-relation between immediate bank areas will be low, and possible interference at this level may be incorporated into the liquid mass of the reservoir. This is an indication of reduced formation of different horizontal zones because of the greater possibility of quickly mixing with the main body of the reservoir. This trend would imply that when adding substantial amounts of nutrients and organic material, the entire reservoir will quickly be subject to the effect of this addition, with a very small probability of forming horizontal pure zones not subject to this impact.

The last index considered, the involvement factor, reached a value of 645, which shows a less accentuated relationship between the drainage basin area and the reservoir area. This means that potential erosion of nutrients into the body of water is lower than the dilation effect on these nutrients will be high.

We therefore believe, based on the morphometric indices analyzed, that the future reservoir will have undefined horizontal space patterns with horizontal circulation, and a trend towards vertical stratification periods in deeper regions of the lake. It will not be especially affected by the drainage basin because of the large volume of water in the reservoir. The time the water remains in the reservoir will determine a mainly longitudinal flow with a certain uniformity in the transversal section.

Eutrophization is the excessive growth of aquatic plants because of the wide availability of nutrients. This phenomenon can lead to lower water quality because it reduces sunlight penetration and the concentration of dissolved oxygen, which is used to decompose dead algae. In terms of the level of atrophy, lakes and reservoirs can be classified according to the concentration of phosphorus and water (table 6.1).

Table 6.1
Reservoir classification in terms of the level of atrophy based on phosphorus concentration in water.

Class of atrophy	Total phosphorous concentration (mg P/L)
Ultraoligotrophic	< 0,005
Oligotrophic	< 0,01 – 0,02
Mesotrophic	0,01 – 0,05
Eutrophic	0,025 – 0,1
Hipereutrophic	> 0,1

Obs.: The overlapping values between two ranges indicates a difficulty in establishing specific ranges

Slight increases in the level of nitrates and phosphates in waters and rivers often lead to aspiration phenomena (eutrophization) or an increased number of organisms of specific species. Algae adopt this type of behavior and do so in relation to other types of elements such as sulfur, potassium, magnesium and other elements The fact that in natural water elevation only of nitrogen or phosphorus produces an increased number of organisms means that this water normally contains sufficient quantities of other elements.

Despite the fact that much more nitrogen is required by organisms than phosphorus, in terms of pollution, phosphorus is of much greater importance because even though there is an insufficient nitrogen supply, this can be obtained from the atmosphere, while it is impossible to control levels in water.

Phosphorus, mainly produced by waste water, can be better controlled when preventing pollution. Phosphorus is a highly reactive element and in well oxygenated water it forms in soluble compounds which tend to precipitate, with a large number of metallic cations including calcium. Furthermore, it is widely known that phosphate is absorbed in iron hydroxide (III) and aluminum hydroxide flakes, settling at the bottom of the reservoir. This means that the quantity of phosphate available in waters depends on the concentration of iron III and aluminum in the water, as well as its hardness.

According to the results of the water analysis carried out for this study, the Piedade River presents a concentration of phosphorus is a .close to the dam which, in lakes and reservoirs, would be classified as mesotrophic. However, as the flow system in lakes allows sedimentation of adsorbed phosphates with other particles or as small precipitates, the effective dissolved phosphorus concentration in water will be lower than that present in river water.

The ammonia nitrogen concentration in the Piedade River, in the ADA, was lower than the 3.7 mg/L N level for pH levels below 7.5 (as specified in CONAMA Resolution No. 357, from March 2005). The nitrates and nitride results in the diagnosis indicate their concentration the Piedade River is below that established environmental legislation for class 2 water.

Complementing the evaluation on the risk of developing eutrophization processes in the future SHS reservoir, phosphorus concentrations were estimated using empirical model known worldwide, constructed by Vollenweider (1976), developed mainly for temperate lakes (Von Sperling,1995). Sala and Martino (1991) analyzed experimental data from 40 lakes and reservoirs in Latina America and the Caribbean obtaining, from linear regression, the corrected ratio of Ks (coefficient for phosphate loss from sedimentation) for the environments.

The mathematical expression of the model is:

$$P = \frac{1000L}{V(\frac{1}{t} + K_S)}$$

Where:

- *P*: Is the phosphorous concentration in the reservoir, in gP/m^3 or mg/L;
- *L*: Is the affluent phosphorous load in KgP/year;
- *V*: Is the reservoir volume in m^3;
- *t*: Is the time in years
- K_S: Is the coefficient for phosphorous lost through sedimentation, in year^{-1}.

The empirical expression for Ks obtained by Sala and Martino (1991) is $KS = \frac{2}{\sqrt{t}}$.

Sperling stated that because it was based on regional data (including Brazilian data), the empirical model developed by Salas and Martino (1991) should be the model used for planning and managing lakes and reservoirs under our conditions. He also added that a critical eye and the experience of the researcher must always be present to avoid distortions, given the specific nature of each reservoir or lake.

Considering the amount of phosphates reaching the SHS as the amount from the river and reservoir drainage area, we can state that the inflowing phosphorous level of the future reservoir is at a critical level, 0,11 mg P-PO4/L or 0,035 mg P/L, calculated from monitoring in December 2003, the rainy season. Knowing the average long term flow of the Piedade river, 11.9 m^3/s, we can estimate the phosphorous flowing into the river as 13,471 kg P/year.

Based on the fact that the reservoir volume is 17,520,000 m^3, we can determine the dwell time as approximately 0.047 years and a Ks coefficient of 9.3 $year^{-1}$. We can therefore estimate phosphorous concentration in the reservoir as 25.1 mg P/m^3 or 0.025 mg P/L.

Application of the Vollenweider (1976) empirical model, adapted by Salas and Martino (1991), indicated that the phosphorous concentration in the future Piedade SHS reservoir is characteristic of mesotrophic lakes. Note that this model was mainly developed for temperate lakes and, even with the correction for the Ks coefficient proposed by Salas and Martino, it must be used with caution.

Not accounting for exception factors (anthropogenic factors), the pH value of natural water oscillates between 6.5 and 8.5. The pH influence on the eutrophization process is mainly based on the fact that at higher pH values (> 0.8) phosphates adsorbed by iron (III) and aluminum hydroxides are released again, enriching the water's nutrients. pH above 8.0 can occur naturally in reservoir water during sunny periods because of photosynthesis involving algae, removing CO2 and change the carbonate system (Boers, 1991).

Average pH values on site at the location of the future reservoir, close to the dam, vary between 7.21 and 7.95. The water retention period in the reservoir is characteristic of intermediate environments according to CONAMA 357;05, at affluent flow rates above 5.1 m^3/s. During lower flow periods (dry season) there may be excessive proliferation of algae and excessively high pH. However, we can only evaluate the interaction of this parameter with phosphorous enrichment in the reservoir after it has been created.

In light of this, we can see that there are factors which are favorable and other unfavorable for eutrophization in the reservoir. Morphometric index analysis shows that the reservoir is not highly influenced by the drainage basin, a fact corroborated by diagnostics conducted in the area. The trends presented show that eutrophization is unlikely in the reservoir, although it is related to the interaction of physical and chemical phenomena with external influences. The synergy between different phenomena occurring in the reservoir after it has been formed will be accompanied by the *Limnologic and Water Quality Monitoring Program.*

In terms of plankton communities, please note that there will be a trends towards substantial reduction in organism densities because of reservoir stabilization, which may be followed by a slight rise in population. This means that communities will develop based on plankton organisms and present a composition more similar with lake environments.

Benthic communities will be subject to variation in depth mainly because of light penetration and sediment composition. We therefore estimate that these communities will be more abundant in peripheral areas of the future reservoir. We also believe that in these areas, the main substrate will be clay based, favoring the appearance of organisms more suited to these substrates. Typical rock based substrates will be more restricted because of the loss of these habitats and the substantial reduction of water flow speed over the surface as these organisms are adapted to the speed of the current.

Organic material reaching the water course undergoes a natural neutralization process which mainly includes dilution, sedimentation and biochemical stabilization, a process called self-purification (Branco, 1996). When a pollutant is introduced into this body of water, a specific quantity of oxygen is required mainly to oxidize the organic material, based on aerobic digestion processes carried out by microorganisms. This process is called deoxygenation.

On the other hand, when the oxygen is consumed by the bacteria, this creates a deficit in relation to saturation concentration. This deficit leads to a diffusive flow of oxygen from the air into the body of water. This diffusion will occur faster the more turbulent the water is, because in still waters diffusion mainly occurs through molecular diffusion (slower) and in turbulent water this mechanism is mainly turbulent diffusion (faster). Additionally, the algae use photosynthesis to contribute towards oxygenation of natural water. This process is called reoxygenation.

Oxygen concentration in the future reservoir was estimated using the mathematical model from Streeter-Phelps (Von Sperling, 1995), which takes into consideration the following factors:

- Only atmospheric reaeration
- Oxygen consumption from biological decomposition of organic material; and
- Piston flow, i.e. looking at the body of water as a continuous reactor, mixing downstream water with upstream water.

This model is restricted to the aerobic conditions of the body of water, no including or modeling the anaerobic decomposition of organic material. The mathematical expression of the model is:

$$C_t = C_S - \left[\frac{K_1 L_0}{K_2 - K_1} (e^{-K_1 t} - e^{-K_2 t}) + D_0 e^{-K_2 t} \right]$$

Where:

- C_t: Is the concentration of dissolved oxygen in mg/L, in time "t", in days;
- C_S: Is the saturation concentration of dissolved oxygen in mg/L;
- K_1: Is the deoxygenation coefficient in d^{-1};
- K_2: Is the reoxygenation coefficient;
- L_0: Is the DBO_5 concentration in mg/L, at initial time (t = 0); and,
- D_0: Is the oxygen deficit ($C_s - C_0$) in t = 0.

The study considered some of the results obtained from the sampling point on the Piedade river (PIE-01) and data in bibliographic references, cited in Table 6.2. We chose to use data collected in December which represents the most critical situation.

Table 6.2
Input data in the mathematical model

Parâmetros	PIE-01 – Dezembro/03
DBO_5 (mg O_2/L)	1.51
Dissolved Oxygen (mg O_2/L)	7.21
Piedade river temperature (°C)	22.0
Altitude above sea level (m)	639
Reservoir length (km)	4.42
Deoxygenation content (dia^{-1})	0.30
Physical reaeration constant (dia^{-1})	0.37

Considering the long term average flow of the Piedade river, 11.9 m^3/s, we obtain a water dwell time of approximately 17 days.

Below is a calculation for the self-purification study on the Piedade SHS stretch of the river.

LIMIAR ENGENHARIA AMBIENTAL

SELF-PURIFICATION STUDY

Reservoir section

DBOr =	*1,51*	DBO of the Piedade river (mg/L)
Tr =	*22*	Temperature of the Piedade river (°C)
ODr =	*7,21*	OD of the Piedade river (mg/L)
K1 =	*0,3*	Deoxygenation constant (1/dia)
K2 =	*0,37*	Physical reaeration constant (1/dia)
H =	*639*	Height above sea level (m)
v =	*0,26*	River surface flow speed (km/dia)
Dist =	*4, 420*	Lake distance to the dam (km)

Cálculo da OD de saturação (mg/L)

$$Csl = (14{,}652 - 0{,}41022 \cdot Tr) + 0{,}799 \cdot 10^{-2} \cdot Tr^2 - 0{,}77774 \cdot 10^{-4} \cdot Tr^3$$ *Csl =* *8,67*

$$Cs = (1 - \frac{H}{9450}) \cdot Csl$$ *Cs =* *8,08*

Cálculo da DBO carbonácea (mg/L)

$$Lr = \frac{DBOr}{1 - e^{-K1 \cdot 5}}$$ *Lr =* *1,9*

Cálculo do déficit inicial de oxigênio (mg/L)

$$Dr = Cs - ODr$$ *Dr =* *0,87*

Correção de K1 e K2

$$K1T = K1 \cdot 1{,}047^{Tr-20}$$ *K1T =* *0,33*

$$K2T = K2 \cdot 1{,}029^{Tr-20}$$ *K2T =* *0,39*

Cálculo do tempo crítico (dias) e do ponto crítico (km)

$$tc = \frac{1}{K2T - K1T} \times \ln\left[\frac{K2T}{K1T} \times \left(1 - Dr \times \frac{K2T - K1T}{Lr \times K1T}\right)\right]$$ *tc =* *1,38*

$$Xc = v \cdot tc$$ *Xc =* *0,36*

Cálculo do déficit crítico de oxigênio (mg/L)

$$Dc = \frac{K1T}{K2T} \cdot Lr \cdot e^{K1T \cdot tc}$$ *Dc =* *1,05*

Cálculo do OD crítico (mg/L)

$$ODc = Cs - Dc \qquad ODc = 7{,}03$$

Cálculo da DBO carbonácea crítica (mg/L)

$$Lc = Lr \cdot e^{-K1T \cdot tc} \qquad Lc = 1{,}24$$

Cálculo da DBO_5 crítica (mg/L)

$$DBOc = Lc \cdot (1 - e^{-K1 \times 5}) \qquad DBOc = 0{,}96$$

Cálculo da DBO remanescente no rio a montante do barramento (mg/L)

$$t = \frac{Dist}{v} \qquad t = 17{,}040$$

$$L = Lr - (Lr(1 - e^{(-K1 \cdot t)})) \qquad L = 0{,}012$$

Cálculo de pontos adicionais

$$C_t(t) = Cs - \left(\frac{K1T \cdot Lr}{K2T - K1T}\right) \cdot (e^{-K1T \cdot t} - e^{-K2T \cdot t}) + Dr \cdot e^{-K2T \cdot t}$$

According to the results of the mathematical method, oxygen concentration will always be above 7.03 mg/L O2 (Critical point) along the reservoir water course (Figure 6.1). It is important to note that all of the calculations were based on data from the physical and chemical analysis of the Piedade river, and the mathematical model used is widely acknowledged worldwide.

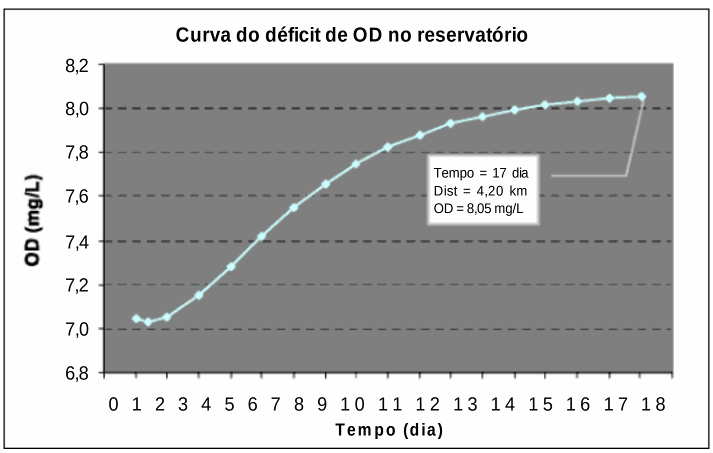


Figure 6.1 Dissolved oxygen deficit curve in the Piedade SHS reservoir at the most critical point (December 2003).

Based on the surveys conducted, we believe that the water course will contain sufficient quantities of dissolved oxygen for oxygenation of nutrients and organic material in this basin, which leads us to a low probability that there will be processes compromising the environmental and sanitary quality of the future system stop

The section of the Piedade river in the SHS area of influence was seen to be very stable throughout the hydrological cycle in terms of physical and chemical quality of the water. There are obviously variations in several of the parameters analyzed, but these are mainly due to variations in regional climate conditions throughout the year, and could be considered natural fluctuations based on seasonal variations in temperature and rainfall.

The biological communities are also subject to variations depending on the hydrological cycle. Based on the phyto, zooplankton and zoobenthic analysis, we saw no biological loss in terms of species or diversity during the analysis period. The community parameters measured in this water course suggests that the environment is dynamically stable, although there have been previous events which have affected diversity, suggested by the lower levels of ´phytoplankton. These events may include the construction of upstream dams and modifications to land usage, such as the removal of the original vegetation for farming activities.

Evaluation of the morphological impacts shows that the reservoir is not highly influenced by the drainage basin, a fact corroborated by diagnostics conducted in the area. Application of the Vollenweider (1976) empirical model, adapted by Salas and Martino (1991), indicated that the phosphorous concentration in the future Piedade SHS reservoir is characteristic of mesotrophic lakes. Therefore, the trends that have been presented showed that it is unlikely that they will be eutrophization in the reservoir, although it is related to the interaction of physical and chemical phenomena with external influences. The synergy between different phenomena occurring in the reservoir after it has been formed will be accompanied by the *Limnologic and Water Quality Monitoring Program.*

6.2 BIOTIC ENVIRONMENT

Changes to the Piedade SHS engineering project will not result in the appearance of further environmental impacts on the biotic environment. Mainly based on the increased reservoir area, some previously identified environmental impacts will be intensified, for example vegetation suppression, however in the newly affected areas we found no different types of vegetation to those described in previous studies based on the original project.

The proposed environmental programs to mitigate any impacts will be maintained, however they will be adapted when implemented based on alterations to the development project. The SHS Piedade reservoir will affect three waterfalls which may represent important environments for martin reproduction and nesting, as well as two locations on the TVR. Therefore, based on the magnitude of these changes, the impact is commented on below:

6.2.1 Loss of Habitats for Martin Species (STREPTOPROCNE ZONARIS and CYPSELOIDES SENEX)

Reservoir of filling or flow reduction (TVR) in areas around the waterfalls may destroy habitats for two species of martin, registered in the project area. Two species of martin (*Streptoprocne zonaris* and *Cypseloides senex*), both have a highly specific connection with this habitat because of shelter and nesting, with colonies around the sites.

During on-site visits to adapt to the EIA to the new engineering project, the waterfalls which will be flooded by the reservoir were visited but this species was not present in the area. However, the time of year that the inspections were made were not the most suitable for finding martins, because the reproductive phase of most neotropical birds had ended. Furthermore, the flow is observed in the bodies of water was higher, which is an important factor in dispersing species of martin.

The effects of this impact, if the presence of martins is confirmed around the waterfalls, may be considered direct, regional, negative, long-term, irreversible, important, high magnitude and significant. The effects can be mitigated by executing the "Martin (*Cypseloides senex* and *Streptoprocne zonaris*) Monitoring Program" already proposed in the PCA (LIMIAR, 2004), in order to confirm the presence of the species in this locations and draw up measures for conservation and effective control. The aforementioned program will be adapted to the new areas affected by the project however the methodological procedures and objectives will remain the same

6.2.2 SOCIOECONOMIC ENVIRONMENT

This study, carried out between March 12 and 16 2007, focused on updating information regarding the municipal region of Monte Alegre de Minas, updating information on properties located in the low flow section (based on changes to the water channel route) and detailed surveys on new properties affected by the reservoir and power station.

Notes of the observations made in a new field survey do not include changes to preventive and mitigating measures indicated previously, because any interference from the new Piedade SHS project in terms of properties affected can also be mitigated/monitored by the Land and Improvement Negotiation and Socioeconomic Aspect Monitoring Programs, Support Plan. We should point out that these actions should include the new properties and inhabitants affected by the project (21 properties are affected altogether, following alterations to the Piedade SHS project).

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