FACT OR FICTION

A Review of the Hydrovia Paraguay-Paraná Official Studies

Full Report and Executive Summary

Huszar, P., Petermann P., Leite A., Resende E., Schnack E., Schneider E., Francesco F., Rast G., Schnack J., Wasson J., Garcia Lozano L., Dantas M., Obrdlik P., Pedroni R. (1999). *Fact or Fiction: A Review of the Hydrovia Paraguay-Paraná Official Studies.* Toronto, Canada. World Wildlife Fund/World Wide Fund for Nature (WWF). 217 pp.

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In North America:
WWF Canada
245 Eglinton Avenue East, Suite 410
Toronto, Ontario M4P 3J l
Canada
Phone: + 1 416 489 8800
Fax: + 14164893611
E-mail: aleite@wwfcanada.org

WWF-US
Latin America and Carribean Program
1250 Twenty-Fourth St., NW.
Washington, DC 20037-1175
USA
Phone: + 1 202 293 4800
Fax: 1 202 296 5348
E-mail: paulo.lyra@wwfus.org

In Europe:
WWF-Auen-Institut
Josefstrasse 1
W-7550 Rastatt
Germany
Phone: + 49 72 22 38 07
Fax: + 49 72 22 38 99
E-mail: wenger@wwf.de

In Latin America:
WWF Bolivia Program Office
Calie Guemes #4
Barrio Equipetrol
Santa Cruz de la Sierra
Bolivia
Phone/Fax: + 59 13 32 54 16
E-mail: pcaffrey.wwf@infonet.com.bo

WWF-Brazil
SH1S EQ QL 6/8
Conjunto E - 2 andar
71620-430 Brasilia, Brazil
Phone: + 55 61 248 2899
Fax: +556 1 3643057
E-mail: bernadete@wwf.org.br

Fundación Vida Silvestre
Defensa 245/5 1,
6 Piso
1065 Buenos Aires
Argentina
Phone: + 54 1 331 4864
Fax: +541 331 3631
E-mail: fvsadg@vidasilvestre.org.ar

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Back Cover Photos: (clockwise from top) Woman selling fish in Corumbá, Brazil: André Leite/WWF Canada; Jabiru stork *(Jabiru mycteria):* André Leite/WWF Canada; Rufescent tiger-heron *(Tigrisoma lineatum):* André Leite/WWF Canada; Barge near Puerto Esperanza, Brazil: André Leite/WWF Canada; Fishermen, Aunción, Paraguay: André Leite/WWF Canada; Marsh deer *(Blastocerus dichotomus):* André Leite/WWF Canada; Fresh and salt water lakes in the Pantanal of Nhecolândia, Brazil: André Leite/WWF Canada; Water hyacinth *(Eichhornia crassipes):* André LeiteIWWF Canada; Dredge operating on the Tamengo Channel, Bolivia: André Leite/WWF Canada.

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A REVIEW OF THE HYDROVIA PARAGUAY-PARANÁ OFFICIAL STUDIES

WWF Report Co-ordinator:
André Leite

REVIEW AND CRITIQUE OF THE ENVIRONMENTAL IMPACT ASSESSMENT

Scientific Panel Co-ordinator:
Peter Petermann

Scientific Panel:
Dr. Mário Dantas
Prof. Fernando O. de Francesco
Dr. Luis Carlos Garcia Lozano
Dr. Petr Obrdlik
Raul M. Pedroni
Georg Rast
Dr. Emiko Kawakami de Resende
Dr. Enrique Schnack
Dr. Juan Alberto Schnack
Dr. Erika Schneider
Dr. Jean-Gabriel Wasson

Contributions from:
Helmut Friedrich
André Leite
Dr. Guy Morrison
Dr. Arnildo Pott
Dr. Edith Wenger

REVIEW AND CRITIQUE OF THE ECONOMIC FEASIBILITY STUDY:

Dr. Paul Huszar

Contributions from:
Sigrid Andersen
André Leite

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André Leite, M.A.
Director, Hydrovia Paraguay-Paraná Campaign
and Report Co-ordinator
World Wildlife Fund Canada

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EXECUTIVE SUMMARY

PART I BACKGROUND

The Paraguay-Paraná River system flows south through Brazil, Bolivia, Paraguay, Argentina, and Uruguay, draining La Plata Basin and spanning an area of 1.75 million square kilometers. The ParaguayParaná River system forms a 3,440 kilometer waterway from the mouth of La Plata Basin, on the Atlantic coast between Uruguay and Argentina, to Cáceres in the state of Mato Grosso, Brazil, in the heart of South America (Figure 1.1).

In 1991, Argentina, Brazil, Paraguay, and Uruguay formed MERCOSUR, the Southern Cone Common Market of South America. MERCOSUR represents Latin America's largest economic base, with a market of nearly 200 million people and a gross regional product of U.S. $427 billion per year. Because the waterway passes through these countries, it has a high symbolic value for the integration of their economies.

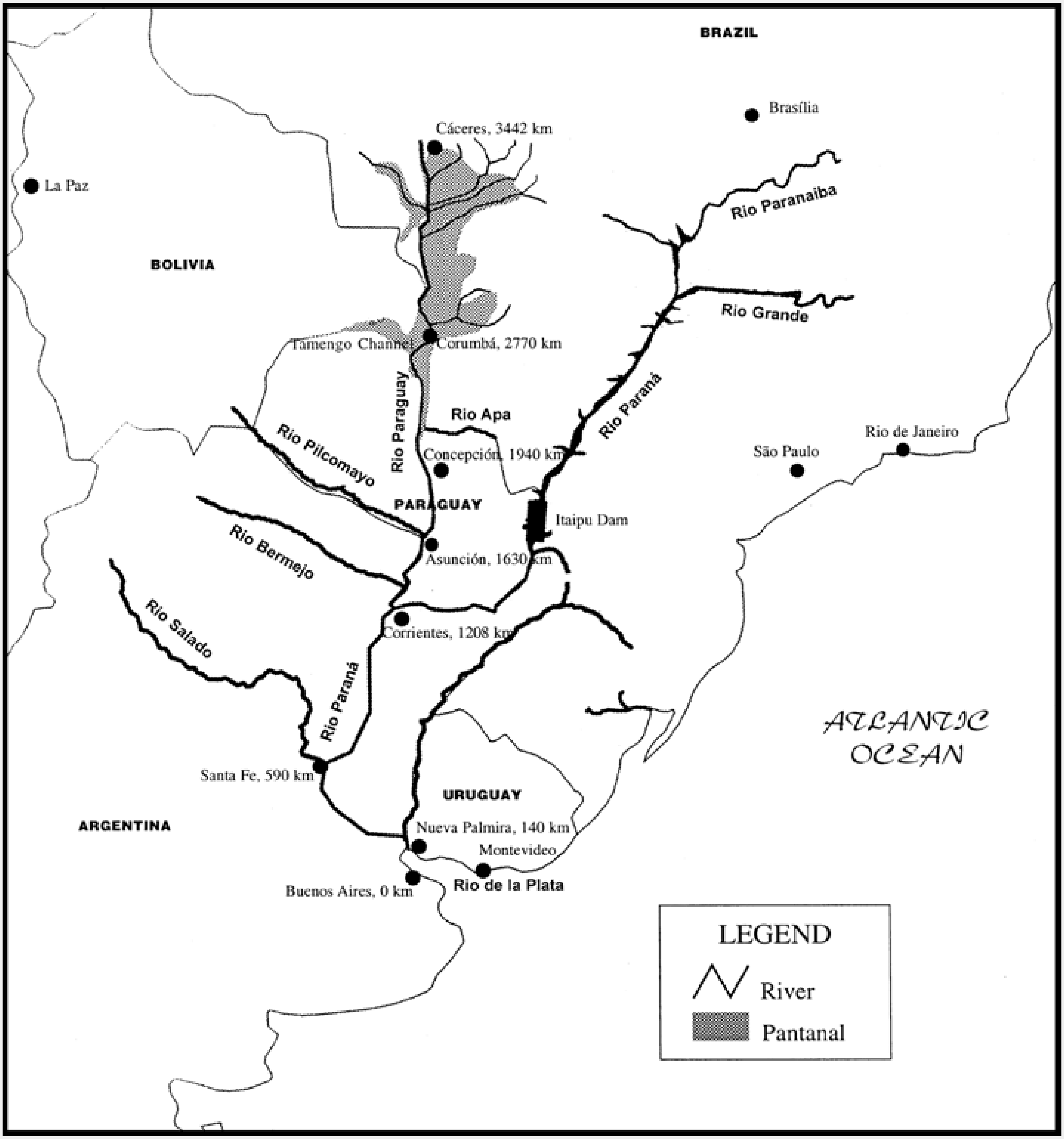
A major impediment to increased trade for Latin America, and hence economic growth, is the lack of transportation infrastructure. Although the river system has been used as a waterway since pre-Columbian times, and ports and other navigational improvements have been constructed since then, transportation facilities have been poorly maintained. The World Bank estimates U.S. $14 billion per year will be required until 2005 to compensate for over 15 years of neglected attention to transportation infrastructure in Latin America (Burki & Edwards, 1995). Within MERCOSUR, several transportation projects are underway or in the planning stages. One of the most ambitious and controversial of these is the Hydrovia Project.

The initial goal of the Hydrovia Project was to make the Paraguay-Paraná River system navigable yearround from Nueva Palmira, Uruguay to Cáceres, Brazil (Internave Engineering, 1992) (Figure 1.1). This would be achieved by dredging a uniformly deep and wide river-bed within this section of the river system. Presently, vessels of up to 100 meters in length can navigate only the first 1,208 kilometers up to Corrientes, Argentina, at which point smaller vessels must be used to reach Asunción, Paraguay. Navigation upstream of Asunción becomes increasingly difficult (Jelen, 1995) due to the occurrence of sand banks and rock outcrops.

The rivers pass through landscapes characterized by extensive floodplain wetlands. Most famous of these is the Pantanal, an ecosystem of global importance, which lies predominantly in Brazil, with smaller portions in Bolivia and Paraguay. Renowned for abundant wildlife and fisheries (Dubs, 1983; Por, 1995), and as a staging area for waterfowl and shorebirds that migrate throughout the Western Hemisphere, the Pantanal is the dominant wetland feature of the southern half of South America and is arguably the greatest freshwater wetland in the world.

The Pantanal is a complex set of different ecosystems, each exhibiting specific characteristics due to the variation in water regimes among seasons and years. Every year in the Pantanal is unique, depending on remote precipitation and local rainfall. The source of water and the slope of the terrain also characterize the flooding cycles of the Pantanal.

Figure 1.1 Map of Project Site



Source: André Leite, WWF Canada

Disruption of the natural balance of the Pantanal by dredging and other interventions would alone make the existing development proposal questionable.

In 1989, the Brazilian government commissioned Internave Engineering to conduct a feasibility study of the Hydrovia Project. Internave's report, released in 1992, concluded that the Project was both physically and economically feasible. The study, however, contained many calculation errors and omitted environmental costs.

One year following the Internave Engineering study, Wetlands for the Americas commissioned an analysis of the potential environmental benefits and costs of the Hydrovia Project (Bucher et al. , 1993). Conducted by a multidisciplinary group of scientists, the analysis showed the Project was not feasible when environmental costs were considered. Moreover, it highlighted numerous potential environmental costs that should be considered in a more complete assessment of the Project. Foremost among these was severe detrimental impact on the Pantanal.

A second important report on the economics of the Hydrovia Project was prepared by World Wildlife Fund (WWF). The report, "Who Pays the Bill?" (CEBRAC et al. , 1994), highlighted that, in purely economic terms, the Hydrovia Project is not a good investment for the countries.

In response to the Wetlands for the Americas and WWF studies, as well as pressure from many nongovernmental organizations, the Inter-American Development Bank (IDB) rejected the findings of Internave Engineering and called for a more complete and accurate study of the Hydrovia Project. In 1995, the Intergovernmental Committee on Hydrovia (CIH) — a multilateral body of the governments of Argentina, Bolivia, Brazil, Paraguay, and Uruguay — commissioned two 18-month-long studies of the proposed Hydrovia Project. The studies were administered by the United Nations Office for Project Services (UNOPS). Figure 1.2 depicts the structure around the CIH, and Figure 1.3 details the thematic and geographic mandates of the two studies.

The first study, consisting of an engineering-economic analysis of the Hydrovia Project, was conducted by a consortium of consulting firms: Hidroservice, Louis Berger, and EIH (collectively HLBE). The second study, an environmental impact assessment (EIA), was conducted by a consortium of consulting firms: Taylor Engineering Inc., Golder Associates Ltd., Consular Consultores Argentinos Asociados S.A., and Connal Consultora Nacional (collectively TGCC). IDB provided approximately U.S. $11 million for both studies. The two analyses were supposed to be linked together in order to identify and measure the environmental costs, thereby providing a complete analysis of the benefits and costs of the Project and, therefore, its overall social value and desirability.

These studies concluded that environmental consequences of the Project are negligible and that the Project is feasible from both an engineering and an economic standpoint. The results were accepted by the CIH in December 1996 and were sent to the participating countries for their approval and commitment to begin construction of the Project. Although formal approval of the EIA has yet to be given, Argentina, Bolivia, Brazil, and Paraguay have begun the first steps of dredging.

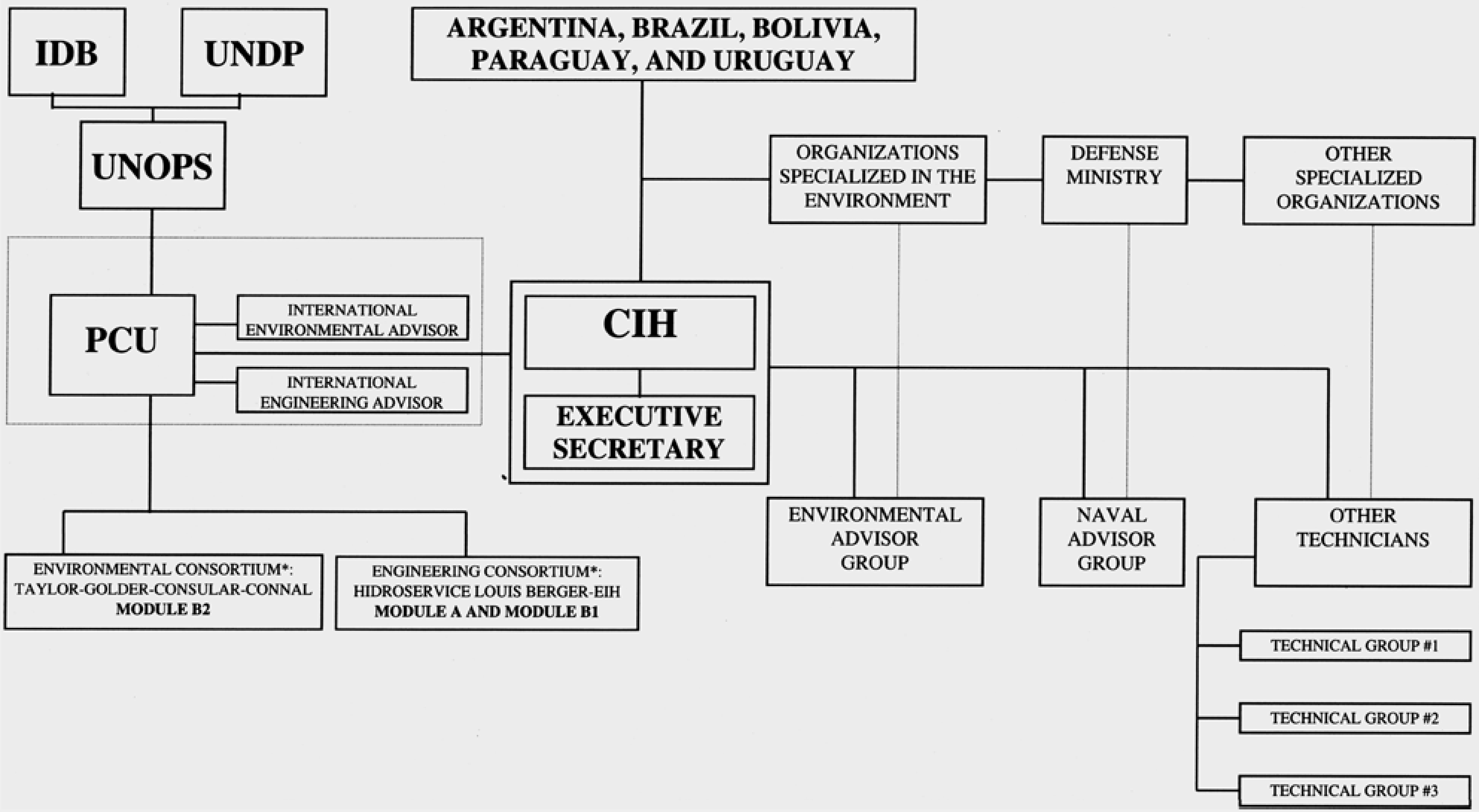
When draft studies were released in December 1996, WWF commissioned a review of both studies through a multidisciplinary group of international experts. Three teams were formed: a regional team with experts from the countries directly affected by the Project; an international team, with experts on river ecology and hydrology; and an economic team, responsible for reviewing the economic component of the engineering-economic feasibility analysis undertaken by HLBE.

The teams examined a complete set of volumes comprising the Final Report of the EIA and the engineering-economic analysis, released in February 1997. They worked independently under the same methodological guidance, travelling extensively in the region. During a week-long meeting, all the consultants shared their findings, conclusions, and recommendations. The review began in March 1997 and finished in August 1998. Two papers were produced: (1) Review and Critique of the Economic Feasibility Study and (2) Review and Critique of the Environmental Impact Assessment. Great effort has been taken to avoid repetition in material presented in the earlier critiques; therefore, this present independent review should be seen as a sequel to the earlier publications expressing concern over the Hydrovia Project.

The environmental concerns that arise from the proposed Hydrovia Project. have been expressed in several publications (Bucher et al. , 1993; CEBRAC et al., 1994; Ponce, 1995; Galinkin et al. , 1996; Hamilton, 1996; EDF/CEBRAC, 1997). They provide the necessary background to understand the natural resources that could be seriously affected if the Hydrovia Project was implemented as planned, as well as some of the social consequences that could follow. They also investigate critically the economic feasibility of the Project.

This independent review does not attempt to produce an alternative EIA. It will show, however, that the attempt to produce an EIA has failed, and will make recommendations for further planning under the circumstances. This review will also show that there are a number of conceptual, procedural, measurement, and calculation errors in the engineering-economic analysis, which when corrected, significantly alter HLBE' s conclusions. These corrections lead to the conclusion that the Hydrovia Project is not economically feasible.

Figure 1.2 CIH -- ORGANIZATIONAL STRUCTURE



*On September 23rd, 1991, in New York, the chancellors of the four MERCOSUR countries (Argentina, Brazil, Paraguay, and Uruguay) and Bolivia signed a technical co-operation agreement with IDB, which involved U.S. $7.5 million for the following studies: a technical-economic feasibility study, a socio-economic feasibility study, cartography, signalization, and environmental studies of the Hydrovia Project. The agreement was followed by the signing of additional agreements to help in the execution of the Hydrovia Project. In addition, the Financing Fund for the Development of La Plata Basin (FONPLATA) gave U.S. $1.6 million, and the United Nations Development Program (UNDP), gave U.S. $485,240. A contribution of U.S. $1.3 million by IDB towards technical services was also granted to the Project Coordination Unit (PCU). This resulted in a total of U.S. $10,885,240 involved in the waterway studies and for the management of the CIH.

Source: Gucovsky (1996), and André Leite, WWF Canada.

PART II THE HYDROVIA PARAGUAY-PARANÁ PROJECT

2.1 Goals for the Improvement of the Paraguay-Paraná River System

The proposed plan of the Hydrovia Project is to create and maintain a navigation channel in the Paraguay and Paraná Rivers that is sufficiently deep and wide to guarantee “round-the-clock” navigation for 90 percent of the year during the following 10 years. The size of the canal would be determined by the size of the barges. The planned improvements of the Paraguay-Paraná waterway consist of several parts:

a) modifications of the river channel morphology to make it suitable for year-round traffic and larger convoys than presently use the waterway;

b) signalization of the river channel to permit 24-hour traffic and to improve safety; and

c) construction of new harbor facilities and other infrastructure, as well as improvement of existing facilities to service the increased shipping capacity of the new river channel.

2.2 Description of the Hydrovia Paraguay-Paraná Project

In planning the Hydrovia Project, several divisions of the Paraguay-Paraná River system have been developed:

a) Planning units: The Project was divided into three sections: Module A, from Nueva Palmira (Uruguay) to Corumbá and Tamengo Channel (Brazil/Bolivia); Module B1, from Nueva Palmira to Cáceres (Brazil), including the Tamengo Channel; and Module B2 which refers to environmental analysis, environmental impact assessment, and monitoring and mitigation studies carried out on the entire Project’s extent (Figure 1.3). Note that since only signalization will be necessary on the stretch from Nueva Palmira to Santa Fe, Module A details only the necessary, immediate, short-term engineering interventions (dredging and signalization) from Santa Fe to Corumbá. Module A also includes an environmental impact assessment of the Nueva Palmira-Corumbá and Tamengo Channel reach. Module B1 refers to the preliminary, shortterm engineering work and preliminary economic and technical feasibility analyses for the Corumbá-Cáceres reach. Module B1 also refers to the preliminary long-term, engineering studies for the Nueva Palmira-Cáceres reach. The term “preliminary” is used because if any of these planned interventions is undertaken, the studies will have to be completed.

b) Navigation units: Decisions were made for each module concerning the future minimum size of the waterway. The greatest convoy size would travel from Santa Fe to Asunción (four-by-five barges per convoy), while the size would be reduced between Asunción and Corumbá, including the Tamengo Channel (four-by-four barges per convoy) — scenario F2E1 (HLBE). Smaller one-by-two barges per convoy would be used from Corumbá to Cáceres — scenario B2[1]. This would imply that all greater convoy sizes would show even less tolerable ecological impacts, without any economic benefit. HLBE's recommendation, however, is clearly not to implement scenario B2 if the Ferronorte is built. The Ferronorte railway, currently under construction, could carry soybeans from Cuiabá to São Paulo and Rio de Janeiro, and to the port of Sepetiba, Brazil, for shipment to other major markets in the Far East (Silva, 1996).

c) Ecoregions: Based on Bucher et al. (1993), the river basin was subdivided according to hydrological characteristics: Pantanal/Upper Paraguay (Cáceres to Apa River); Lower Paraguay (Apa River to ConfluencialParaná River); Lower Paraná (Confluencia to Santa Fe); and Delta (Santa Fe to Nueva Palmira). These ecoregions are not ecologically homogeneous and therefore are not entirely satisfactory subdivisions. For example, the Bermejo River and the Pilcomayo River are significantly different from other rivers in the basin in their physical and chemical characteristics.

It must be emphasized here that the engineering plans for the modifications of the river channel are still largely incomplete. This is true for both Modules A and B1. For example, there are only general recommendations for the disposal of dredged material, but no definite plans. There is no indication in the assessment of how many sites along the river may not be able to meet the general recommendations for disposal of dredged material.

Dredging plans for Module A are probably complete, but specific plans cannot be found in either the engineering study by HLBE or in the EIA. A detailed judgement about their immediate impacts is thus precluded. Plans for Module B1 are still incomplete, but again the EIA does not even reveal the existing parts of these plans. Only the modifications and signalization of the river channel are part of the EIA, although improvements in the harbor facilities and shipping should have been included in the studies, since they, too, could cause environmental impacts.

For both modules, the basis for the calculation of the amount of sediments to be dredged is not explained, though this information is crucial for both the economic feasibility analysis and the EIA.

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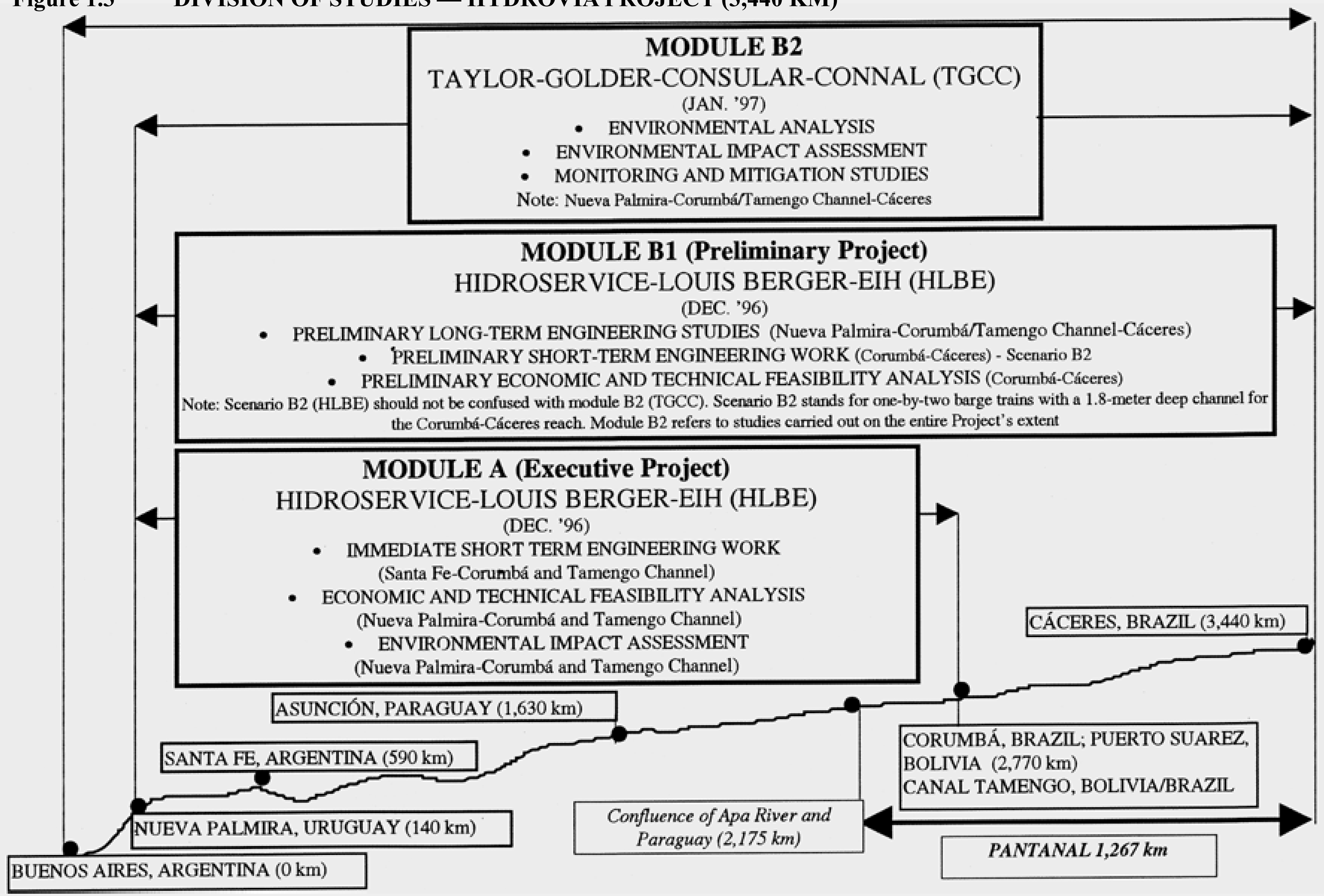
[1] Scenario B2 (HLBE) should not be confused with module B2 (TGCC). Scenario B2 stands for one-by-two barge trains with a 1.8-meter deep channel for the Corumbá-Cáceres reach. Module B2 refers to studies carried out on the entire Projects extent.

Figure 1.3 DIVISION OF STUDIES — HYDROVIA PROJECT (3,440 KM)



The Project was divided into three sections: Module A from Nueva Palmira (Uruguay) to Corumbá and Tamengo Channel (Brazil/Bolivia); Module B1, from Nueva Palmira to Cáceres (Brazil), including the Tamengo Channel; and Module B2 which refers to environmental analysis, environmental impact assessment, and monitoring and mitigation studies carried out on the entire Project's extent. Note that since only signalization will be necessary on the stretch from Nueva Palmira to Santa Fe, Module A details only the necessary, immediate, short-term engineering interventions (dredging and signalization) from Santa Fe to Corumbá. Module A also includes an environmental impact assessment of the Nueva Palmira-Corumbá and Tamengo Channel reach. Module B1 refers to the preliminary, short-term engineering work and preliminary economic and technical feasibility analyses for the Corumbá-Cáceres reach. Module B1 also refers to the preliminary long-term, engineering studies for the Nueva Palmira-Cáceres reach. The term 'preliminary" is used because if any of these planned interventions is undertaken, the studies will have to be completed.

The Tamengo Channel provides the only link for Puerto Suarez and Puerto Aguirre the main Bolivian transportation ports. The Channel is the only link from Bolivia to the Paraguay River across the Brazilian border.

Source: André Leite, WWF Canada.

PART III REVIEW AND CRITIQUE OF THE HYDROVIA PARAGUAY-PARANÁ ECONOMIC FEASIBILITY STUDY

HLBE conducted an engineering-economic evaluation of a total of 21 scenarios for improving navigation on the Paraguay-Paraná River system. A "base case" against which to compare a number of scenarios was defined (Table 1.1). As explained in detail later, the "base case" is in fact not an independent scenario from the so-called "alternative scenarios," but a required part of each alternative scenario.

HLBE concluded that several scenarios are economically feasible, and from these the CIH selected a scenario (F2E1) that would accommodate four-by-five barge trains on the Santa Fe-Asunción reach with a three-meter deep channel, and four-by-four barge trains on the Asunción-Corumbá reach with a 2.6-meter deep channel.

HLBE evaluated alternative scenarios for the Corumbá-Cáceres reach of the river and concluded that scenario B2, which would accommodate one-by-two barge trains with a 1.8-meter deep channel, would be economically feasible, provided that the Ferronorte railroad from Cuiabá to Santos is not completed. [2]

3.1 Evaluations of the Scenarios

Evaluations of the scenarios differ from the way the base case was treated, thus making the scenarios appear more favorable:

a) A 20-year period was used for the base case evaluation, while a 24-year period was used for evaluation of the alternative scenarios. The effect on the Net Present Value (NPV) for the alternative scenarios is not large, but this type of carelessness is indicative of much of the HLBE analysis.

b) HLBE's initial construction and annual maintenance costs for its base case scenario differ between its evaluation of the base case in isolation and its evaluation of the alternative scenarios. Lower costs are used by HLBE to evaluate the base case, making it appear economically feasible; and then higher costs are used when the scenarios are evaluated, making the alternative scenarios appear more economically feasible in comparison to the base case.

c) Multiplier benefits associated with the construction and operation of scenario E2E1 (Table 1.1), or what can be considered benefits to development, are included in the evaluation.

d) No additional environmental costs are identified with scenarios E2E1 and F2E1. HLBE assumes that all environmental costs would result from constructing the base case, and additional dredging for these scenarios would have no additional environmental costs.

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[2] Scenario B2 (HLBE) should not be confused with module B2 (TGCC). Scenario B2 stands for one-by-two barge trains with a 1.8-meter deep channel for the Corumbá-Cáceres reach. Module B2 refers to environmental analysis, environmental impact assessment, and monitoring and mitigation studies carried out from Nueva Palmira to Cáceres.

e) HLBE' s alternative scenarios are not additions to the base case, but actually require its construction. These scenarios should be evaluated in terms of all of their benefits and costs. As the alternative scenarios and base case are interdependent projects, the correct analysis is to evaluate the NPV of each project and select the one with the greatest NPV (Sassone & Schaffer, 1978). HLBE calculates only the total values of benefits and costs for the scenarios under consideration. Table 1.1 uses the data from HLBE to calculate the total values of benefits and costs for the scenarios under consideration.

Table 1.1 Summary of HLBE's Base Case and Scenario EM, F2E1, and B2 Evaluations Adjusted to Reveal Total Benefits and Costs

Benefits and Costs	**Base Case**	**E2E1**	**F2E1**	**B2/F2E1**
Convoy Design				
Santa Fe—Asunción	4x4	4x4	4x5	4x5
Asunción—Corumbá	3x4	4x4	4x4	4x4
Corumbá—Cáceres	—		—	1x2
Channel Depth				
Santa Fe—Asunción	2.0 m	3.0 m	3.0 m	3.0 m
Asunción—Corumbá	2.0 m	2.6 m	2.6 m	2.6m
Corumbá—Cáceres	—	—	—	1.8 m
Navigation Hours per Day	18	22	22	22
	(millions U.S. $)	(millions U.S. $)	(millions U.S. $)	(millions U.S. $)
Benefits of Improved Navigation				
Annual 1997	0	0	0	0
Annual 1998	$21.15	$31.74	$31.74	$40.52
Annual 2016	$32.69	$55.78	$61.12	$83.11
Other Benefits to Development				
Annual 1997	0	0	0	0
Annual 1998	0	$3.05	$3.05	$3.05
Annual 2016	0	$8.00	$8.00	$12.89
Dredging and Signals				
Initial	$29.94	$86.49	$87.78	$102.25
Annual	$6.62	$18.18	$18.92	$21.86
Environmental Costs				
Initial	$0.76	$0.76	$0.76	$0.95
Annual 1998	$0.23	$0.23	$0.23	$0.35
Annual 2016	$0.38	$0.38	$0.43	$0.50
Net Present Value (NPV)	$90.96	$91.33	$85.36	$148.65
Internal Rate of Return (IRR)	50.62%	25.21%	24.18%	28.45%

Source: 1-1Lb1 (199b), Tables 9.11 and 2.23

Regardless of which scenario is being recommended, WWF' s review indicates that the economic feasibility of all of HLBE' s scenarios is highly doubtful. There are numerous errors in the evaluation, which when corrected, indicate that none of the scenarios meet the minimum economic requirements of the IDB, and none of the scenarios produce positive net economic returns to society. Instead, HLBE's errors systematically contribute to overestimating benefits of the Project while underestimating costs.

3.2 Measurement and Calculation of Errors

There are a number of measurement and calculation errors in HLBE's cost-benefit analysis, concerning: a) probability of a collapse in navigation and benefits of guaranteeing navigation; b) alternative transportation of regional production; c) growth of regional production; d) construction costs; and e) environmental costs.

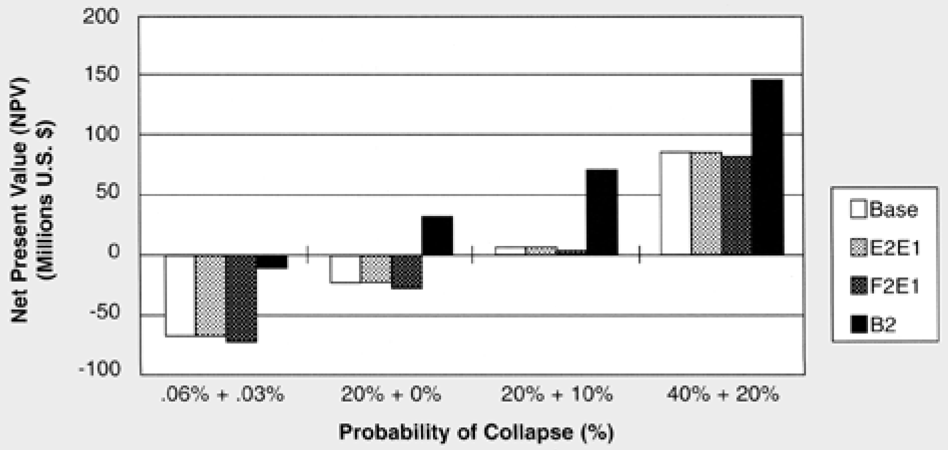
a) HLBE exaggerates the probability of a collapse in navigation and, as a result, the benefits that would be produced by avoiding such a collapse.

   Even if it is assumed, as HLBE does, that monthly flows are independent events, then it is each monthly observation that has a 1/25, or four percent, probability of occurring, not each year as indicated by HLBE. The probability of three months with flows below two meters then must be $(l/25)^3$ = $(4 \text{ percent})^3$ = 0.0064 percent. If 10 of their artificial years have three months with flows below two meters on the Asunción-Corumbá reach, then the probability of what HLBE calls a collapse is 10 times 0.0064 percent, or 0.064 percent, not the 40 percent they suggest. Similarly, if five of the artificial years have three months with flows below two meters on the Santa Fe-Asunción reach, then the probability of a collapse is five times 0.0064 percent, or 0.032 percent, not the 20 percent HLBE calculates.

   In addition, HLBE states that a collapse in navigation occurs when flows are too low for shipments for a three-month period; however, HLBE calculates the benefits of avoiding a collapse as the savings in transportation costs for 12 months.

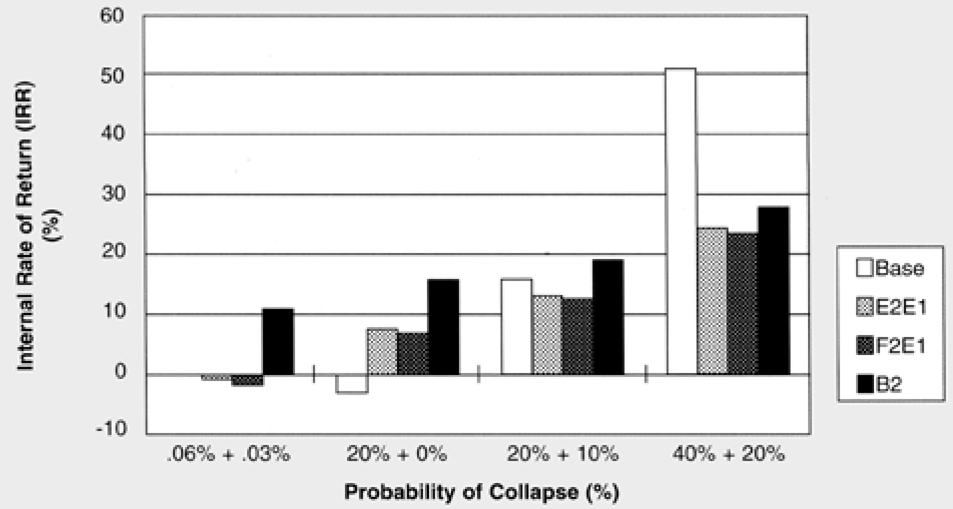
Figure 1.4 Effects of Changing the Probability of a Collapse

a. Effects on NPV



(Asunción-Corumbá & Santa Fe-Asunción Reaches)

b. Effects on IRR



(Asunción-Corumbá & Santa Fe-Asunción Reaches)

b) HLBE ignores competition from alternative forms of transportation, with the exception of the Ferronorte railroad.

Other modes of transportation are also being improved and constructed in the region. For example, it now seems clear that the Ferronorte railroad will be completed and that, as a result, scenario B2 is not economically feasible. While HLBE recognized this possibility, improvements to and construction of other transportation routes in the region were completely ignored.

a) HLBE likely overestimates the growth in shipments from the region, particularly soybean.

   HLBE assumes past growth trends will continue into the future when evidence from research groups such as the Fundação Centro Brasileiro de Referências e Apoio Cultural (CEBRAC) indicates that past trends are not likely to continue. As a consequence, HLBE estimates cargo loads that are not likely possible or sustainable.

   HLBE's projections of annual growth rate in soybean production corresponds more with the growth trend in the early 1980s than for more recent trends from the late 1980s or the first part of the 1990s.

a) HLBE omits relevant construction costs.

   HLBE assumes that a large portion of the basic costs of the Project, the base case, are not attributable to the Project at all. The base case, however, is an integral part of the Project for it is required in the basic construction of all scenarios. Therefore, ignoring the base case in the analysis was a tremendous oversight.

   Dredging costs were overestimated for the smaller alternatives. The size of dredgers was chosen to meet requirements of the large-scale dredging scheduled for the greater channel alternatives. The fixed cost for transportation of super-dredgers from pass to pass is much too high to justify their use in the small-scale dredging necessary for the smaller alternatives. More realistic assumptions would thus show possibilities to economize on dredging costs in the smaller alternatives. Thus the economic feasibility studies are biased toward the greater alternatives.

a) HLBE assumes there will be no significant impacts to the environment, even in the Pantanal.

   The HLBE estimates environmental losses to be only two percent of total commercial fishing value and annual losses to be less than one percent of total commercial fishing value. It should also be noted that the reports produced by HLBE and TGCC do not agree on the impacts the Project will have on fisheries. HLBE assumes very small impacts, while **TGCC** estimates that the impacts could be very serious in some reaches. HLBE also fails to include economic values for the broad range of environmental impacts identified by previous studies (e.g., Bucher & Huszar, 1995). This makes HLBE's identification and measurement of environmental costs of the Project unacceptable.

3.3 Benefits of Reduced Transportation Costs

The benefits of reduced transportation costs will be concentrated among a relatively small number of large-scale enterprises.

HLBE identifies two mining companies, which together dominate iron ore production (Scudder & Clemens, 1997). Since soybean production, mining, and petroleum are dominated by large-scale enterprises, the benefits of reduced transportation costs will be concentrated among a relatively small number of large-scale enterprises, but not enjoyed by small landholders and indigenous peoples.

3.4 Displacement by Increased Soybean Production

Small-scale producers and fishermen will be displaced by increased soybean production.

The effects on indigenous people are particularly severe because they do not always hold clear titles to the lands they inhabit and use. Banck and den Boer (1991) found that soybean production expansion has been entirely at the expense of small-scale agriculture in Brazil's Rio Grande do Sul state. Bartolome (1989) points out that one of the costs of displacing small landholders is the forced migration into urban slums and into neighboring countries as illegal immigrants. Costs are imposed on those displaced in the form of decreased incomes, decreased employment opportunities, and, often they need to migrate out of the region. Often migration is into cities, and thus another cost of the displacement is the influx of a poor and untrained population to the slums of cities that are already unable to cope with the health and crime problems they experience.

Local fishemen will suffer from reduced catches, and downstream water users will have higher treatment costs. Besides the costs to commercial fishing identified by HLBE, recreation and subsistence fishing would also be impaired. Subsistence fishing is practised by low-income residents of the region, including indigenous peoples. These activities will be jeopardized by the direct and indirect effects the Hydrovia Project will have on the river system.

3.5 Distribution by Country

Argentina and Bolivia stand to gain the most from the Project in both absolute and relative terms and can be expected to be strong advocates of the Project, while Brazil should have little interest.

Argentina's use of the waterway for shipping soybeans will increase the most in absolute terms, while Bolivia will increase the most in relative terms. Both Paraguay and Brazil will decrease their use of the waterway for soybean shipments in both absolute and relative terms. Paraguay, though its use of the waterway for soybean shipments will decline, will likely continue to support the proposed Project for the shipment of other cargo.

It should be noted that HLBE's data contradict statements promoting the Hydrovia Project made by Mr. Jesus Gonzalez, chairman of the CIE and Argentina's Undersecretary of Ports and Waterways. Mr. Gonzalez contends that once the Hydrovia Project is completed ". . . Brazil is going to ship about 11 million to 15 million tons of grain cargo through the waterway, fundamentally soybeans" (Webb, 1997). But HLBE predicts a decline, not an increase, in soybean shipments from Brazil via the Hydrovia Project.

In order for the predictions of Mr. Gonzalez to be realized, roughly 50 percent of Brazil's current soybean production will have to be shipped via the Hydrovia Project; alternatively, production in Mato Grosso and Mato Grosso do Sul will have to increase by 500 percent and be exported entirely via the Hydrovia Project. Neither of these scenarios seems likely.

3.6 Distribution of Benefits and Costs

The distribution of benefits and costs from the Hydrovia Project is such that the decision process will be heavily weighted in favor of the Project regardless of its net benefits.

The formation of strong groups favoring the Project will inevitably control the decision-making process, with weak groups opposing it. Benefits and costs are characterized by three differences that contribute to this asymmetrical distribution of political power:

a) The benefits are concentrated among a relatively small number of people and are easily recognized by them, while the costs are spread thinly over the general population and are less obvious.

   For this reason, it is relatively easy to organize groups to promote the Project but not to oppose it.

b) The benefits are largely pecuniary, while the costs are mostly non-pecuniary.

   The bottom line can easily be calculated from promoting the Project, but not from opposing it. Therefore, it is relatively easy to raise funds to promote the Project, but not to oppose it.

c) Benefits are immediate while the costs may not be incurred until sometime in the future.

   Again, pro-groups are more easily formed than con-groups.

For example, there are a relatively small number of dredging companies, barge companies, and shippers that will earn higher pecuniary profits immediately with construction of the Project. However, environmental damages from the Project will be borne by a broad population. As well, they are largely non-pecuniary costs, difficult to quantify, and may not be recognized until long after the Project is completed.

As a development project, the Hydrovia Project should contribute to improving the general welfare of the population of the region. IDB recognizes this as one of its criteria for providing funds, but HLBE ignores the issue of an equitable distribution of benefits and costs from the Project.

PART IV REVIEW AND CRITIQUE OF THE ENVIRONMENTAL IMPACT ASSESSMENT (EIA) OF THE HYDROVIA PARAGUAY-PARANÁ PROJECT

The conclusion from the Environmental Impact Assessment (EIA) for the Hydrovia Project states that environmental consequences are negligible and that the Project is feasible from an engineering and an economic standpoint. The results were accepted by the CIH in December 1996 and were sent to the participating countries for their approval and commitment to begin construction of the Project. Although formal approval of the EIA has yet to be given, Argentina, Brazil, Bolivia, and Paraguay have begun the first steps of dredging for the Project.

The final report of the EIA (TGCC, 1997) is an enormous document of 13 volumes, some 3,300 pages, and hundreds of tables and figures. It should be emphasized here that the EIA report itself does not lend support to any attempt to analyze it. The main conclusions are optimistic regarding the potential impact of the Hydrovia Project. As this contradicts many earlier findings (e.g., Bucher et al., 1993), a careful study seems warranted.

Even a superficial examination reveals that errors occur in typing, calculation, logic, facts, conceptualization, methodology, omissions, and so on. A large number of any one of these types of errors can be found in the EIA.

The EIA attempts to apply ecological methods in its assessment process; for example, the concept of indicator species, ecological land classification, and hydrological computer models. These attempts, however, continually failed to produce any useful and informative results. For instance, 50 species of fishes are selected as “bio-indicators,” but due to their large number and the effort required to monitor them, they may not serve as useful indicators. On the other hand, of the hundreds of bird species available for monitoring the Project, just one, the great white egret, was selected as the indicator species for all the changes that might result. It was chosen for its cosmopolitan distribution and great adaptability, although these traits suggest it may not be useful as an indicator species.

Only modifications and signalization of the river channel, in particular the localized deepening and widening of the riverbed, are part of the EIA (TGCC, pp. 9-43). Improvements for the harbor facilities and shipping, however, should have been included in the studies since they, too, could cause environmental impacts. There are several direct and indirect impacts of the Project, listed in the Hydrological section of WAIF’ s full report, that are also omitted in the EIA. This is, of course, completely insufficient, since the impacts have already been identified (e.g., by Ponce, 1995). This is a clear example of how the EIA fails to meet established standards of assessment.

WWF’s analysis is based on seven different concerns and impacts of the EIA: 4.1) legal, conceptual, and procedural aspects of the EIA, 4.2) hydrological impacts, 4.3) impacts relating to landscape feature, vegetation, and flora, 4.4) impacts on terrestrial fauna, 4.5) impacts on the aquatic invertebrate fauna, 4.6) impacts on water and sediment quality, and 4.7) impacts on fish and fisheries.

4.1 Legal, Conceptual, and Procedural Aspects of the EIA

The EIA attempts to evaluate the impact from dredging in a zone of “intensive influence” around the dredging site. The zone is assumed to cover an area with a radius of only 30 meters or about 2,800 square meters. This is only about 10 percent of the dredging area itself, and it highlights drastically how the consultants underestimated the zone of impacts, even though the correct data were available.

In the EIA, several conflicting definitions for direct and indirect impacts are given. Definitions similar to the ones by Erickson (1994) are given in the EIA (TGCC, pp. 2-18), except that direct impacts that do not occur in the immediate vicinity of the dredging are classified as indirect.

Further examples of confused definitions abound. For the ecological land classification, only the dredging itself was considered a direct impact, while even areas a short distance away (less than 30 meters) are believed only indirectly affected (e.g., by turbidity, human access, noise, and light) (TGCC, Fig. 11. 1.6.2). For the terrestrial vertebrate fauna, an indirect impact would be one that could occur more than 10 kilometers from the river (TGCC, pp. 11-89). In the chapters on water quality, direct impacts would be those related to the construction, while indirect impacts would be those related to the operation of the Project (TGCC, pp. 10-20). Cumulative impacts were considered to be the combined effects of construction and operation of the Project (TGCC, pp. 11-57). Further confusion is created by the terms “direct” and “indirect” influence (TGCC, pp. 1-24), which seem to refer to the area of potential impacts.

Thus, by inflating the term indirect impact, the EIA hides the fact that truly indirect impacts are either ignored or downplayed in the EIA. Worse still, truly cumulative impacts resulting from other existing or planned development projects are not considered.

The magnitude of an impact was classified in the EIA as follows (TGCC, pp. 2-18):

a) High impacts are those affecting more than 15 percent of a resource.
b) Moderate impacts are those affecting five to 15 percent of the resource.
c) Low impacts are those affecting less than five percent of the resource.

A slightly different definition is given, however, in the EIA (TGCC, Table 10.1.4):

a) High impacts affect more than 15 percent of the natural variation [of the resource].
b) Moderate impacts affect six to 15 percent of the natural variation.
c) Low impacts affect one to five percent of the natural variation.
d) Negligible impacts affect less than one percent of the natural variation.

These definitions are in contradiction to the repeated statement found in the EIA that certain impacts are insignificant because the natural variation of the resource was greater than the changes caused by the Project.

The projected impacts contain contradictions and misconceptions in the definition and use of technical terms, which ultimately influences the decision-making process for the EIA.

4.2 Hydrological Impacts of the Hydrovia Project

The EIA contains comparisons of the observed hydrological data for seven years (1984 to 1990), with two different model simulations for the same years. For the second simulation, the original model parameters were modified to include additional information on the riverbed. The EIA claims that it showed better agreement with the observed data. This is questionable, as the following comparisons from CorumbálLadário show:

a) Flood peak discharge: Simulated values are 74 to 116 percent of those observed for the first simulation (mean difference: ±12 percent), and 64 to 99 percent for the second (mean difference: ±15 percent). The EIA calculated average peak discharge for the seven years used for comparison, and found it to be only 1.7 percent different from error calculations from the observed average peak discharge in the first simulation. The second simulation, when compared with the observed average peak discharge, had a difference of 13.9 percent. The EIA, employed the second model, which seems to be the poorer performing one.

b) Timing of the peak flood: The simulations miss the observed date of the peak flood for up to four months in both simulations. The real hydrological data from Ladário show a very peculiar relation between the height and the date of occurrence of the peak flood, reflecting the temporal retention of the flood wave by the Pantanal. The simulated values, however, do not fit into this characteristic pattern.

c) Water level: The simulated water level is about 3.2 meters too high at Corumbá and increases downriver. At Corrientes, the simulated water level, independent of the Project or land-use changes, is projected to be about six meters too high.

d) Pantanal flooding I: When the simulated and real water discharge data are used to estimate the corresponding areas inundated in the Pantanal, the differences become even greater. Based on estimations of the maximum area inundated for a period of seven years using the simulated data, values are between 57 and 120 percent for the first simulation (mean difference: ±16 percent; maximum area flooded in a year of low rainfall), and 41 to 99 percent for the second simulation (mean difference: ±21 percent).

e) Pantanal flooding II: The values yielded through simulations of the flooding of the Pantanal are too great. Maximum discharge in a low water year should have a corresponding inundated area in the Pantanal less than 30,000 square kilometers, yet the EIA estimates 50,000 square kilometers. The minimum area in a low water year would be less than 6,770 square kilometers; the EIA calculates more than 15,000 square kilometers.

For these reasons, the model cannot be expected to produce realistic, reliable results.

For a proper assessment, it would have been necessary to analyze how the simulated hydrological changes influence the environment, and then to determine the magnitude and significance of these potential impacts. In the EIA, however, the hydrological changes were declared insignificant before any impact assessment was instigated. This declaration of insignificance was accepted uncritically.

Disposal of dredged material from increased river bed erosion resulting from removal of geomorphological control points was also not considered.

The assessment of impacts on the landscape features and vegetation is based on Ecological Land Classification (ELC). ELC is a method for arranging a complex landscape mosaic into a hierarchical order with a limited number of habitat types, called “ecosections,” as the base units.

The ELC encounters two problems:

a) The landscape mosaic of floodplains has natural variability. Besides the seasonal changes, accounted for in the ELC, the landscape mosaic can change according to the severity of the annual flood peak, and as a consequence of natural shifting of the riverbed.

b) ELC is based on the assumption that the ecosections are ecologically independent of one another. This is certainly not true in the floodplains of the Project region. Hydrological changes could influence greater areas, but with different impacts in different ecosections. A reduction of the flooding time and area could turn pools in the Pantanal into salt pans or grassland, but it could also turn grassland into forest. It is not clear how ELC could help to assess impacts of hydrological changes on the vegetation.

The hydrological model, meant to simulate the hydrological changes that the Project might cause, has been unable to produce realistic information. A comparison with real, observed hydrological data shows that the model simulations failed to produce realistic values for all relevant parameters, such as water discharge, water levels, seasonal variation of low and high water, and flooding of the Pantanal.

This is certainly due to the inadequate use of the existing data base, such as precipitation and vegetation cover, but also due to the inability of the model to simulate the water retention in the Pantanal floodplain and due to insufficient consideration of the planned interventions in the riverbed. From the treatment of the results in the EIA, it appears that only selected data were used, thus leading to an underestimation of impacts.

4.3 Impacts of the Hydrovia Project on Landscape Features, Vegetation, and Flora

The nature of the assessment of impacts on vegetation and landscape features is not appropriate. Theoretical concepts such as FITRAS (Pulse Function — Phase Frequency, Intensity, Tension, Regularity, Amplitude, Seasonality) are too sophisticated to be of practical use, considering the vast extension of the region, the low quality and resolution of available data, and the limited understanding of ecological interactions. Consequently, the chapters on landscape features, vegetation, and flora contain more theoretical reasoning than concrete facts about the region.

The floristic part of the EIA produced a measure of species richness in different parts of the region, including areas that are not part of the Hydrovia Project (e.g., the Uruguay River). The EIA did not attempt to comprise a catalogue of plant species, a task which was regarded as impossible given the limited availability of time and human and economic resources. So the EIA produced a "compilation" instead of a catalogue, which was meant to be contained in an appendix but which is apparently missing (TGCC, pp. 4-4). The compilation was based on 1,620 species selected from 8,000 examples found in herbaria, literature, and during the field investigation (TGCC, pp. 4-3). The EIA did not try to verify the species names found in the data sources, so species could be listed several times under different names (TGCC, pp. 4-4).

With this compilation, the EIA pursued an ambitious plan to "relate the spatial and temporal complexity of the flora... to the principal factors which could cause the presence of plant species ... in the area of the Project" (TGCC, pp. 4-1). The only other data recorded for the ecoregion in which the plant occurred was the hydrological situation (e.g., "high water/inundated soil" or "low water/soil not water covered") (TGCC, pp. 4-4). It remains unclear whether this is related to the water stage or the topographical situation of the sampling site.

The differences in species numbers are discussed and some "speculation" is given (TGCC, pp. 4-Sff), but this is not reliable, and did not contribute to the impact assessment process.

Obviously, these considerations are based on incorrect numbers of plant species, at least for the Pantanal. There are more than 1,755 terrestrial plant species in the Pantanal alone, and a further 220 aquatic plant species (Abson, Pott, & Silva, 1997; Pott & Pott, in press). On the other hand, it would be interesting to know which species are to be found in the "river course" habitat category in the delta. In the ecological land classification, this habitat (Al) is described as "grassland, dominated by one species" (TGCC, Table 7.7), yet elsewhere it was found to have the highest species number of any habitat type in any ecoregion (TGCC, Fig. 4.1.a.2).

The Pantanal is known for its species richness. Within the Upper Paraguay basin, Pott and Pott (in press) note the existence of 3,350 species of higher plants, of which 1,755 occur within the Brazilian Pantanal. They also describe 220 species of aquatic species from the Pantanal region. This information has not been used in the EIA.

Proper environmental assessment should evaluate potential impacts of the Project on the flora, vegetation, and landscape features of the region. The only valuable information, however, is a rather imprecise, general statistical analysis of habitat types potentially affected by the dredging. The EIA does not consider all sources of potential impacts, and regards only parts of the environment affected. This, combined with significant errors, makes the EIA critically incomplete and faulty.

There is no assessment of the impacts on the flora of the region. There is only a superficial analysis of the number of species in different parts of the region, which is based on inaccurate numbers, and even then, it is not considered in the impact assessment. Flora is addressed in a key question regarding the risk of introducing exotic species, but the answer is based on incorrect assumptions.

The EIA does, however, make a great effort to develop and apply models to predict the impacts of the Hydrovia Project on vegetation and landscape features. Unfortunately, the attempts to assess the impacts failed, for several reasons:

a) the data base was incomplete and inaccurate;
b) the models were inappropriate for the problem; and
c) not all potential sources of impacts were considered.

4.4 Impacts of the Hydrovia Project on Terrestrial Fauna

The assessment of impacts on the terrestrial fauna is unsatisfactory, since all sources of impacts are not covered, the magnitude of potential impacts is greatly underestimated, and monitoring is incomplete.

The Pantanal bird list contains more than 40 species that do not occur in the region. This is over 20 percent of the total of 187 species tabled in the EIA. This mistake is apparently due to the use of the list "Birds of the region of the Pantanal" by Brown (1986; used also by Dubs, 1992), where those species that are only known from the neighboring Amazonia or Cerrado, but not from the Pantanal, are correctly identified as such, but are not in the EIA.

There must be serious doubt about whether the number of 18 indicator species is sufficient to account for environments with very high biodiversity. Each indicator species was given an IAH value (index of aptitude of habitat or index of habitat suitability) for every habitat, according to each habitat's presumed importance for the species.

The IAHs do not distinguish among critical habitats, such as those used for reproduction versus resting. While the assignment of species to habitats is acceptable, the numeric values do not weigh the relative importance of different habitats in a realistic way.

While it is repeatedly emphasized in the EIA that the models used are preliminary, the results of the assessment are treated as definitive and reliable.

Table 1.2 Frequency of Indicator Species Encountered During the EIA Field Study

	Region:	Pantanal		Lower Paraguay		Lower Paraná		Delta
	Season:	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Scientific name	**English name**							
Jacanajacana	WattledJacana	46	30	28	3	73	25	12
Jabiru mycteria	Jabiru Stork	16		1				
C'asmerodius aibus	Common Egret	49		397	1		7	9
Rynchops nigra	Black Skimmer	270		13	9			
Phalacrocorax olivaceus	Neotropical Cormorant	360	18	778	26	46		15
Gaibula ruficauda	Rufous-tailed Jacamar	7	3					
Icterus cayanensis	Epaulet Oriole	5		36	1			
Anodorhynchus hyacinthinus	Hyacinthine Macaw	17						
Alouatta caraya	Black Howler Monkey	57	11	21			4	
Lutra ion gicaudalis	Neotropical River Otter	3		5				4
Panthera onca	Jaguar	7	1					
Blastocerus dichotomus	Marsh Deer	12						
Hydrochaeris hydrochaeris	Capybara	124	19	21	3	1		134
Caiman crocodilus	Spectacled Caiman	55						
Caiman latirostris	Caiman							
Eunectes notaeus	Anaconda							1
Boa constrictor	Boa Constrictor							
Tupinambis teguixin	Tegu Lizard	1						

Note: The numbers of animals recorded in the surveys are small, except for the jaguar *(Panthera onca);* but these records were tabulated from feces and remains of prey (TGCC, pp. 11-73). Higher numbers represent colonial animals (e.g., *Casmerodius albus, Rynchops nigra, Phalacrocorax olivaceus, Anodorhynchus hyacinthinus, Hydrochaeris hydrochaeris).*

Source: TGCC (1997), Tables 11.2.3.9 to 11.2.3.12 and André Leite, WWF Canada.

To calculate the relative loss of habitat in relation to total habitat available for every indicator species, it was assumed that all habitat was lost in a radius of 30 meters around the site of dredging, with indirect impacts in an area of two-kilometers radius around the site of dredging (TGCC, pp. 11-23).

The 30-meter radius seems to be based on a profound misconception about the magnitude of the interventions planned. In contrast, the two-kilometer radius does make sense. It can be expected that colonially breeding wading birds or skimmers will abandon colonies in the vicinity of dredging sites, especially if the disturbance is repeated annually in the breeding season. Jaguars and other large mammals will almost certainly avoid these areas.

According to TGCC, the comparison of habitat available and habitat impacted for the indicator species seems to indicate that only between 0.06 percent and 0.31 percent of the available habitat for any species would be lost.

Reproductive habitats are critical for most species. For example, while the skimmer needs open water or flooded areas for feeding, it is much more sensitive to disturbances to its breeding habitat. How much of the area of potential breeding sites is affected? Table 1.3 shows the result of an analysis using only breeding habitats, re-calculated from TGCC' s numbers based on a directly affected area of two-kilometers radius.

Table 1.3 Re-calculated Percentage of Breeding Habitat of Several Wetland Species in Close Vicinity (2 km) to Dredging Sites in the Pantanal

	Breeding Habitat	Habitat Available	Habitat Affected	%
Jabiru Stork, Great Egret, Neotropical Cormorant	Fl, F2, F3	135.239 ha	31.121 ha	23
Skimmer	D, E	980 ha	138 ha	14

Note: The jabiru stork is not atypical bird of the gallery forest, as was assumed in the EIA (TGCC, pp. 11-67); (e.g., Sick, 1984).

The potential loss of 14 to 23 percent of breeding habitat seems realistic and is unacceptably high. The impact on breeding populations, especially of colonial waterbirds, can obviously be much greater than the data presented in the EIA suggest.

The assessment of impacts on the terrestrial fauna is thus based on inadequate evaluation of the relative importance of habitats, and consequently comes to unrealistic and optimistic interpretations of the magnitude of impacts. Using a more realistic approach, it can be shown that species that are colonial breeders in gallery forests, sandbars, or beaches can expect an enormous loss of critical habitat (especially breeding sites). This does not include loss of habitat caused by the operation and maintenance of the Project.

Other problems included:

a) Incomplete data and analysis: Impacts in Module A (Santa Fe-Corumbá) were not assessed, and the impact of hydrological changes, especially in the Pantanal, was not analyzed. Ecological interrelations were not adequately analyzed and considered.

b) Errors in the data: The EIA contains incorrect information about distribution and habitat requirements of the terrestrial fauna. The field studies were insufficient to improve the available information.

c) Inaccurate results: Since the assessment of the loss of habitats for indicator species was based on biased assumptions of habitat requirements, the potential impacts are not accurate. Impacts on critical habitat in the Pantanal (e.g., breeding sites) would potentially be very serious.

Based on expert analysis of the available information, WWF believes that important habitats and wildlife refuges will be endangered by the Project. If more realistic assumptions had been applied, greater impacts would have been identified.

4.5 Impacts of the Hydrovia Project on Aquatic Invertebrate Fauna

The EIA contains an incomplete and inadequate diagnosis of the aquatic invertebrate fauna of the region of the Project; therefore, potential impacts of the Project are not assessed at all in the EIA. This is a serious shortcoming of the EIA, as the aquatic invertebrate fauna is, due to ‘its ecological position and direct exposure to the impacts of the Project, a critically affected resource.

The diagnosis is incomplete in the following aspects:

a) Zooplankton, a key group due to its critical position in the aquatic food webs, was omitted.

b) Only the main river channel was considered, although the region of potential impacts on the biotic environment also includes the floodplains.

c) The published information considered in the EIA is poorly used.

d) Habitat of the aquatic fauna is insufficiently described.

e) No description of the ecological relationships of the aquatic fauna of the region is given.

f) There is very little information on the Upper Paraguay River.

The field studies are inadequate, as can be seen from the following facts:

a) The number of sample sites and the number of samples taken at each site are insufficient and do not include floodplain habitats.

b) The habitat conditions at the sampling sites are not described adequately.

c) The sampling protocol is poorly documented, if at all.

d) Sampling was not repeated at different water stages.

e) Data on control factors of the aquatic fauna were insufficiently collected.

f) The number of species found in the field studies is only a small fraction of the species known to occur in the river.

The impact assessment itself (i.e., the analysis of the potential impacts of the Project on the aquatic invertebrate fauna) is completely missing in the EIA. Although in the evaluation of impacts the aquatic fauna is addressed, this is misleading as it refers only to fish. Given the ecological importance of aquatic invertebrates, their complete absence in the assessment of impacts is a serious flaw of the EIA.

Aquatic invertebrates are seriously affected by the Project through:

a) Removal, disposal, and transport of sediments due to dredging.

b) The increased turbidity due to dredging and increased navigation.

c) The expected hydrological changes caused by the implementation of the Project.

d) The increased risk of accidental release of pollutants.

e) The greater possibility of introduction of exotic species.

f) The disruption of the faunal interchange between river and floodplain, caused by hydrological changes and/or disposal of dredged sediments on riverbanks or in lateral branches.

The impacts will be higher in the Upper Paraguay River, where they could be of great magnitude and duration. Due to the greatly increased navigation, the complete collapse of the existing aquatic invertebrate community cannot be dismissed.

4.6 Impacts of the Hydrovia Project on Water and Sediment Quality

The assessment in the EIA of the impact of the Project on water and sediment quality is based, unlike most other resources assessed, on a comprehensive review of published information and an extensive field study, adding valuable information. The otherwise insufficient information was effectively supplemented. However, some questions remain insufficiently answered, such as the pollution situation in the Tamengo Channel. The use of bio-indicators, especially fish, to monitor the levels of pollution in the aquatic flora and fauna could have given a more complete picture of the actual situation.

Generally, the levels of pollution of the aquatic environment seem to be low, despite the fact that large amounts of pollutants, such as agrochemicals, and mercury used in gold mining, are being released to the environment in the Paraguay-Paraná basin. The fate of those pollutants seems to be poorly understood, and the possibility that they will reach the main rivers in the future cannot be excluded.\

The potential sources of impacts were comprehensively identified and explained in the EIA, but the existing information does not permit a quantification of the impacts. The measures of mitigation recommended in the EIA do not appear realistic (e.g., the widening of the navigation channel to reduce the mobilization of sediments by passing convoys).

In a strange contrast to the comprehensive and thorough identification of potential impacts, the classification of those impacts is characterized by superficial and euphemistic statements. Despite the fact that a quantification of impacts is hardly possible in any case, almost all impacts are considered to be of "low" magnitude.

4.7 Impacts of the Hydrovia Project on Fish and Fisheries

Extensive compilations were made of the fish and fisheries throughout the Project region. Though the EIA contains a complex attempt to select a number of indicator species from the list of fish species of several segments of the Paraguay and Paraná Rivers, they are not used to qualify and quantify the expected impacts of the planned actions of the Project.

Although the EIA performed an extensive review of available information about fish and fisheries in the Project area, many variables made reliability of these predictions of the potential impacts on fish and fisheries uncertain. Factors such as the fluctuating dimension of the area, insufficient knowledge about the biology and ecology of fishes, lack of local knowledge about the functioning of tropical floodplains and/or wetlands, and the uncertainties related to the ability of the hydrological modeling to foresee changes in the flood parameters (time, duration, level), all contributed to this unreliability.

PART V WWF'S RECOMMENDATIONS

It is essential to emphasize that WWF supports sustainable development and is not opposed to the rational use of the Paraná and Paraguay Rivers for navigation. WWF is also not opposed to the necessary improvements of the existing transport infrastructure in La Plata Basin (e.g., the Ferronorte railway and the improved signalization for safety of the existing waterway). However, as the results of the WWF analysis show, the planned massive interventions in the riverbed are neither necessary for the continued use of the waterway, nor economically feasible. Ecologically, they are threatening valuable natural resources of global outstanding importance, especially in the Pantanal.

5.1 Recommendations Based on the Legal, Conceptual, and Procedural Aspects of the EIA

a) Based on the experience with this EIA document, future EIAs require better terms of reference and quality control to ensure the terms of reference are properly met. Only then will they be useful and valuable tools for decision-making processes.

b) The legal basis for the EIA should be developed and made consistent in the MERCOSUR countries, applying the best state-of-the-art guidelines used internationally.

c) Public participation of regional institutions and NGOs devoted to environmental research and planning should become a central part of the EIA process.

5.2 Recommendations Based on Hydrological Impacts

a) The assessment of hydrological impacts must not be used in its current form, as a basis for decisions on the Project.

b) Plans for large-scale dredging in the Paraguay River (Corumbá-Cáceres reach) must be abandoned until a more comprehensive EIA is done, as the hydrology is highly sensitive to interventions and consequences could be very serious for the environment.

c) No decision on the Project should be taken before a realistic, objective assessment of the impacts has been made. In particular, no irreversible interventions, such as the removal of rocks, or shortening of the river course, should be allowed. Reversible interventions, such as the dredging of mobile sediments from the river bottom are allowed.

5.3 Landscape Features, Vegetation, and Flora Recommendations

a) The assessment is inadequate to use as a basis for making decisions concerning implementation of the Project. Decisions should be postponed until a more competent and focused study of the impacts on the landscape, vegetation, and flora is completed.

b) This assessment should be based on a more comprehensive analysis of the actual situation, and on more realistic assumptions about the sources of impacts such as hydrology, accidents, disposal of dredged material, wave action, and land-use change.

5.4 Terrestrial Fauna Recommendations

a) The existing EIA does not supply representative information on a fundamental level, and should therefore not be used as a basis for decisions on the Project.

b) Planning of the Project should not continue before the consequences for the terrestrial fauna are properly analyzed. This is especially true for any action with irreversible consequences for the river morphology.

c) Plans for the Corumbá-Cáceres reach should be abandoned due to the probable impact on species that could otherwise become critically endangered.

d) Information about the distributions and population sizes of species, the terrestrial invertebrates, and ecological interactions must be used in a new assessment of the impacts of the Project on the terrestrial fauna.

5.5 Aquatic Invertebrate Fauna Recommendations

a) No decisions on the Project should be taken before potential impacts of the Project on the aquatic fauna are thoroughly analyzed.

b) No irreversible interventions in the riverbed, such as removal of geomorphological control points, should take place before their potential consequences for the ecosystems of the rivers are known.

c) The plans for the Corumbá-Cáceres reach should be abandoned, as the existing information is sufficient to expect a very serious disturbance to this critical habitat of outstanding importance (i.e., the Pantanal), due to change in hydrology and the expected increase in shipping traffic.

5.6 Water and Sediment Quality Recommendations

a) The assessment should be supplemented by additional studies of the sediment quality at critical sites, especially the Tamengo Channel.

b) The fate of pollutants, e.g., agrochemicals and mercury, released in the river basins should be monitored carefully to ensure that the levels of pollution remain as low as they appear to be now.

c) The levels of contamination, e.g., heavy metals and pesticides, in bio-indicators, especially fish, should be studied, and monitoring programs developed and implemented.

5.7 Fish and Fisheries Recommendations

a) The data base alone is not enough to adequately evaluate the possible impacts of the planned actions of the Project. The basic questions arise from the uncertainties within the hydrologic modeling concerning the reduction of floodable area and duration of inundation.

b) Since fishing is a very important source of food and income for the local population (more than 3,500 commercial and subsistence fishermen and 60,000 sportfishermen a year in the Pantanal), fisheries-related impacts must be carefully assessed before any kind of decision is made.

c) From an ecological point of view, impacts on fish need to be evaluated carefully because they are the base of the food web for numerous animal species, especially birds and caimans. Most important are a number of globally endangered species like the jaguar, jabiru stork, giant otter, and neotropical river otter, whose populations, so far, are not endangered in the Pantanal per se.

PART VI WWF’S CONCLUSIONS

6.1 Specific Technical Conclusions of the EIA

WWF’ s scientific panel for this independent review of the EIA for the Hydrovia Paraguay-Paraná Project has reached the following conclusions:

a) Both the technical plans and the EIA for the Project are faulty, incomplete, and inconclusive, and are therefore inadequate as the basis for political decisions concerning the Project. The main conclusions of the EIA, which are generally optimistic regarding the impacts of the Project, are either unfounded or inaccurate, due to a multitude of errors. Those errors are conceptual, methodological, calculatory, and factual, and are found in almost all parts of the EIA.

b) As the EIA consistently underestimates or ignores sources of impacts, it is likely the real impacts will be much more serious. The Project has the potential to seriously affect natural resources at a regional, national, hemispheric, and global level. The consequences could negatively affect the lives of the millions of people who depend on such things as flood control and healthy water from the rivers. It could also affect natural environments of global importance (e.g., the Pantanal), as acknowledged, for instance, in the Brazilian constitution.

c) The hydrological impacts of the Project deserve the most thorough analysis, as they are likely to have irreversible and serious consequences for humans and the natural environment. However, the modeling of the hydrological impacts in the EIA proved to be unreliable, as the simulated data of water discharge, water levels, and flooding of the Pantanal were unrealistic. In addition to these flaws, interpretation of the simulated impacts was inadequate and bound to underestimate the magnitude of impacts.

d) Evaluation of the impacts for the Project concerning the natural environment is largely based on subjective and unsubstantiated opinions, not on a scientifically sound assessment and analysis. Quantification of impacts was only attempted for a few aspects, as a rough estimation of the proportion of landscape features and vertebrates (birds, reptiles, and mammals). This attempt contained errors on the distribution and ecology of species, and a fundamental underestimation of the magnitude of dredging, making the results and interpretation in the EIA worthless. The EIA fails to contain estimations on the distributions and population sizes of species, and identification of key habitats.

e) The EIA is inadequate as a document for public distribution and consideration, as it is excessively voluminous (more than 3,300 pages), expensive (more than U.S. $1,000 to purchase), and difficult to obtain. Its awkward structure; confusing and contradictory concepts, methods, and definitions of terms; incomplete documentation of data; poor illustrations; and unnecessary and repetitive tables; leave this document far from appealing to read or suitable for analysis.

6.2 General Conclusions of the EIA and the Engineering-Economic Feasibility Analysis

EIAs are valuable tools to estimate and evaluate potential consequences of projects and thus, to guide decision making on their size and implementation. In order to be effective, EIAs must be clear, objective, and conclusive. If not, they are unable to serve as reliable decision-making tools.

Certainly, there are many reasons why the studies failed to produce the expected results: time was short, the region was too vast, and existing information was widely dispersed and often not readily accessible. All this might have been excusable if the studies did not maintain that the results and conclusions were generally reliable and valid.

WWF advises that the EIA should not be considered conclusive as the available data are limited and the existing data are unreliable. It is therefore not possible to rely on its conclusions. The EIA does not provide a solid foundation as a decision-making tool, regardless of various political, economical, engineering, or environmental alternatives. Any decisions based on the EIA' s conclusions will be premature, possibly incorrect, with the potential for causing irreversible damage to the environment.

WWF advises that HLBE's Engineering-Economic Feasibility Study is seriously flawed and should not be used as a basis for evaluating the economic feasibility of the Hydrovia Project. WWF's analysis showed that correcting these errors, either singularly or in concert with one another, lead to an economic evaluation which does not support the Hydrovia Project as proposed by HLBE. That is, a corrected evaluation of the scenarios identified by HLBE showed negative net economic returns which will not contribute to improving the general welfare of the population of the region.

Therefore, based on all the evidence reached by WWF's scientific and economic panels, it is recommended that the Project be halted, only to be reinitiated after a meticulous, critical analysis be conducted.

People living in the region of the Hydrovia Project will suffer the consequences of misguided decisions. They deserve a more serious, competent, and comprehensive consideration of impacts concerning their future.

SECTION I:

REVIEW AND CRITIQUE OF THE HYDROVIA PARAGUAY-PARANÁ ECONOMIC FEASIBILITY STUDY

by Dr. Paul C. Huszar

with contributions from:

Sigrid Andersen and André Leite

Photo 1. Silos for loading barges with soybeans. Tamengo Channel, Bolivia.
Photo: André Leite/WWF Canada

INTRODUCTION

The Paraguay-Paraná River system flows south through Brazil, Bolivia, Paraguay, Argentina, and Uruguay, draining La Plata Basin and spanning an area of 1.75 million square kilometers. The Paraguay-Paraná River system forms a 3,440 kilometer waterway from the mouth of La Plata Basin, on the Atlantic coast between Uruguay and Argentina, to Cáceres in the state of Mato Grosso, Brazil, in the heart of South America (Figure 1.1).

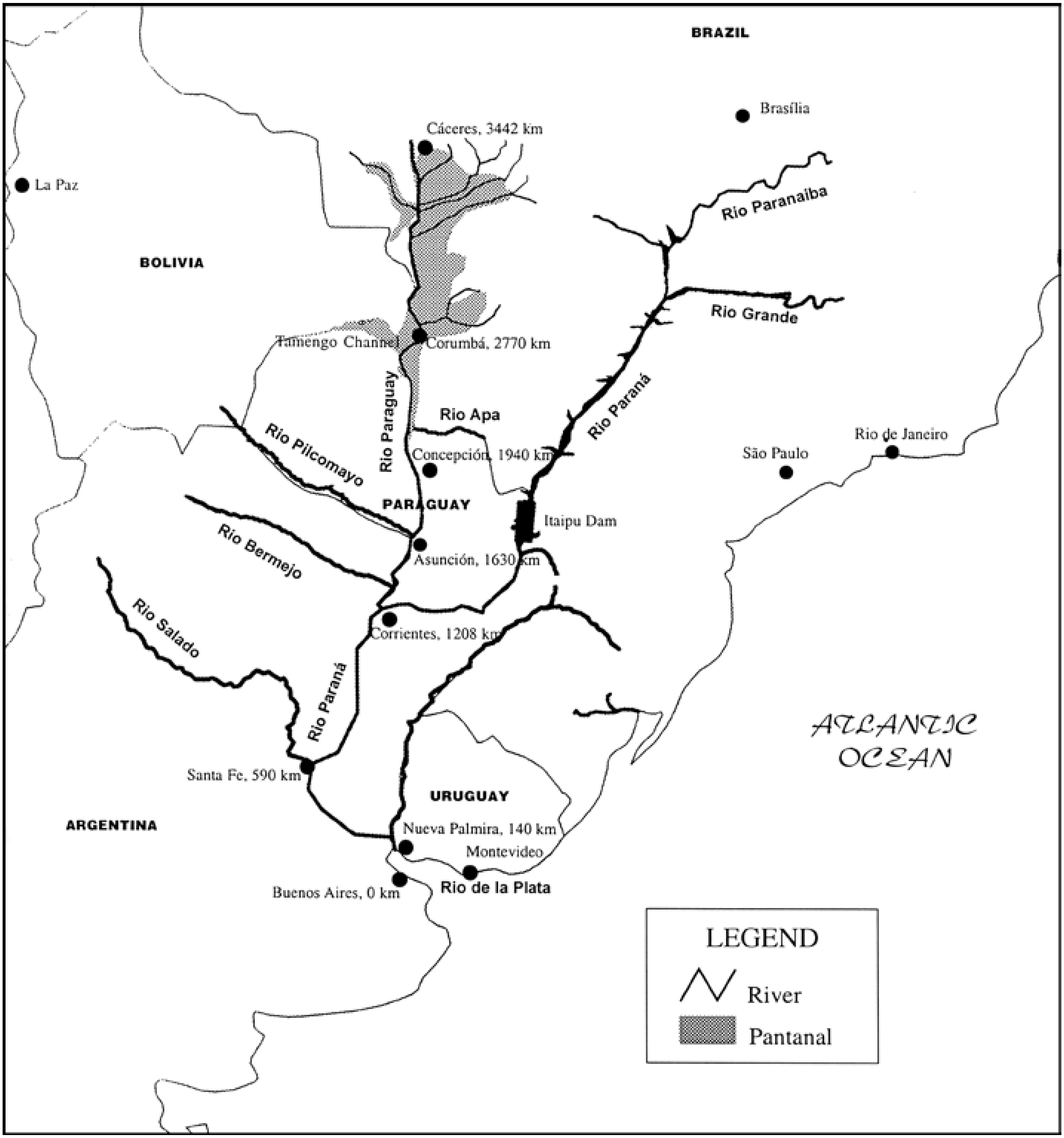
In 1991, Argentina, Brazil, Paraguay, and Uruguay formed MERCOSUR, the Southern Cone Common Market of South America. MERCOSUR represents Latin America's largest economic base, with a market of nearly 200 million people and a gross regional product of U.S. $427 billion per year. Because the waterway passes through these countries, it has a high symbolic value for the integration of their economies.

A major impediment to increased trade for Latin America, and hence economic growth, is the lack of transportation infrastructure. Although the river system has been used as a waterway since pre-Columbian times, and ports and other navigational improvements have been constructed since then, transportation facilities have been poorly maintained. The World Bank estimates U.S. $14 billion per year will be required until 2005 to compensate for over 15 years of neglected attention to transportation infrastructure in Latin America (Burki & Edwards, 1995). Within MERCOSUR, several transportation projects are underway or in the planning stages. One of the most ambitious and controversial of these is the Hydrovia Project.

The initial goal of the Hydrovia Project was to make the Paraguay-Paraná River system navigable year-round from Nueva Palmira, Uruguay to Cáceres, Brazil (Internave Engineering, 1992) (Figure 1.1). This would be achieved by dredging a uniformly deep and wide river-bed within this section of the river system. Presently, vessels of up to 100 meters in length can navigate only the first 1,208 kilometers up to Corrientes, Argentina, at which point smaller vessels must be used to reach Asunción, Paraguay. Navigation upstream of Asunción becomes increasingly difficult (Jelen, 1995) due to the occurrence of sand banks and rock outcrops.

The rivers pass through landscapes characterized by extensive floodplain wetlands. Most famous of these is the Pantanal, an ecosystem of global importance, which lies predominantly in Brazil, with smaller portions in Bolivia and Paraguay. Renowned for abundant wildlife and fisheries (Dubs, 1983; Por, 1995), and as a staging area for waterfowl and shorebirds that migrate throughout the Western Hemisphere, the Pantanal is the dominant wetland feature of the southern half of South America and is arguably the greatest freshwater wetland in the world.

Figure 1.1 Map of Project Site



Source: André Leite, WWF Canada

The Pantanal is a complex set of different ecosystems, each exhibiting specific characteristics due to the variation in water regimes among seasons and years. Every year in the Pantanal is unique, depending on remote precipitation and local rainfall. The source of water and the slope of the terrain also characterize the flooding cycles of the Pantanal.

Disruption of the natural balance of the Pantanal by dredging and other interventions would alone make the existing development proposal questionable.

In 1989, the Brazilian government commissioned Internave Engineering to conduct a feasibility study of the Hydrovia Project. Internave's report, released in 1992, concluded that the Project was both physically and economically feasible. The study, however, contained many calculation errors and omitted environmental costs.

One year following the Internave Engineering study, Wetlands for the Americas commissioned an analysis of the potential environmental benefits and costs of the Hydrovia Project (Bucher et al., 1993). Conducted by a multidisciplinary group of scientists, the analysis showed the Project was not feasible when environmental costs were considered. Moreover, it highlighted numerous potential environmental costs that should be considered in a more complete assessment of the Project. Foremost among these was severe detrimental impact on the Pantanal.

A second important report on the economics of the Hydrovia Project was prepared by World Wildlife Fund (WWF). The report, "Who Pays the Bill?" (CEBRAC et al., 1994), highlighted that, in purely economic terms, the Hydrovia Project is not a good investment for the countries.

In response to the Wetlands for the Americas and WWF studies, as well as pressure from many non-governmental organizations, the Inter-American Development Bank (IDB) rejected the findings of Internave Engineering and called for a more complete and accurate study of the Hydrovia Project. In 1995, the Intergovernmental Committee on Hydrovia (CIH) - a multilateral body of the governments of Argentina, Bolivia, Brazil, Paraguay, and Uruguay - commissioned two 18-month-long studies of the proposed Hydrovia Project. The studies were administered by the United Nations Office for Project Services (UNOPS).

The first study, consisting of an engineering-economic analysis of the Hydrovia Project, was conducted by a consortium of consulting firms: Hidroservice, Louis Berger, and EIH (collectively HLBE). The second study, an environmental impact assessment (EIA), was conducted by a consortium of consulting firms: Taylor Engineering, Inc., Golder Associates Ltd., Consular Consultores Argentinos Asociados S.A., and Connal Consultora Nacional, SRL (collectively TGCC). IDB provided approximately U.S. $11 million for both studies. The two analyses were supposed to be linked together in order to identify and measure the environmental costs, thereby providing a complete analysis of the benefits and costs of the Project and, therefore, its overall social value and desirability.

These studies concluded that environmental consequences of the Project are negligible and that the Project is feasible from both an engineering and an economic standpoint. The results were accepted by the CIH in December 1996 and were sent to the participating countries for their approval and commitment to begin construction of the Project. Although formal approval of the EIA has yet to be given, Argentina, Bolivia, Brazil, and Paraguay have begun the first steps of dredging.

The purpose of this section of the report is to review and critique the economic aspects of HLBE's engineering-economic feasibility analysis. It is divided into four main chapters. Chapter 1 summarizes the conclusions of the HLBE report and attempts to reveal how it arrived at these conclusions. The basis for these conclusions is then analyzed in chapter 2, which identifies numerous errors in the HLBE analysis that make the conclusions questionable. Chapter 3 expands the discussion to include equity issues. Analysis to date has been concerned with efficiency issues but has not considered fairness of the distribution of benefits and costs of the proposed Project. Finally, chapter 4 addresses the political-economy issues surrounding the project and attempts to explain how environmentally and economically unsound projects continue to draw political support.

CHAPTER I HLBE’S CONCLUSIONS

The HLBE report (1996b) states that the primary benefits of the Hydrovia Project are (1) reduced chance of interruptions during transportation due to low river flows, and (2) reduced transportation costs resulting from the use of larger barge trains and around-the-clock navigation. The primary costs of the Project are the initial dredging and annual maintenance of the channel. In addition, there are costs for the signage necessary to mark the channel and make navigation safer.

Photo 2. Barge loaded with cattle going down the Paraguay River. Corumbá, Brazil.
Photo: André Leite/WWF Canada

The HLBE report first analyzes a “base case” scenario which would eliminate the risk of transportation interruptions due to low river flows. The base case is analyzed for two reaches of the river: Asunción-Corumbá and Santa Fe-Asunción. HLBE then analyzes a number of alternative scenarios that incrementally increase the size of the Project beyond the base case. As discussed in chapter 2, this approach introduces error into their calculations.

Lastly, HLBE analyzes several alternative scenarios for navigation improvements in the Corumbá-Cáceres reach, which includes the heart of the Pantanal. This analysis contradicts earlier statements by the CIH and the Brazilian government that alterations within the Pantanal would not be considered.

1.1 HLBE’s Base Case

Table 1.1 summarizes HLBE’s economic evaluation of the base case. The initial and annual 1997 values are taken from HLBE’s Table 9.2 (HLBE, 1996), but future values have been interpolated from HLBE’s data, since they are not given by HLBE.

HLBE calculates that guaranteeing navigation from Santa Fe to Corumbá would yield a benefit cost ratio (B/C) of 2.30 and a Net Present Value (NPV) of U.S. $92,405 million, when a 12 percent discount rate is used. The Internal Rate of Return (IRR) is calculated to be 55 percent. Presumably, HLBE uses a 12 percent discount rate because this is the minimum rate of return acceptable for IDB loans. HLBE concludes that the base case of guaranteeing navigation is economically feasible.

In evaluating the base case, HLBE considered two reaches of the Paraguay River, the Santa Fe-Asunción reach and the Asunción-Corumbá reach. Given HLBE’s estimates of benefits and costs, the strongest economic case for guaranteeing navigation is in the Santa Fe-Asunción reach. Ensuring navigation in the Asunción-Corumbá reach has considerably smaller economic returns. The Santa Fe-Asunción reach has an IRR of 115 percent, while the Asunción-Corumbá has an IRR of 39 percent. Therefore, the economic feasibility of ensuring navigation on the Asunción-Corumbá reach of the Paraguay River will be significantly more sensitive to errors in the measured benefits and costs.

Table 1.1 Summary of HLBE’s Base Case Evaluation

Benefits and Costs	Santa Fe-Asunción	Asunción-Corumbá	Santa Fe-Corumbá
Convoy Design*	4×4	3×4	
Channel Depth*	2.0 m	2.0 m	
Navigation Hours per Day*	18	18	
	(millions U.S. $)	(millions U.S. $)	(millions U.S. $)
Savings with Guaranteed Navigation			
Annual 1997*	$47.25	$29.26	$76.51
Annual 2016‡	$62.16	$54.49	$116.64
Present value (20 yr @ 12%)1↑	$340.63	$238.95	$579.57
Probability of Collapse*	20%*	40%*	
Benefits of Guaranteed Navigation			
Annual 1997*	$9.45	$11.70	$21.15
Annual 2016‡	$12.43	$21.79	$34.23
Present value (20 yr @ 12%)↑	$68.12	$95.58	$163.70

Benefits and Costs	Santa Fe-Asunción	Asunción-Corumbá	Santa Fe-Corumbá
Costs of Dredging and Maintenance			
Initial*	$5.59	$20.37	$25.96
Annual in l997*	$1.78	$3.95	$5.74
Annual in 2016‡	$1.78	$3.95	$5.74
Present value (20 yr @ 12%)↑	$18.92	$49.90	$68.82
Environmental Costs			
Initial*	$0.172	$0.588	$0.760
Annual in 1997*	$0.041	$0.191	$0.232
Annual in 2016‡	$0.070	$0.314	$0.384
Present value (20 yr @ 12%)↑	$0.478	$2.018	$2.496
Internal Rate of Return (IRR)‡	115%	39%	55%
Net Present Value (NPV)‡	$48,726	$43,680	$92,405
Benefit/Cost Ratio (B/C)↑	3.51	1.84	2.30

Source: HLBE (1996), Table 9.2.

*= values given by HLBE

‡=values interpolated from HLBE

↑ = values interpolated from HLBE which agree with values given by HLBE

1.2 HLBE's Scenario Evaluations

HLBE analyzes a total of 21 scenarios as improvements over the base case, the most important of which are discussed here. While HLBE's (1996) tables measure the additional benefits over the base case, the costs of each scenario are included in total terms. Table 1.2 is a simplified and corrected summary of HLBE's evaluations of these scenarios. It adjusts HLBE's presentation to correspond with their analysis of incremental benefits and costs.

Moreover, the scenario HLBE recommends is not clear. HLBE claims to prefer scenario E2E1, but CIH selected scenario F2E1. In a separate analysis at the end of the report, an evaluation of all scenarios for the Corumbá-Cáceres reach are added and HLBE concludes that scenario B2 is preferred.[3] HLBE, however, selects scenario B2 with numerous attached qualifiers, which suggests a lack of enthusiasm for this option. All of these scenarios are described and evaluated later in this section.

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[3] Scenario B2 (HLBE) should not be confused with module B2 (TGCC). Scenario B2 stands for one-by-two barge trains with a 1.8-meter deep channel for the Corumbá-Cáceres reach. Module B2 refers to the environmental analysis, environmental impact assessment, and monitoring and mitigation studies carried out from Nueva Palmira to Cáceres.

1.2.1 PREFERRED SCENARIO

Of the 13 scenarios evaluated for incremental improvements to the base case in the Santa Fe-Corumbá reach, HLBE concludes that scenario EM is preferred. Scenario EM would accommodate four-by-four barge trains on the Santa Fe-Asunción reach of the Paraguay and Paraná Rivers with a three-meter deep channel, and four-by-four barge trains on the Asunción-Corumbá reach of the Paraguay River with a 2.6-meter deep channel. While other scenarios have a greater economic return, EM allows barge trains of the same size to travel from Santa Fe to Corumbá, thus avoiding the reconfiguring of barge trains at Asunción necessitated by other scenarios. HLBE calculates the NPV of scenario E2E1's incremental benefits and costs over the base case to be U.S. $24.83 million and its IRR to be 17 percent.

1.2.2 SELECTED SCENARIO

While EM is HLBE's preferred scenario, the CIH selected scenario F2E1. Scenario F2E1 would accommodate four-by-five barge trains on the Santa Fe-Asunción reach with a three-meter deep channel, and four-by-four barge trains on the Asunción-Corumbá reach with a 2.6-meter deep channel.

F2E1 has very similar costs to EM, but has the additional advantage of allowing larger barge trains in the Santa Fe-Asunción reach. This benefit, however, does not show up in greater estimated benefits in the HLBE calculations (see Table 1.2). HLBE calculates the NPV of the incremental benefits and costs of scenario F2E1 over the base case to be U.S. $19.58 million and its IRR to be 16 percent.

1.2.3 CORUMBÁ-CÁCERES SCENARIO (SCENARIO B2)

Finally, HLBE evaluates eight additional scenarios for navigational improvements in the Corumbá-Cáceres reach of the river. These scenarios are evaluated in conjunction with the F2E1 scenario for the Santa Fe-Corumbá reach. The selected scenario is B2/F2E1, which would accommodate four-by-five barge trains on the Santa Fe-Asunción reach with a three-meter deep channel, four-by-four barge trains on the Asunción-Corumbá reach with a 2.6-meter deep channel, and one-by-two barge trains on the Corumbá-Cáceres reach with a 1.8-meter deep channel.

The Ferronorte railroad is expected to connect Cuiabá, Brazil, to the port of Santos on the Atlantic coast of Brazil. HLBE concludes that if the Ferronorte railroad is not completed before the year 2021, then the scenario B2 between Corumbá and Cáceres is the most preferred alternative. Without Ferronorte, HLBE calculates the NPV of the incremental benefits and costs of scenario B2, along with scenario F2E1, to be U.S. $105.51 million and its IRR to be 27 percent (see Table 1.2). However, if Ferronorte is completed prior to 2005, HLBE concludes that scenario B2 is not economically feasible. It is likely Ferronorte will be completed before 2005.

Table 1.2 Summary of HLBE's Scenario E2E1, F2E1, and B2 Evaluations Adjusted to Reveal Incremental Benefits and Costs

Incremental Benefits and Costs Over Base Case	E2E1	F2E1	B2 w/F2E1
Convoy Design			
Santa Fe-Asunción*	4×4	4×5	4×5
Asunción-Corumbá*	4×4	4×4	4×4
Corumbá-Cáceres*			1×2
Channel Depth			
Santa Fe-Asunción*	3.0 m	3.0 m	3.0 m
Asunción-Corumbá*	2.6 m	2.6 m	2.6 m
Corumbá-Cáceres*			1.8 m
Navigation Hours per Day*	22	22	22
	(millions U.S. $)	(millions U.S. $)	(millions U.S. $)
Benefits of Improved Navigation			
Annual 1997*	$10.58	$10.58	$19.37
Annual 2020*	$26.56	$26.56	$60.62
Other Benefits to Development			
Annual 1997*	$3.05	$3.05	$3.05
Annual 2020*	$9.38	$9.38	$15.35
Dredging and Signals			
Initial*	$56.54	$57.84	$72.50
Annual*	$11.56	$12.30	$15.36
Environmental Costs			
Initial*	0	0	$0.19
Annual*	0	0	$0.12
Net Present Value (NPV)↑	$24.83	$19.58	$105.51
Internal Rate of Return (IRR)↑	17%	16%	27%

Source: HLBE (1996), Tables 9.11 and 2.23.

*=values given by HLBE

↑=values derived from HLBE which agree with values given by HLBE

1.2.4 EVALUATIONS

HLBE's evaluations of the scenarios differ from that of the base case in several important ways. First, no additional environmental costs are identified with scenarios E2E1 and F2E1. HLBE assumes that all environmental costs would result from constructing the base case, and additional dredging for these scenarios would have no additional environmental costs.

Second, multiplier benefits associated with the construction and operation of scenario E2E1, or what can be considered benefits to development, are included in the evaluation.

Third, estimated costs of the base case are higher in the evaluation of the scenarios than in the evaluation of the base case alone. In the evaluation of the scenarios, initial dredging costs of the base case are U.S. $29.944 million rather than U.S. $25.961 million, and annual dredging costs are U.S. $6.618 million rather than U.S. $5.738 million. To compute the incremental benefits and costs of the scenarios, HLBE subtracts the base case costs from those of the scenarios. Thus, using higher base case costs has the effect of reducing the incremental scenario costs, thereby increasing the economic returns calculated for the scenarios.

Fourth, while the base case evaluation is for a 20-year period from 1997 to 2016, the scenarios are evaluated for a 24-year period from 1997 to 2020.

In summary, HLBE makes a number of errors in its scenario evaluations, which make the scenarios appear more economically feasible than they actually are. These errors and others are considered further in the next chapter.

CHAPTER 2 EVALUATION OF HLBE'S ANALYSIS

There are a number of conceptual, procedural, measurement, and calculation errors in the HLBE analysis, which when corrected significantly alter HLBE's conclusions. The following analysis corrects the conceptual and procedural errors, addresses the measurement and calculation errors, and illustrates the consequences of correcting these errors. These corrections lead to the conclusion that the Hydrovia Project is not economically feasible.

Photo 3. Barge loaded with minerals going down the Paraguay River. Near Laguna Uberaba, Brazil.
Photo: André Leite/WWF Canada

2.1 Conceptual and Procedural Errors

First, the HLBE analysis is conducted using the base case as the "without project" condition. This, however, is misleading. The base case represents significant alterations to the river system and is part of the project proposed by HLBE to reduce interruptions to navigation and reduce transportation costs. By treating the base case separately from the alternative scenarios, HLBE confuses the analysis and, subsequently, causes errors. By subtracting the costs of the base case from the costs of the alternative scenarios, the scenarios appear less costly than they actually are. This error is corrected by including HLBE's base case as one of the alternative projects (Table 2.1).

Second, HLBE's alternative scenarios are not additions to the base case, but actually require its construction. These scenarios should be evaluated in terms of all of their benefits and costs. As the alternative scenarios and base case are interdependent projects, the correct analysis is to evaluate the NPV of each project and select the one with the greatest NPV (Sassone & Schaffer, 1978). HLBE calculates only the total values of benefits and costs for the scenarios under consideration. Table 2.1 uses the data from HLBE to calculate the total values of benefits and costs for the scenarios under consideration.

Third, HLBE's initial construction and annual maintenance costs for its base case scenario differ between its evaluation of the base case in isolation and its evaluation of the alternative scenarios. Lower costs are used by HLBE to evaluate the base case, making it appear economically feasible; and then higher costs are used when the scenarios are evaluated, making the alternative scenarios appear more economically feasible in comparison to the base case. Since the higher costs are repeated numerous times in the HLBE report, while the lower costs appear once, it is assumed that the higher costs are the "correct" values and are therefore used in Table 2.1 to correct HLBE's evaluation of the base case.

Fourth, HLBE's calculations assume that benefits resulting from navigational improvements will be realized while the Project is under construction. This is not the case, as benefits will be realized only after the improvements are made. Table 2.1 therefore, assumes that the benefits of the alternative scenarios begin in 1998 rather than 1997.

Finally, HLBE analyzes the base case for the 20-year period from 1997 to 2016, which is conventional for this type of project. However, the alternative scenarios are evaluated for the 24-year period from 1997 to 2020. The effect on the NPV for the alternative scenarios is not large, but this type of carelessness is indicative of much of the HLBE analysis.

Table 2.1 Summary of HLBE's Base Case and Scenario E2E1, F2E1, and B2 Evaluations Adjusted to Reveal Total Benefits and Costs

Benefits and Costs	Base Case	E2E1	F2E1	B2/F2E1
Convoy Design				
Santa Fe-Asunción	4×4	4×4	4×5	4×5
Asunción-Corumbá	3×4	4×4	4×4	4×4
Corumbá-Cáceres	—	—	—	1×2
Channel Depth				
Santa Fe-Asunción	2.0 m	3.0 m	3.0 m	3.0 m
Asunción-Corumbá	2.0 m	2.6 m	2.6 m	2.6m
Corumbá-Cáceres	—	—	—	1.8 m
Navigation Hours per Day	18	22	22	22
	(millions U.S. $)	(millions U.S. $)	(millions U.S. $)	(millions U.S. $)
Benefits of Improved Navigation				
Annual 1997	0	0	0	0
Annual 1998	$21.15	$31.74	$31.74	$40.52
Annual 2016	$32.69	$55.78	$61.12	$83.11

Benefits and Costs	Base Case	E2E1	F2E1	B2/F2E1
Other Benefits to Development				
Annual 1997	0	0	0	0
Annual 1998	0	$3.05	$3.05	$3.05
Annual 2016	0	$8.00	$8.00	$12.89
Dredging and Signals				
Initial	$29.94	$86.49	$87.78	$102.25
Annual	$6.62	$18.18	$18.92	$21.86
Environmental Costs				
Initial	$0.76	$0.76	$0.76	$0.95
Annual 1998	$0.23	$0.23	$0.23	$0.35
Annual 2016	$0.38	$0.38	$0.43	$0.50
Net Present Value (NPV)	$90.96	$91.33	$85.36	$148.65
Internal Rate of Return (IRR)	50.62%	25.21%	24.18%	28.45%

Source: Derived from Tables 1.1 and 1.2 of this report

From Table 2.1 it can be seen that, given the values from the HLBE study, the alternative scenario with the greatest NPV is B2, in the Corumbá-Cáceres reach along with F2E1 in the Santa Fe-Corumbá reach. When the HLBE data are correctly calculated, the B2/F2E1 scenario has a NPV of U.S. $148.65 million and an IRR of 28.45 percent. The next-best scenario is E2E1, with a NPV of U.S. $91.33 million and an IRR of 25.21 percent. The third-best alternative is the base case with a NPV of U.S. $90.96 million and IRR of 50.62 percent. The least-preferred alternative should be scenario F2E1, with a NPV of U.S. $85.36 million and an IRR of 24.18 percent. However, as will be seen in the next section, the cost and benefit values used by HLBE are often highly questionable and, when corrected, lead to very different conclusions.

2.2 Measurement and Calculation Errors

There are a number of measurement and calculation errors in HLBE's benefit-cost analysis that fall into the following categories: 2.2.1) probability of a collapse in navigation; 2.2.2) benefits of guaranteeing navigation; 2.2.3) environmental costs; 2.2.4) alternative transportation of regional production; and 2.2.5) growth of regional production. Each of these will be addressed in the following discussion.

2.2.1 PROBABILITY OF A COLLAPSE IN NAVIGATION

HLBE defines a "collapse in navigation" as occurring with river flows below two meters for three months per year (HLBE, 1996). HLBE estimates that there is a 40 percent probability of a collapse in navigation on the Asunción-Corumbá reach and a 20 percent probability of a collapse on the Santa Fe-Asunción reach.

One of the benefits to dredging the river is avoiding interruptions to navigation due to low river flows. HLBE calculates the value of avoiding a collapse in navigation as the differences in the annual transportation costs with and without river navigation multiplied by the probability of a collapse. Since each of the alternative projects considered by HLBE is predicted to guarantee navigation (i.e., prevent a collapse), the greater the probability of a collapse without the alternative projects, the greater the benefits calculated for those projects.

HLBE calculates the probability of collapse by considering data from 25 years of monthly observations for water flow at two locations of the river. Using this data, flow-months are sorted and placed in order irrespective of their associated years. Therefore, the lowest flow-month of January is associated with the lowest flow-month of February and lowest flow-month of March, etc. Thus, artificial years of low flows sorted by month are created. This procedure assumes that monthly flows are independent so, for example, the flows in February are not dependent upon the flows in January. This assumption, however, is incorrect.

HLBE then counts the number of artificially created years in which flows were below two meters for at least three months. Since each artificial year represents 1/25 of the sample, HLBE concludes that each has a four percent chance of occurring. The appearance of 10 artificial years with collapses in the AsunciónCorumbá reach produces a probability of 40 percent (i.e., 10 multiplied by four percent), and five artificial years with a collapse in the Santa Fe-Asunción reach produces a probability of 20 percent (i.e., five times four percent). These calculations are clearly wrong.

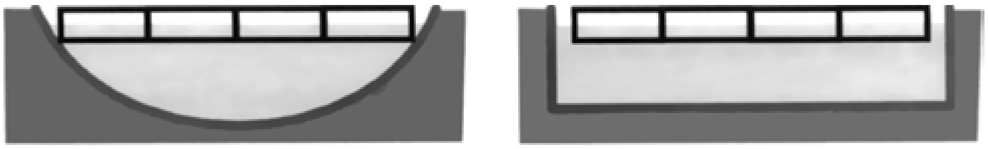
Even if it is assumed that monthly flows are independent events, as constructed by HLBE, then it is each monthly observation that has a 1/25, or four percent, probability of occurring, not each year. The probability of three months with flows below two meters then must be $(1/25)^3$ = $(4 \text{ percent})^3$ = 0.0064 percent. If 10 of their artificial years have three months with flows below two meters on the Asunción-Corumbá reach, then the probability of what HLBE calls a collapse is 10 times 0.0064 percent, or 0.064 percent, not 40 percent. Similarly, if five of the artificial years have three months with flows below two meters on the Santa Fe-Asunción reach, then the probability of a collapse is five times 0.0064 percent, or 0.032 percent, not the 20 percent HLBE calculates.

Moreover, the hydrological basis for HLBE's calculations is questionable. Both in his paper published by the Environmental Defense Fund (Dunne, 1997) and in a personal communication, Dr. Thomas Dunne, a hydrology professor at the University of California, Santa Barbara, questions HLBE's findings. In Dr. Dunne's e-mail of March 5, 1997, he states:

> The reaches are hundreds of kilometers long, and the thalweg of the natural channel winds back and forth across the channel over, for example, the entire reach Corumbá-Asunción. It would be dubious to assume that the levels at these two widely spaced points could accurately represent those for an entire meandering reach with a mobile thaiweg. In addition, these records are of water stage (surface elevation) only. They do not contain information on the elevation of the channel bed or depth of flow. Thus, it is not known, from the information presented, how much of a measured change in water-surface elevation, either between two consecutive months or the seasonal minimum levels in consecutive years, was due entirely to changes in water discharge or whether the bed elevation also changed. In other words, from what they say in the report, I do not see how they got flow depths from gauge heights.

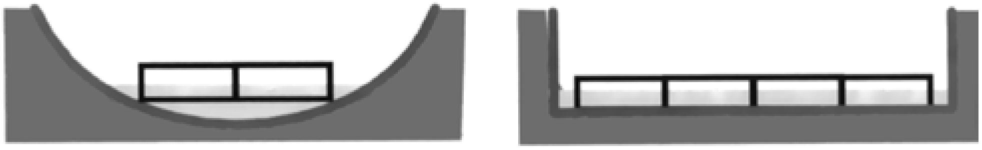
Mr. Ricardo dos Santos, owner of the NAVEMAR S.R.L. barge company in Asunción and President of the Comision Permanente de Transporte de la Cuenca del Plata (CPTCP), an association of barge companies from Argentina, Bolivia, Brazil, Paraguay, and Uruguay, provided an alternative explanation for collapses in navigation (personal interview, March 1997). Mr. dos Santos did not agree with the term “collapse”, rather he explained that although low flows may necessitate reconfiguration of barge trains as the channel narrows, navigation is still possible. The explanation for the effects of low flows is depicted in Figures 2.la and 2.lb. Normal flows allow four-by-four barge trains (Figure 2.la), but low flows necessitate reducing the width of the barge trains (Figure 2. i b). The length of the trains may also have to be limited as room to navigate turns decreases. HLBE assumes that normal flows allow four-by-four barge trains (Figure 2.1c), but low flows cause navigation to cease abruptly (Figure 2.1d).

Figure 2.1 Barge Navigation with Normal and Low Flows



a. Actual Situation

c. HLBE's Conceptualization



b. Low Flow & Small Barge Train

d. Low Flow & HLBE Collapse

Cessation of navigation, as explained by Mr. dos Santos, is determined by economic and not simply physical conditions. When the costs of the barge trains that can navigate the river exceed the returns from the shipments, navigation may stop. But this is not a frequent occurrence, nor does it last for more than two or three months. Mr. dos Santos estimated that shipments are interrupted for a maximum of three months, no more than once in five years (i.e., 20 percent of the time), in the Asunción-Corumbá reach of the river, and are never interrupted in the Santa Fe-Asunción reach.

Table 2.2 and Figure 2.2 illustrate the effects of changing the probability of a collapse on HLBE's calculations of NPV and IRR for the alternative scenarios. If HLBE's methodology for calculating a collapse is used, but the calculations are corrected to reflect the actual probabilities of 0.06 percent for the Asunción-Corumbá reach and 0.03 percent for the Santa Fe-Asunción reach, then the NPVs of all of the alternative scenarios, including the base case, are negative. In summary, none of the alternatives are economically feasible with a 12 percent discount rate.

Table 2.2 and Figure 2.2 also show that using the probabilities of 20 percent on the Asunción-Corumbá reach and zero percent on the Santa Fe-Asunción reach still yields negative NPVs and IRRs less than 12 percent for all but the B2/F2E1 scenario. That is, by using the probabilities of a collapse from a knowledgeable barge company owner, the base case, E2E1 and F2E1 are not economically feasible.

For illustrative purposes, a simple halving of the HLBE probabilities indicates the sensitivity of HLBE's assumed probabilities of a collapse. As shown in Table 2.2 and Figure 2.2, if the probability of a collapse on the Asunción-Corumbá reach is reduced from 40 percent to 20 percent and the probability of a collapse on the Santa Fe-Asunción reach is reduced from 20 percent to 10 percent, then the NPVs of all the scenarios are reduced dramatically and the IRRs are near IDB's 12 percent cutoff rate, below which projects cannot be funded.

The high sensitivity of the economic feasibility of the alternative scenarios to the probability of a collapse and the extremely questionable values used by HLBE raise serious doubts as to the validity of HLBE's calculations of NPV and IRR.

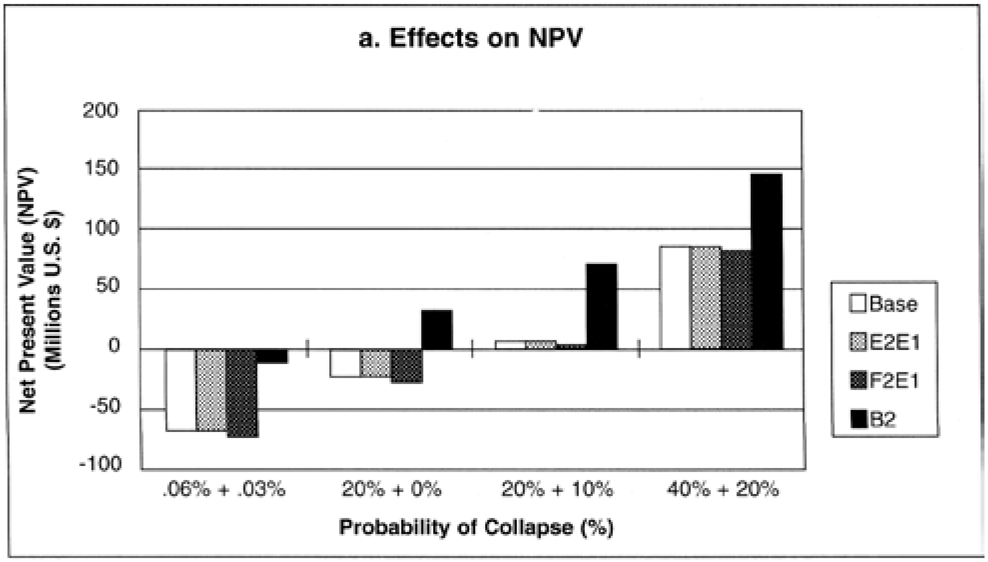
Table 2.2 Effects of Changing the Probability of a Collapse on NPV and IRR

Probability of Collapse		**Base Case**		**E2E1**		**F2E1**		**B2/F2E1**	
Santa Fé-Asunción	Asunción - Corumbá	NPV (millions U.S. 5)	IRR (%)	NPV (millions U.S. 5)	IRR (%)	NPV (millions U.S. $)	IRR (%)	NPV (millions U.S.$)	IRR (%)
0.03%	0.06%	–70.13	—	–70.00	–0.38	–75.73	–1.46	–12.44	10.59
0%	20%	–24.96	–2.26	–24.59	8.15	–30.56	7.25	32.74	15.62
10%	20%	9.10	16.25	9.47	13.44	3.50	12.53	66.80	19.40
20%	40%	92.41	50.62	91.33	25.21	85.36	24.18	148.65	28.45

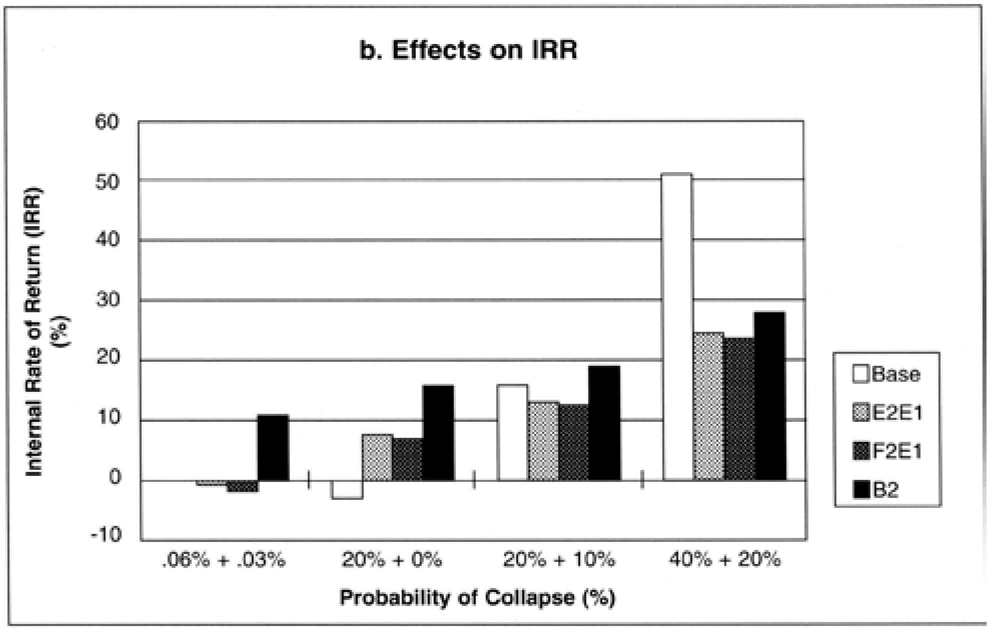
2.2.2 BENEFITS OF GUARANTEEING NAVIGATION

Of importance is the value lost in a collapse. HLBE calculates value as the loss of the annual savings o shipping by water. Again this seems misleading: for cargoes that are shipped every month of the year, the losses restricted to the months when shipping by water is not possible. Costs are simply due to storage and losses in value of the product while waiting to be shipped. Even when these cargoes cannot be stored and must be shipped by alternative modes, the lost benefits are simply for the period when alternative transportation must be used (e.g., three months), not for the entire year as HLBE assumes. Moreover soybean production-which accounts for a significant portion of the transportation needs of the region-requires transportation only seven months per year, and this corresponds with the high water season; therefore, low flows are not likely to affect soybean shipments.

Figure 2.2 Effects of Changing the Probability of a Collapse



(Asunción-Corumbá & Santa Fe-Asunción Reaches)



(Asunción-Corumbá & Santa Fe-Asunción Reaches)

The effects of different durations of collapse on the NPVs and IRRs of the alternative scenarios using HLBE's assumed collapse rates of 40 percent in the Asunción-Corumbá reach and 20 percent in the Santa Fe-Asunción reach are provided in Table 2.3 and Figure 2.3. If a collapse occurs for a three-month period, then the NPV of all the scenarios except the base case are negative and the IRRs fall below IDB's 12 percent cutoff rate. Using HLBE's numbers for collapse rates, but calculating the benefits of guaranteeing navigation as the transportation cost savings for only three months instead of one year, only the base case is economically feasible. With HLBE's assumed collapse probabilities and definition of a collapse in navigation being three months, the base case has a NPV of U.S. $20.46 million and IRR of 17.59 percent. The other scenarios have negative NPVs and IRRs below 12 percent.

Table 2.3 Effects of Protecting Against Varying Months of Collapse on NPV and IRR

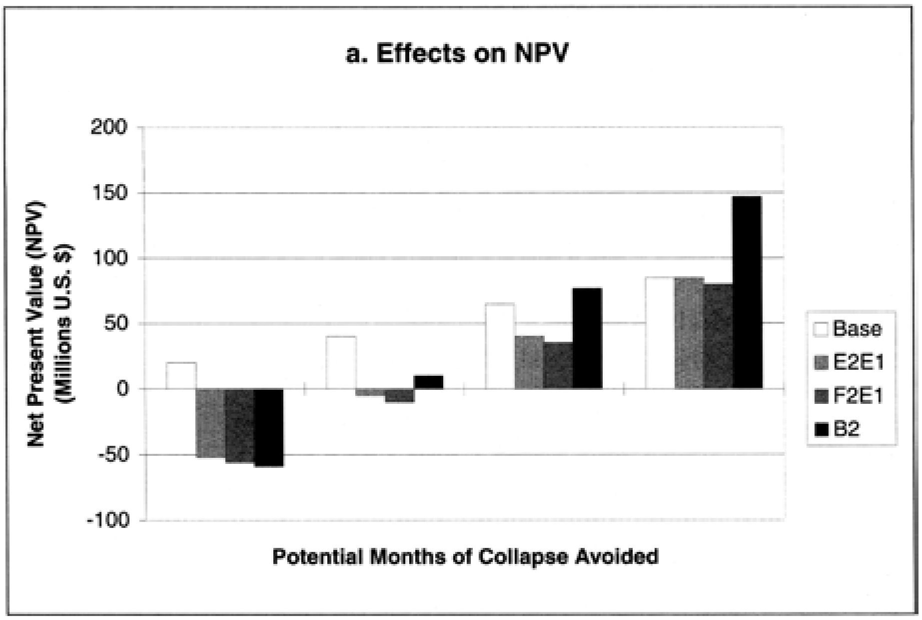
Months of Collapse*	Base Case		E2E1		E2E1		B2/F2E1	
	NPV (millions U.S. S)	IRR (%)	NPV (millions U.S. $)	IRR (%)	NPV (millions U.S. $)	IRR (%)	NPV (millions U.S. 5)	IRR (%)
3	20.46	17.59	–51.38	5.17	–57.35	4.42	–60.45	5.43
6	43.96	26.11	–3.81	11.48	–9.78	10.69	9.25	12.99
9	67.46	37.24	43.76	18.12	37.79	17.22	78.95	20.56
12	92.41	50.62	91.33	25.21	85.36	24.18	148.65	28.45

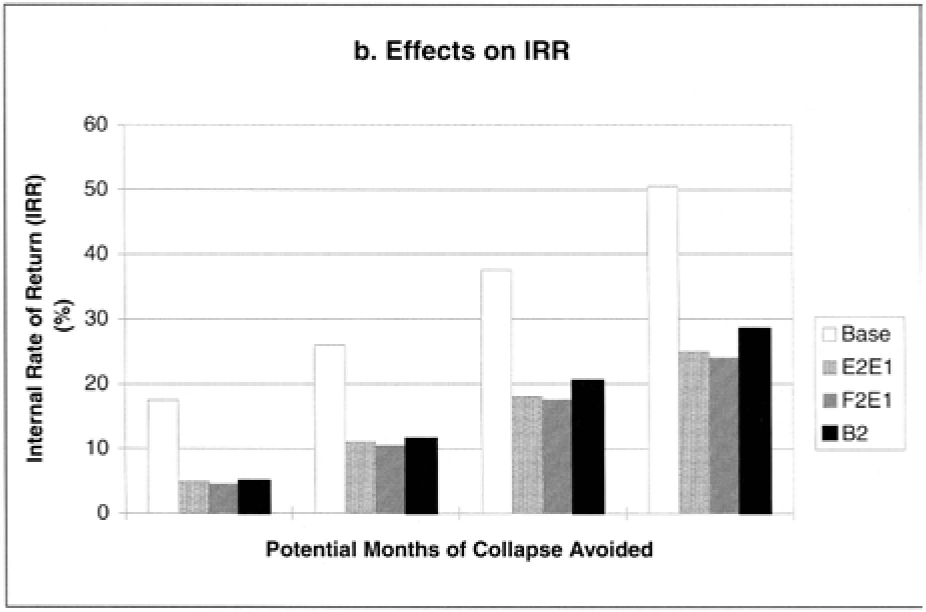
*HLBE defines a collapse in navigation as occurring when folws are too low for barge traffic for 3 months, but calculates benefits of avoiding a collapse as transportation cost savings for 12 months.

To reiterate, HLBE states that a collapse in navigation occurs when flows are too low for shipments for a three-month period; however, HLBE calculates the benefits of avoiding a collapse as the savings in transportation costs for 12 months. As already noted, this does not make sense. This over estimation of benefits by HLBE results in positive NPVs and IRRs greater than 12 percent for all of the scenarios.

Two other values for the length of a collapse and, therefore, the potential benefits of guaranteeing navigation are illustrated in Table 2.3 and Figure 2.3. These are provided to illustrate the sensitivity of the results based on HLBE's assumption. Doubling the length of a potential collapse (i.e., doubling the potential benefits) from three months to six months does not increase the NPVs and IRRs of scenarios E2E1 and F2E1 enough to judge them economically feasible. And while scenario B2 in the Corumbá-Cáceres reach of the river now has a positive NPV of U.S. $9.25 million and IRR of 12.99 percent, it is still clearly inferior to the returns of the base case, which has a NPV of U.S. $43.96 million and IRR of 26.11 percent. It requires a tripling of the length of the potential benefits, corresponding to a collapse of at least nine months, to produce positive NPVs and IRRs greater than 12 percent for all scenarios.

Figure 2.3 Effects of Changing the Months of Protection





As in the previous examination of the probabilities of a collapse, HLBE's calculations are also sensitive to the assumed duration of a collapse. Both HLBE's definition of a collapse and the hydrology of the river system indicate that the maximum period when navigation may be interrupted is three months. Using HLBEs values for savings of transportation costs for three months indicates that only the base case may be economically feasible.

2.2.3 ENVIRONMENTAL COSTS

There are several problems with HLBE's estimation of environmental costs. First, the only environmental costs believed to be associated with the initial and annual dredging of the waterway are losses to fishing. This seems inadequate. Earlier reports (e.g., Bucher & Huszar, 1995) identify a range of likely environmental costs, which are ignored by HLBE.

Second, HLBE estimates the value of fish losses as simply the reduced value of commercial fishing. Besides the "use" value of fish, there are other values, such as the role of the fish in the food chain for other wildlife that should be considered. Even if the analysis is restricted to the sole use of fish by humans, commercial fishing is not the only use. While HLBE recognizes both commercial and sport fishing values earlier in its report, only losses to commercial fishing are considered when actually measuring environmental costs. According to HLBE's own data, neglecting losses due to sportfishing has the effect of underestimating the potential losses by approximately 50 percent.

Third, HLBE considers only the direct impacts of reduced fish populations. Reduced commercial fishing catches will affect other sectors of the economy, such as restaurants and sellers of fishing equipment. Moreover, reduced incomes by commercial fishers will reduce incomes to others from whom they buy.

That is, HLBE does not account for the indirect or multiplier effects of commercial fishing on the local and regional economies. These indirect impacts may be three to four times the direct impacts.

Fourth, HLBE calculates losses to commercial fishing as a linear function of the proportion of the river affected by the "plume" from dredging. Moreover, HLBE's calculations imply that the impact of dredging has a duration of only one year. Both of these assumptions seem highly questionable and require examination by qualified scientists.

Fifth, HLBE estimates the annual value of commercial fishing to be U.S. $34 million, but estimates the loss to commercial fishing to be only U.S. $0.76 million due to initial dredging and only U.S. $0.23 million annually due to maintenance dredging. HLBE therefore estimates environmental losses to be only two percent of total commercial fishing value and annual losses to be less than one percent of total commercial fishing value. These insignificant losses seem too small to be credible.

Finally, HLBE assumes that the commercial fishing losses of scenarios E2E1 and F2E1 are the same as for the base case and that losses are only slightly greater for scenario B2 in the Corumbá-Cáceres reach, despite the fact that these scenarios entail much more dredging than the base case. However, the initial dredging costs of the base case are U.S. $25.96 million and the annual maintenance dredging costs are U.S. $6.62 million. The initial dredging costs for scenario E2E1 of U.S. $79.23 million are 3.05 times greater and the annual maintenance dredging costs of U.S. $14.30 million are 2.16 times greater than for the base case. Similarly, the initial dredging costs for scenario F2E1 of U.S. $80.52 million are 3.10 times greater and the annual maintenance dredging costs of U.S. $15.03 million are 2.27 times greater than for the base case.

The initial dredging costs for scenario B2 of U.S. $94.83 million are 3.65 times greater than the base case, yet the commercial fishing losses estimated by HLBE are only U.S. $0.95 million, 1.25 times greater than for the base case. Annual dredging costs for B2 are U.S. $17.65 million, 2.67 times greater than for the base case, but annual commercial fishing losses are estimated to be only U.S. $0.35 million, 1.52 times greater. Moreover, HLBE's nominal values of environmental costs for B2 are contrary to the fact that the Pantanal is broadly acknowledged to be the most environmentally sensitive and significant reach of the river. Dredging in the Pantanal, therefore, would have a broad range of environmental costs. Fortunately, this has led the Brazilian government to conclude it would not sanction dredging in the Pantanal.

It should also be noted that the reports produced by HLBE and TGCC do not agree on the impacts the Project will have on fisheries. HLBE assumes very small impacts, while TGCC estimates that the impacts could be very serious in some reaches.

Generally, HLBE's method of measuring environmental costs has the potential to minimize their actual significance. While it is beyond the scope of this study to measure the magnitude of environmental costs associated with the alternative scenarios, the following discussion examines what critical values of environmental costs would make the Project unfeasible. The purpose of the following discussion is to determine how great environmental costs would have to be in order to judge whether alternative scenarios are not economically feasible and to assess if such values could realistically occur.

Table 2.4 and Figure 2.4 display the critical environmental costs for different combinations of probabilities of a collapse and potential months of collapse avoided. The critical environmental costs are in terms of their NPV. In calculating the NPV of the critical environmental costs, it is assumed that environmental costs will be proportional to the extent of dredging and, therefore, the amount of dredging costs. Table 2.4 contains four parts, corresponding to the base case and scenarios E2E1, F2EI, and B2.

Table 2.4 Critical Environmental Costs for Project to be Unfeasible with Different Months of Protection and Probability of Collapse (NPV in Million U.S. $ and Percent of Dredging Costs)

a. Base Case

Months Protected	Probability of Collapse		
	20% & 0%	20% & 10%	40% & 20%
3	0	0	$23.2(33%)
6	0	0	$46.7(67%)
9	0	0	$69.9 (100%)
12	0	$11.9(17%)	$93.4(133%)

b. E2E1

Months Protected	Probability of Collapse		
	20% & 0%	20% & 10%	40% & 20%
3	0	0	0
6	0	0	0
9	0	0	$46.1(28%)
12	0	$13.2(8%)	$93.9(57%)

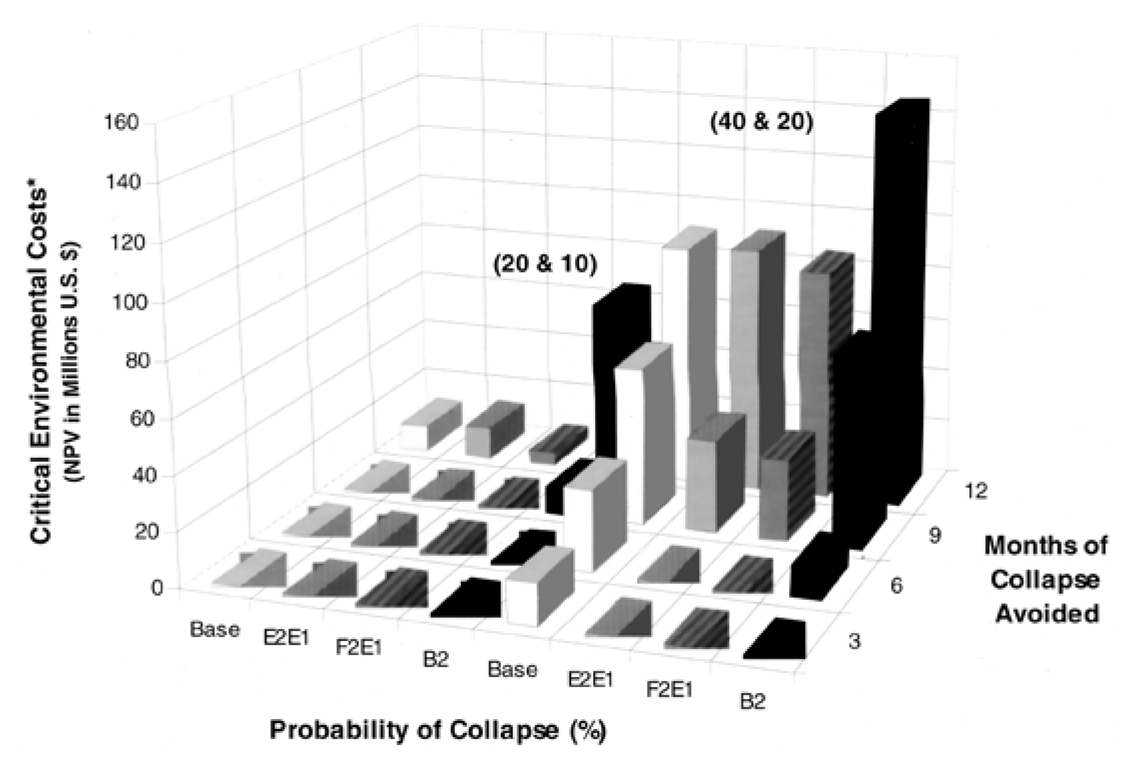
c. F2E1

Months Protected	Probability of Collapse		
	20% & 0%	20% & 10%	40% & 20%
3	0	0	0
6	0	0	0
9	0	0	$41.0(24%)
12	0	$6.8(4%)	$88.8(52%)

d. B2

Months Protected	Probability of Collapse		
	20%&0%	20%&10%	40%&20%
3	0	0	0
6	0	0	$14.0 (7%)
9	0	$12.0 (6%)	$82.3(41%)
12	0	$70.3(35%)	$152.6(76%)

Figure 2.4 **Critical Environmental Costs for Project to Be Unfeasible with Different Months of Protection and Probability of Collapse (Asunción-Corumbá & Santa Fe-Asunción Reaches)**



*The critical environmental cost is the cost to the environment that, if included in the benefit-cost calculations, would make the NPV negative, when the discount rate used is 12 percent, or equivalently make the IRR less than 12 percent.

Assuming a 40 percent probability of a collapse on the Asunción-Corumbá reach of the river and a 20 percent probability of a collapse on the Santa Fe-Asunción reach, and assuming that the benefits of avoiding a collapse apply to all 12 months of the year (i.e., HLBE's assumptions), then environmental costs of U.S. $93.4 million for the base case, U.S. $93.9 million for scenario E2E1, U.S. $88.8 million for scenario F2E1, and U.S. $152.6 million for scenario B2 are the critical values above which the IRR would be less than 12 percent.

The critical environmental costs (i.e., the level of environmental costs required for the Project to be deemed economically unfeasible) under HLBE's assumptions are relatively high. Using these assumptions results in such high benefits for the alternative projects that environmental costs would have to be high in order to judge the alternatives unfeasible. Environmental costs would have to be 133 percent of dredging costs for the base case, 57 percent of dredging costs for scenario E2E1, 52 percent of dredging costs for scenario F2E1, and 76 percent of dredging costs for scenario B2.

As already discussed, HLBE's assumptions are suspect. HLBE incorrectly calculates the value of protecting against a collapse in navigation as the yearly savings in transportation costs from using the waterway when, in fact, the value is the savings for the two to three months when transportation may be interrupted. Correctly calculating the value of benefits as three months of savings instead of a year results in significantly smaller values for the critical environmental costs. The base case would therefore be economically unfeasible if environmental costs have a NPV of U.S. $23.2 million, or 33 percent of dredging costs. Scenarios E2E1, F2E1, and B2 are unfeasible without any environmental costs beyond the commercial fishing losses estimated by HLBE.

As mentioned earlier, HLBE likely overestimates the probability of a collapse. Using HLBE's methodology to calculate the probabilities, but correcting for its miscalculations, results in very small values. Even if HLBE is off by only 50 percent - so that the probability of a collapse is 20 percent on the Asunción-Corumbá reach and 10 percent on the Santa Fe-Asunción reach - and still using HLBE's assumption that avoided losses are for 12 rather than three months, the effect is to make the critical environmental costs much smaller. For instance, the base case is economically unfeasible with environmental costs having a NPV of U.S. $11.9 million, or 17 percent of dredging costs (Table 2.4 and Figure 2.4). Scenario E2E1 is unfeasible with environmental costs having a NPV of U.S $13.2 million, or eight percent of dredging costs; scenario F2E1 is unfeasible with environmental costs having a NPV of U.S. $6.8 million, or four percent of dredging costs; and scenario B2 is unfeasible with environmental costs having a NPV of U.S. $70.3 million, or 35 percent of dredging costs.

If the value of protection is correctly calculated as the savings for a three-month period, and the probabilities of a collapse are still assumed to be the relatively high value of 20 percent for the Asunción-Corumbá reach and 10 percent for the Santa Fe-Asunción reach, then none of the alternatives are economically feasible, even with no additional environmental costs to those assumed by HLBE. HLBE's calculations of NPV are highly sensitive to its measurements of benefits and environmental costs. The benefits depend upon the probability of a collapse and the period of time for which the benefits are realized. HLBE appears to overestimate benefits and underestimate costs. Only modest changes in its basic assumptions will reverse HLBE's conclusions that the base case, EM, F2E1, and B2 are all economically feasible.

2.2.4 ALTERNATIVE TRANSPORTATION

Under the base case and E2E1 and F2E1 scenarios, HLBE assumes the majority of production from the region will be shipped via the waterway. Specifically, HLBE assumes that 42 percent of the soybean production and 100 percent of the iron, manganese, clinker, pulp, and wheat production will be shipped on the waterway, as well as all imports of petroleum. There are, however, competing forms and routes of transportation that either currently exist or are likely to exist in the near future.

Indeed, HLBE recognizes this possibility when discussing the B2 scenario for the Corumbá-Cáceres reach. According to HLBE, completion of the Ferronorte railroad from Cuiabá to the port of Santos on the Atlantic Ocean prior to the year 2021 would result in shipments on the waterway being too small to justify the expense of dredging between Corumbá and Cáceres. The construction of this railroad was nearly completed before being temporarily stopped due to financial problems. It is this interruption in the railroad's construction that leads HLBE to speculate on the possible financial feasibility of scenario B2 through the Pantanal.

However, according to Hydrovia Project critic Mr. Mauricio Galinkin of the non-governmental organization Fundação Centro Brasileiro de Referências e Apoio Cultural (CEBRAC) (personal interview, March 1997), the Noel Company of the United States has recently purchased the São Paulo-Campo Grande portion of the railroad, has been granted a concession for the Corumbá-Bauru portion, and plans to operate the railroad. Also, needed bridge work over the Paraná River is being completed by the Brazilian government. Finally, ample financial backing for the Project has been obtained from PREVI, the pension fund of the Banco do Brasil, so that all indications are that the railroad will soon be completed. Thus, even in terms of HLBE's own analysis, scenario B2 is clearly not economically feasible.

Two other waterway projects will compete with the Hydrovia Paraguay-Paraná for cargo. The Hydrovia Madeira-Amazon will carry cargo to the northeast and is capable of carrying 70 percent of the soybean production and 35.6 percent of the milo production from the region. The Hydrovia Araguaia-Tocantins, will also ship to the north, and can ship 17.7 percent of the soybean, 7.4 percent of the milo, and 14.6 percent of the other cargo from the region (Galinkin et al., 1994).

Improved trucking routes are also being constructed in the region. The Cuiabá-Santarém highway and the Saída para o Pacífico highway are nearly completed and will reduce both the time and cost of shipping by truck.

HLBE's failure to consider the effects of improved alternative transportation results in at least two significant errors. First, when calculating the transportation cost savings of the waterway, they compare improved water transportation with existing alternative road and rail transportation. These alternative modes of transportation, however, are being improved. This therefore results in less savings and benefits than initially estimated by HLBE. Second, calculation of the cargo loads for the waterway assumed that nearly all regional production would be captured by the waterway. The availability of good transportation alternatives leads to another overestimation of benefits by HLBE.

As seen in the above analysis, HLBE's calculations are very sensitive to its estimates of benefits. Reducing the cargo loads captured by the waterway would have the same effect on the NPV of the Project as reducing the number of potential months of collapse avoided. A 25-percent reduction in cargo loads would be equivalent to the values for nine months, a 50-percent reduction would be equivalent to six months, and a 75-percent reduction would be equivalent to three months (see Table 2.3 and Figure 2.3).

A 50-percent loss of cargo loads due to competition from alternative modes of transportation would make scenarios E2E1 and F2E1 unfeasible, even without the other problems already discussed. In conjunctionwith the other problems discussed, competition from the alternative transportation routes currently being completed will drastically reduce the feasibility of all of HLBE's alternative projects and likely render them unfeasible.

2.2.5 GROWTH OF CARGO LOADS

HLBE calculates the benefits of the base case and the alternative scenarios as the savings in transportation costs they would provide over alternative transportation for a growing level of regional exports and imports. Table 2.5 shows HLBE's estimates of regional shipments. During the period from 1997 to 2020, HLBE predicts that regional shipments (in terms of cargo weight) will more than double from 9,671 metric tons to 21,351 metric tons, an increase of 127 percent. HLBE predicts exports will increase for soybeans by 102 percent, iron ore by 207 percent, clinker by 118 percent, pulp by 125 percent, petroleum by 115 percent, and wheat by 171 percent. With approximately 60 percent of the total, soybean shipments dominate HLBE's predicted growth in exports.

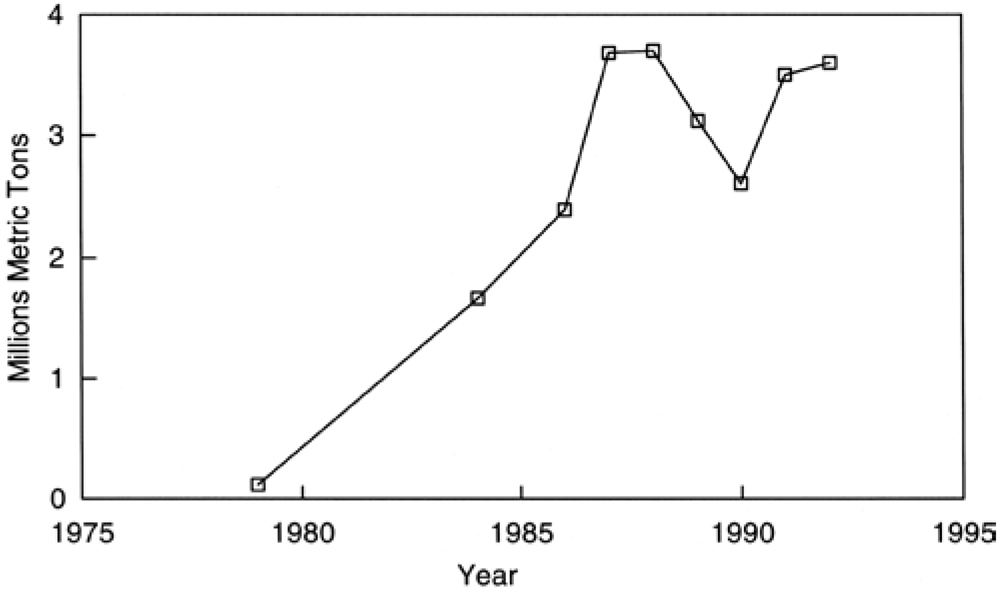
Table 2.5 Growth of Regional Exports and Imports

Product	**Total Regional Exports (1,000tons/yr)**		
	1997	2020	Percent Increase
Soybean	5,885	11,888	102%
Iron	1,400	4,300	207%
Manganese	121	121	0%
Clinker	555	1,212	118%
Pulp	267	600	125%
Petroleum	1,216	2,614	115%
Wheat	227	616	171%
Total	9,671	21,351	127%

Source: HLBE, (1996a), Table 9.1.

These high rates of growth for regional production estimated by HLBE may be more indicative of past trends than of the future, as there is increasing evidence such rates may not be sustainable. For example, Figure 2.5 graphs soybean production in Mato Grosso, Brazil, over the 1979-92 period. After increasing rapidly during the early 1980s, it appears that soybean production has leveled off in the 1990s.

Figure 2.5 Soybean Production in Mato Grosso, Brazil



Source: Data from Abrams et. al. (1994).

There is evidence to suggest that declining land fertility and nematode infestations associated with the extended exploitation of tropical soils are severely curtailing increases of soybean production (Galinkin, personal interview, March 1997). Moreover, HLBE concludes that most of the suitable areas for soybean production in the region have already been developed, making further expansion of soybean production unlikely.

HLBE's projection of a 3.25-percent annual growth rate in soybean production seems to rest upon assumed increases in productivity (i.e., increases in output per hectare) that are not likely given declining soil fertility and increasing pest infestations. HLBE's projections seem to correspond more with the growth trend in the early 1980s and not for the late 1980s or the first part of the 1990s.

If HLBE's estimates of increases in regional production are incorrect, then so are the estimates of cargo loads and, therefore, the estimates of benefits that accrued by the alternative scenarios. It is evident that there is reason to believe that the economic feasibilities of the alternative navigation projects identified by HLBE are questionable.

CHAPTER 3 DISTRIBUTION OF BENEFITS AND COSTS

The benefit-cost analysis conducted by HLBE and evaluated in the previous chapter of this report is an efficiency criterion, for it seeks to determine if the benefits of the proposed project will exceed the costs. Our previous discussion of the HLBE analysis has pointed to numerous areas where the proposed Hydrovia Project is not likely economically efficient and, therefore, should not be adopted in its present form.

Photo 4. Local fisherman. Tamengo Channel, Brazil.
Photo: André Leite/WWF Canada

As a development project, distribution of the benefits and costs should be addressed in the evaluation. The Project's desirability criteria should include not only its economic efficiency, but also its economic equity.

The most important distributional issue involves which individuals in the society gain and lose economic status. The absolute and relative distributions of benefits and costs between the rich and poor members of the affected population needs to be addressed. Within lower income groups are sub-groups such as the indigenous peoples, who are recognized as being treated unjustly and thus require protection from future alterations of the economy. While equity is a value judgment, it is generally agreed that equity within development requires the gap between low- and high-income groups be narrowed and that the lowest income groups be made better-off in absolute terms.

In addition to the social justice issue, the distribution of the benefits and costs from the Project may also affect its economic viability. Funding will likely come from the IDB. As previously discussed, IDB requires a project to have an IRR of at least 12 percent to be eligible for funding. As reported by Scudder and Clemens (1997), the top priority and requirement of the IDB in the 1990s is poverty reduction and equitable distribution of development benefits. They quote the IDB (1997) as stating that:

> As we enter the Eighth Replenishment, the Bank must expand its operation in the social areas. As the region comes out of the acute financial crisis of the 1980s, it is placing greater emphasis on resolving the problems of the "social debt" in order to ensure more equitable development. Operational work in the social sectors, including dialogue, lending, and project execution will be a major focus of the Bank's overall activity to support efforts of borrowers to deal with this challenge in the 1990s. Increased lending in the social sectors will not, however, be sufficient. To maximize its impact during the Eighth Replenishment, the Bank will seek to ensure that its activities overall contribute directly or indirectly to borrowing member countries efforts to reduce poverty and to introduce social and economic reforms. (IDB, 1997)

There are at least two other distributional issues that may not necessarily affect the social desirability of the Hydrovia Project, but likely do affect its political viability. First is the distribution of benefits and costs among the countries involved. Even if the aggregate benefits exceed the aggregate costs of the Project, the distribution among countries must be such that each country receives a positive net benefit, otherwise the country will not support the Project. Second, care must be exercised when subsidizing one of several competing sectors of the economy. Issues of fairness, as well as political lobbying, may reduce support for the Project. In particular, the Hydrovia Project represents a subsidy to water transportation, which competes with road and rail transportation.

The following discussion considers these three distributional issues for the Hydrovia Project. It examines the distribution first by classes and groups of people, then by country and finally by mode of transportation.

3.1 Distribution by Classes/Groups of People

The following discussion of the distribution of impacts by groups is divided between a consideration of impacts identified in the studies of HLBE and TGCC and impacts they fail to consider.

3.1.1 IMPACTS IDENTIFIED BY HLBE AND TGCC

The HLBE economic analysis identifies benefits of the Project in terms of transportation cost savings over alternative modes of transportation and reduced risk of interruption to navigation due to low flows. The costs identified by HLBE are confined to construction and maintenance costs, with minor costs to commercial fishing.

HLBE expects regional trade to increase by 127 percent by the year 2020 (see Table 2.5). However, HLBE argues that this increase will occur even without the Hydrovia Project. If this is the case, then reduced transportation costs must simply mean higher profits for producers of the aforementioned commodities. These producers represent large, concentrated economic interests.

As a share of total shipments, soybeans represent 61 percent, iron ore represents 14 percent, and petroleum represents 13 percent. Soybean production is characterized by large-scale, capital-intensive farming and is conducted by a relatively small number of individual and corporate agricultural enterprises. Mining and petroleum interests are similarly large scale and concentrated. For example, HLBE identifies two mining companies, which together dominate iron ore production (Scudder & Clemens, 1997). In summary, the benefits of reduced transportation costs will be concentrated among a relatively small number of large-scale enterprises.

Barge companies will also benefit from the Project. Revenues will increase due to a greater volume of shipments. Operating costs will be reduced due to economies of scale associated with larger barge trains, the decreased need to reconfigure barge trains due to shallow and narrow channels, and the elimination of interruptions to navigation due to low river flows. These cost-reducing factors will further increase the competitiveness of the use of barges over trucks and trains.

HLBE discusses financing the Project through general tax revenues, user fees on barge operators, or some combination of the two, though no definite plan is offered. Understandably, barge operators are reluctant to support a system of user fees. The likely source of revenues to pay for the Project is general tax revenues, so that the costs of the Project will be spread over the populations of the participating countries.

What may be a cost to the taxpayer, however would be a large and concentrated benefit to the companies that will design, construct and maintain the Project. HLBE has already received approximately U.S. $4.7 million and TGCC has received U.S. $2.8 million for their feasibility/impact studies. If the Project is approved, HLBE stands to earn a great deal more for design and construction work. There appears to be a conflict of interest in HLBE assessing the feasibility of a project for which it would also likely compete for the contract to design and construct. Depending upon which of the current scenarios is adopted, construction and dredging companies in the region would initially receive between U.S. $30 million and U.S. $102 million for initial construction of the Project and another U.S. $7 million to U.S. $22 million annually for its maintenance.

3.1.2 IMPACTS IGNORED BY HLBE AND TGCC

In addition to the distributional impacts ignored by HLBE and TGCC are the potential displacement of small shareholders by large-scale soybean production, increased pollution of the river by increased barge traffic, soil erosion, internal migration, and the degradation of the natural environment.

While HLBE and TGCC assume that the Hydrovia Project will not contribute to an increased area of land for soybean cultivation, there is contradicting evidence. First, HLBE and TGCC predict a twofold increase in soybean production over the next 20 years. This seems to be possible only if soybean land area increases or soybean productivity per unit of land increases. Second, evidence exists that productivity is actually declining, as discussed earlier in section 2.2.5. Therefore, it only seems possible for total production to increase twofold if the land area used for soybean production also increases. Other knowledgeable sources also conclude that the Hydrovia Project will stimulate an expansion of land area in soybean production. Scudder and Clemens (1997) argue that "the completion of the Hydrovia Project will stimulate a more rapid increase in soybean cultivation in Paraguay, Brazil and Bolivia than would have occurred without the Project" (p. 55).

The distributional effect of expanding land in soybean production would be to shift ownership and use from small holders and indigenous peoples to large, capital-intensive soybean operations. Melià (1997) observes that the mere promise of the construction of the Hydrovia Project is already stimulating land speculation for soybean production, and this speculation by large landholders is driving out small landowners and indigenous peoples. The effects on indigenous people are particularly severe because they do not always hold clear titles to the lands they inhabit and use. Banck and den Boer (1991) found that soybean production expansion has been entirely at the expense of small-scale agriculture in Brazil's Rio Grande do Sul state. Bartolome (1989) points out that one of the costs of displacing small landholders is the forced migration into urban slums and into neighboring countries as illegal immigrants.

In addition to a shift from small to large shareholders, the expansion of soybean production has also been associated with an expansion of Brazilian-owned operations into adjacent countries. Sigrid Andersen (personal interview, March 1997) reports that 120 Brazilian soybean farmers now own 500,000 hectares, or 25 percent, of the state of Santa Cruz, Bolivia. Production of soybeans by Brazilian-owned farms grew from seven percent of Bolivia's production in 1993-94 to 25 percent in 1994-95 and continues to expand rapidly. Bolivian-owned farms account for only 35 percent of the country's soybean production, with U.S. companies, such as Cargill, and Japanese companies making up the difference.

Expansion by Brazilian soybean growers is also evident in Paraguay. Galinkin (personal interview, March 1997) speculates that this expansion into Paraguay is making it a colony of Brazil. The area under soybean production in Paraguay nearly tripled from 350,000 hectares in 1982 to 980,000 hectares in 1992 (Abrams et al., 1994). Construction of the Hydrovia Project is expected to accelerate this trend. Foreign ownership of land resources is not necessarily bad, but is generally looked upon by local governments as undesirable.

The large-scale, capital-intensive production of soybean both pushes out small landowners and fails to provide compensatory employment opportunities. Costs are imposed on those displaced in the form of decreased incomes, decreased employment opportunities, and, often, the need to migrate out of the region. Often migration is into cities, and thus another cost of the displacement is the influx of a poor and untrained population to the slums of cities that are already unable to cope with the health and crime problems they experience.

Declining water quality in the rivers due to the Project will have further distributional impacts. Local fishers will suffer from reduced catches, and downstream water users will have higher treatment costs. Besides the costs to commercial fishing identified by HLBE, recreation and subsistence fishing would also be impaired. Recreational fishing is a source of employment and income to small, local operators. Subsistence fishing is practised by low-income residents of the region, including indigenous peoples. These activities will be jeopardized by the direct and indirect effects the Hydrovia Project will have on the river.

Bucher et al. (1993) states that siltation and pollution of the river will persist beyond the construction phase of the Project. While TGCC concludes that shoreline erosion will not be a problem, Bucher and others argue that navigation by large barge convoys will increase erosion of the river's shoreline and bottom, contributing to an increase of suspended solids and a decrease in aquatic organisms and water quality. Additionally, induced development of soybean production will escalate rates of soil erosion and, consequently, siltation in the river.

Increased barge traffic will likely lead to additional chemical pollution and spills. TGCC identifies mining as being stimulated by the construction of the Hydrovia Project. But increased mining will also contribute to the pollution of the river through use of toxic chemicals, such as mercury. Migration into the region, particularly to the cities, will also be a likely consequence of the Project. At present, none of the cities on the Paraguay River treat their sewage before discharging it to the river. With increasing populations, these sources of pollution can be expected to increase. Finally, Bucher et al. (1993) and others argue that increased barge traffic will increase the probability of collisions and subsequent oil and toxic substance spills. HLBE argues, however, that wider channels and improved signage on the river will decrease this probability, despite the increased traffic.

Another consequence of urban migration resulting from the Hydrovia Project may be an increase in health problems. Migration between areas where diseases (i.e. malaria, yellow fever, dengue and forms of leishmaniasis) are endemic and areas where they are not could expose the non-immune population to these diseases, escalating transmission. This phenomenon has occurred in the Amazon region (Bucher et ai., 1993). TGCC, however, does not predict large-scale migration to the region and, therefore, does not expect an increase in the transmission of diseases.

Both HLBE and TGCC conclude that the Project will have negligible impacts on the natural environment. This opinion is not shared by most environmental scientists. Changes in hydrological patterns, degradation and loss of habitat, resource exploitation, spread of exotic species, and chemical and organic pollution are all likely consequences of the Project; and the impacts are likely to be a broad range of losses to biodiversity. The local populations who depend upon this environment for their livelihoods and lives ultimately suffer, but the losses are not confined to the region or even to South America.

For example, the dredging plans for the Corumbá-Cáceres reach may cause a reduction on the groundwater level of the whole Pantanal, consequently affecting the fresh and saltwater lakes of the Pantanal of Nhecolandia. Through an aerial survey commissioned by WWF (in preparation), evidence has been collected that more than 100,000 migratory birds and other native species use this specific ecosystem as feeding areas. This number of identified birds indicates that the area would qualify as an international reserve under the Western Hemisphere Shorebird Reserve Network (WHSRN) system, a category underlining the international importance of the area.

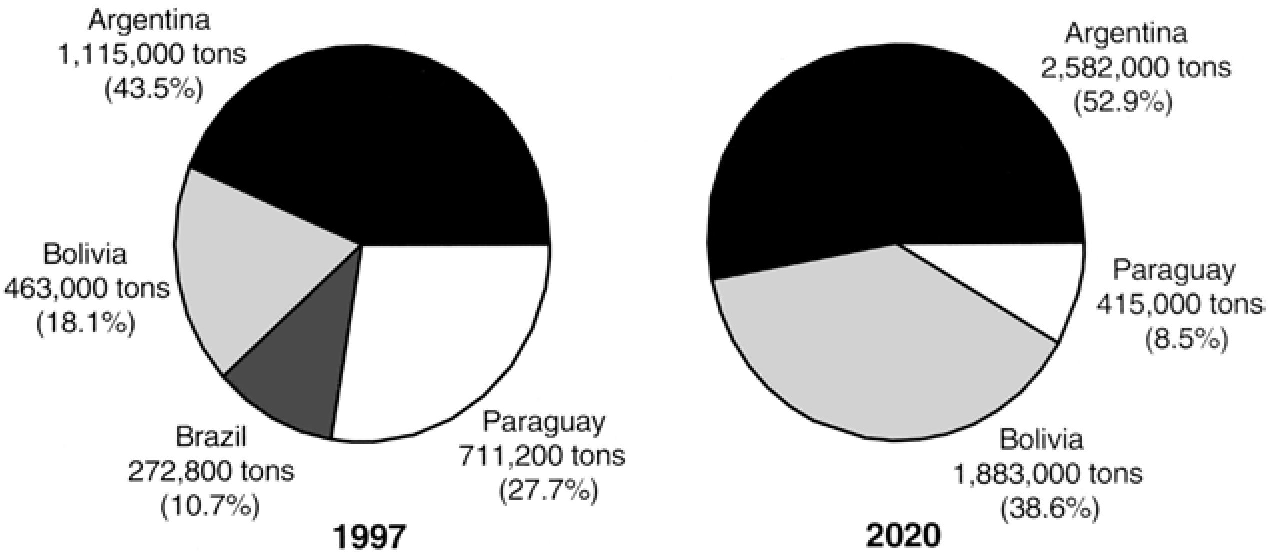
3.2 Distribution by Country

Another distributional issue is how benefits and costs are accrued by country. Chapter 2 raises doubts about whether the Project's benefits would exceed its costs. These benefits and costs may be distributed unevenly over the countries involved and, thus, may shape their political interests in the Project. Countries gaining the most from the Project would be expected to favor its adoption more so than those gaining the least.

HLBE uses predicted growth in regional exports and imports to estimate benefits of the Project. Table 2.5 of chapter 2 shows HLBE's predicted growth of regional shipments by commodity. HLBE concludes that, with the exception of soybeans, these commodities are currently shipped by barges on the river and that all growth in shipments will be carried by the Hydrovia Project. Moreover, Brazil's use of the Paraguay and Paraná Rivers is solely for shipping soybean products.

The absolute and relative use of the Hydrovia Project for shipping soybeans is predicted by HLBE to change over the period from 1997 to 2020 (Figure 3.1). Argentina's use is expected to increase in absolute terms from 1.115 million tons to 2.582 million tons and in relative terms from 43.5 percent to 52.9 percent of total shipments during the 1997 to 2020 period. Bolivia's soybean shipments are predicted to increase dramatically in both absolute and relative terms, increasing from 463,000 tons (18.1 percent) to 1.883 million tons (38.6 percent). On the other hand, Paraguay's shipments will decline from 711,200 tons (27.7 percent) to 415,000 tons (8.5 percent) and Brazil's will decline from 272,800 tons (10.7 percent) to nearly zero.

Figure 3.1 Soybean Shipment Via the Hydrovia Project, by Country



Source: HLBE (1996).

Argentina's use of the waterway for shipping soybeans will increase the most in absolute terms, while Bolivia will increase the most in relative terms. Both Paraguay and Brazil will decrease their use of the waterway for soybean shipments in both absolute and relative terms. In terms of use of the waterway, Argentina and Bolivia stand to gain the most in both absolute and relative terms and can be expected to be strong advocates of the Project, while Brazil should have little interest. Paraguay, though its use of the waterway for soybean shipments will decline, will likely continue to support the proposed Project for the shipment of other cargoes.

It should be noted that HLBE's data contradict statements promoting the Hydrovia Project made by Mr. Jesus Gonzalez, chairman of the CIH and Argentina's Undersecretary of Ports and Waterways. Mr. Gonzalez contends that once the Hydrovia Project is completed ". . . Brazil is going to ship about li million to 15 million tons of grain cargo through the waterway, fundamentally soybeans" (Webb, 1997). But HLBE predicts a decline, not an increase, in soybean shipments from Brazil via the Hydrovia Project. As will be seen in the next section, HLBE does predict increased soybean shipments from Brazil, but by rail, not water.

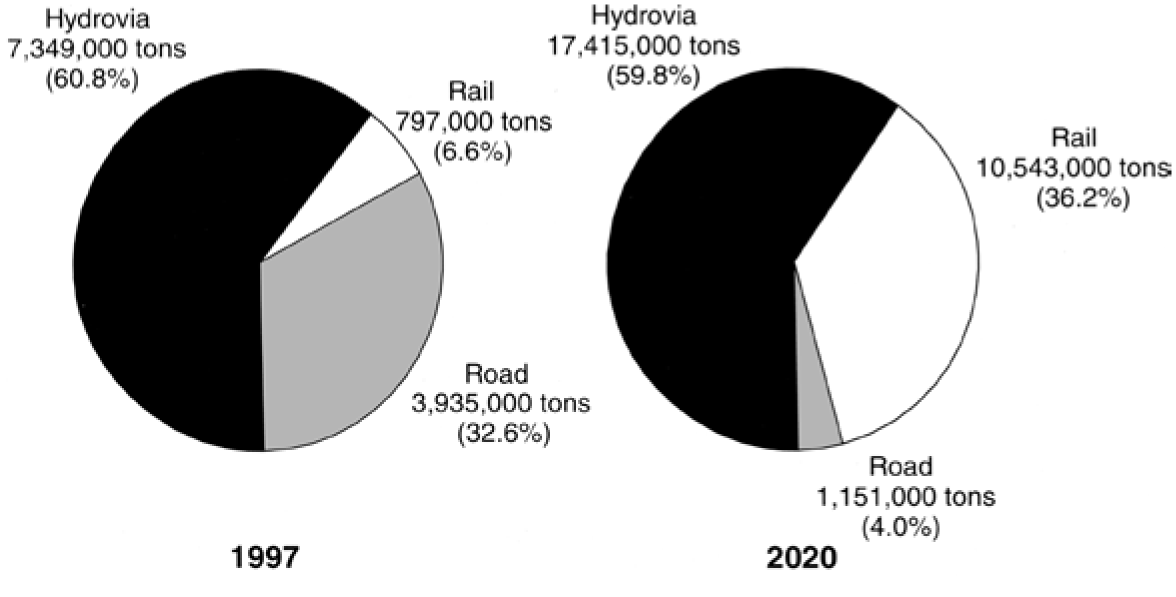
Also of interest is the fact that, over the 10-year period from 1982 to 1992, Brazil's total soybean production averaged about 28 million tons, while production in Mato Grosso and Mato Grosso do Sul states averaged about 2.5 million tons, or eight percent of Brazil's total production (Abrams et al., 1994). In order for the predictions of Mr. Gonzalez to be realized, roughly 50 percent of Brazil's current soybean production will have to be shipped via the Hydrovia Project; alternatively, production in Mato Grosso and Mato Grosso do Sul will have to increase by 500 percent and be exported entirely via the Hydrovia Project. Neither of these scenarios seems likely.

3.3 Distribution by Mode of Transportation

HLBE predicts the distribution of shipments by mode of transportation (Figure 3.2). Shipments in 1997 are estimated to total 12.081 million tons, with 7.349 million tons (60.8 percent) shipped by the Hydrovia Project, 3.935 million tons (32.6 percent) shipped by road, and 797,000 tons (6.6 percent) shipped by rail. By the year 2020, HLBE predicts total shipments to be 29.109 million tons, with 17.415 million tons (59.8 percent) shipped via the Project, 1.151 million tons (4 percent) shipped by road, and 10.543 million tons (36.2 percent) shipped by rail. That is, HLBE predicts shipments via the Project will increase 137 percent, shipments by rail will increase 1.229 percent, and shipments by road will decrease 71 percent.

One interpretation of HLBE's predictions is that government expenditures on the Hydrovia Project (and on improved rail lines as well) will result in both an absolute and relative decline in shipments by road. Barge and train companies are expected to gain, at least in part, at the expense of the trucking industry. Trucking companies and associated activities such as fuel and repair stations will, therefore, bear external costs of government support for alternative transportation modes.

Figure 3.2 Total Shipments by Transportation Mode



Source: HLBE (1996).

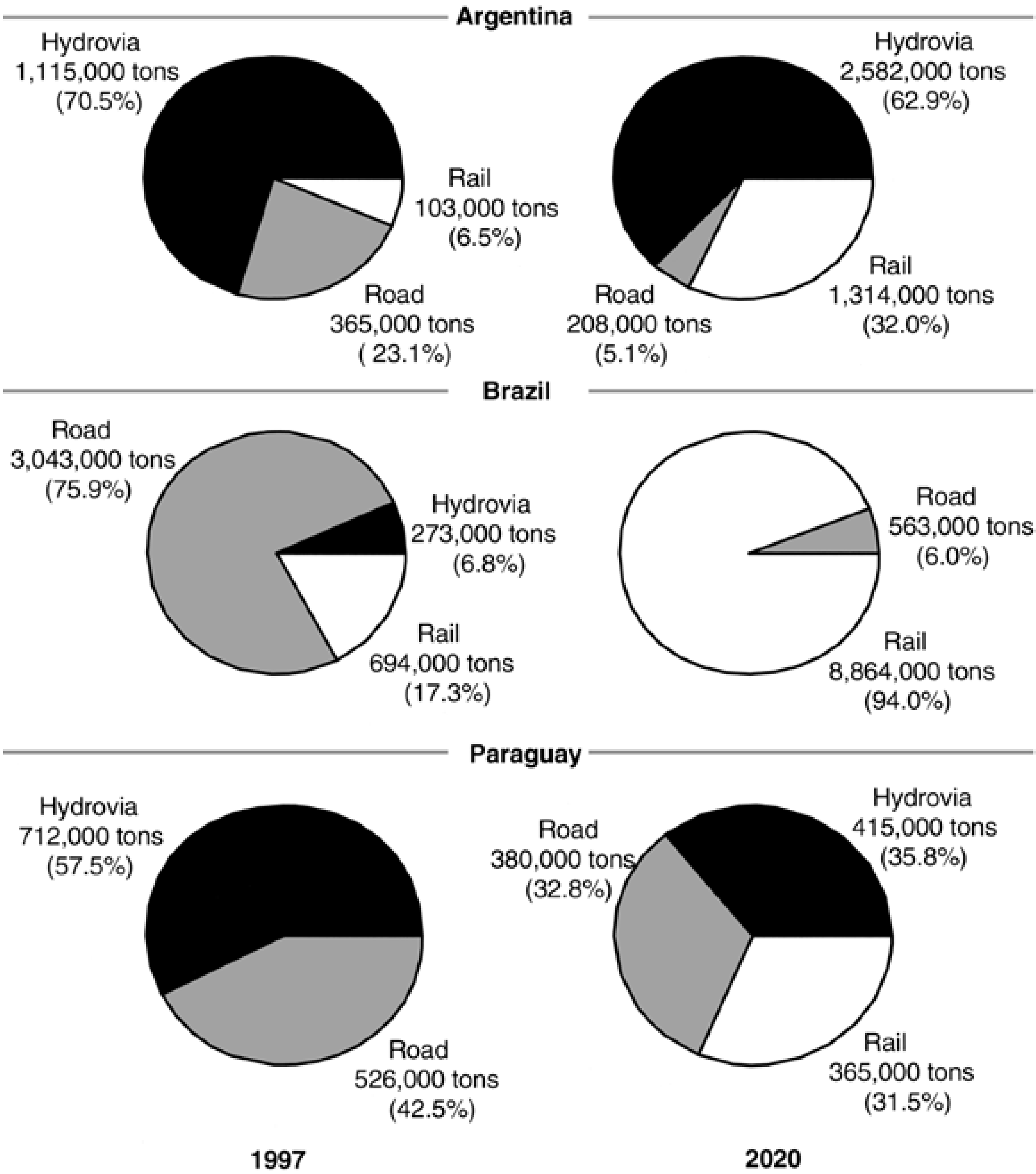
Another interpretation of HLBE's predictions is that they ignore the potential political clout of the trucking industry. Trucking company owners and employees of the trucking industry are likely to lobby for "equal" treatment by government, which would result in increased government expenditures to improve roadways. Such improvements would increase the competitiveness of truck transportation and, consequently, reduce the shares of shipments by the river and rail. This distributional impact would also have the effect of reducing the economic viability of the Hydrovia Project.

Finally, the distribution of shipments by transportation mode predicted by HLBE differs dramatically by country (Figure 3.3). Shipments of iron ore, manganese, clinker, pulp, and petroleum are all assumed by HLBE to be sent only by the Hydrovia Project; but soybean shipments will use road and rail transportation as well. Argentina's soybean shipments via the Project are expected to increase in absolute terms from 1.115 million tons in 1997 to 2.582 million tons in 2020, but to decrease slightly in relative terms from 70.5 percent of total soybean shipments in 1997 to 62.9 percent in 2020. Moreover, Paraguay's soybean shipments via the Project are expected to decline from 712,000 tons (57.5 percent) in 1997 to 380,000 tons (32.8 percent) in 2020 and Brazil's are expected to fall from 3,043,000 tons (75.9 percent) in 1997 to practically zero in 2020.

Interestingly, shipments of soybeans by rail are expected to grow much more dramatically in all three countries (Figure 3.3). Rail shipments over the period from 1997 to 2020 are predicted to increase from 103,000 tons (6.5 percent) to 1.314 million tons (32.0 percent) in Argentina; from 694,000 tons (17.3 percent) to 8.864 million tons (94.0 percent) in Brazil, and from zero to 365,000 tons (31.5 percent) in Paraguay. According to the predictions of HLBE, the shift to rail transportation will be the most dramatic in Brazil, but it also represents major changes in Argentina's and Paraguay's mode for shipping soybeans.

The implications of the shift in the distribution of transportation modes for soybean production are clearly that rail transportation will become an increasingly strong competitor with the Hydrovia Project. Moreover, if the trend continues beyond the time period considered by HLBE, the viability of the Hydrovia Project could be in jeopardy.

Figure 3.3 Distribution fo Soybean Shipments by Transportation Mode and Contry



Source: Data from HLBE (1996).

CHAPTER 4 POLITICAL ECONOMY OF DECISION PROCESS

Given the serious questions raised in the previous analysis as to the desirability of the proposed Hydrovia Project, it seems that the decision makers in the CIH and the involved governments should be less than enthusiastic about the project. This, however, does not seem to be the case. In fact, the presidents of Argentina, Bolivia, and Paraguay are aggressively moving forward with dredging of the river system.

It appears that the distribution of benefits and costs from projects such as the Hydrovia Project is such that the decision process will be heavily weighted in favor of the Project regardless of its net benefits. That is, even if the costs outweigh the benefits of the Project, those favoring the Project will inevitably control the decision-making process and approve the Project.

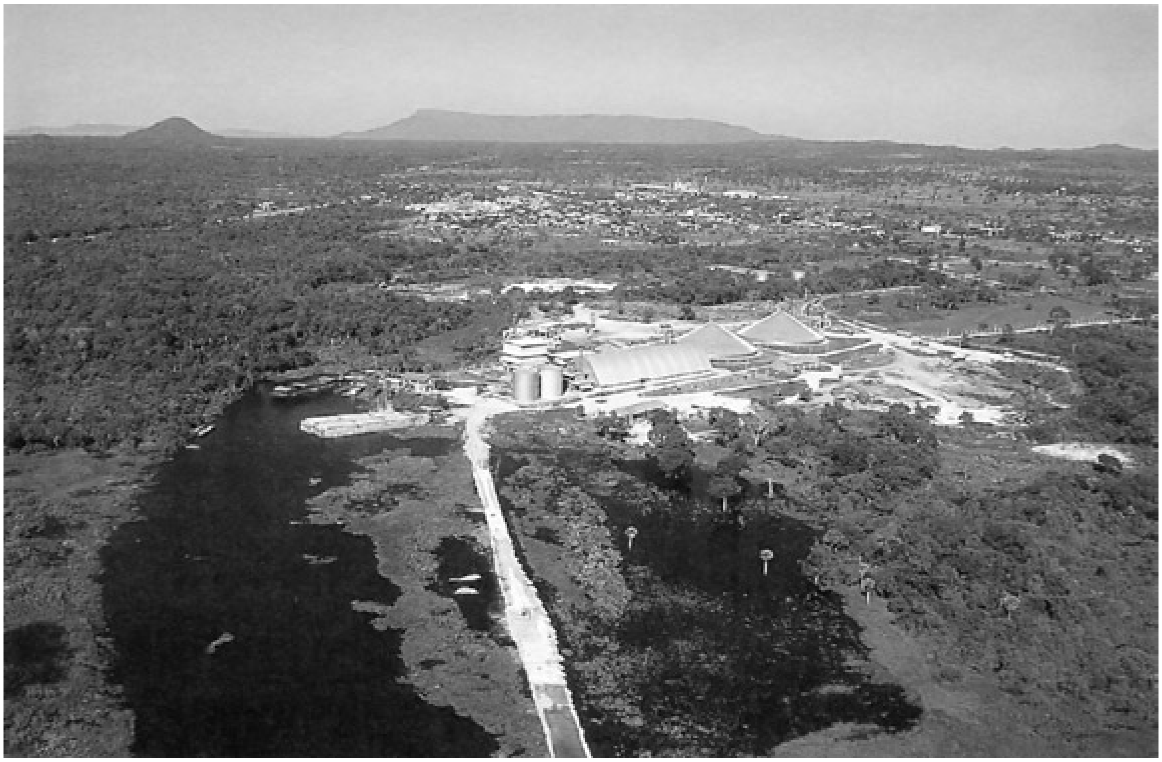


Photo 5. Silos for storage of grains shipped from Santa Cruz de la Sierra by train to the Tamengo Channel, Bolivia/Brazil.
Photo: André Leite/WWF Canada

This political outcome revolves around the actual distribution of benefits and costs and leads to the formation of strong groups favoring the Project and weak groups opposing it. Benefits and costs are characterized by three differences that contribute to this asymmetrical distribution of political power:

a) The benefits are concentrated among a relatively small number of people and are easily recognized by them, while the costs are spread thinly over the general population and are less obvious. For this reason, it is relatively easy to organize groups to promote the Project but not to oppose it.

b) The benefits are largely pecuniary, while the costs are mostly non-pecuniary. The bottom line can easily be calculated from promoting the Project but not from opposing it. Therefore, it is relatively easy to raise funds to promote the Project but not to oppose it.

c) Benefits are immediate while the costs may not be incurred until sometime in the future. Again, pro-groups are more easily formed than con-groups.

For example, there are a relatively small number of dredging companies, barge companies, and shippers that will earn higher pecuniary profits immediately with construction of the Project. However, environmental damages from the Project will be borne by a broad population. As well, they are largely non-pecuniary costs, difficult to quantify, and may not be recognized until long after the Project is completed.

CHAPTER 5 CONCLUSIONS

The consortium of consulting firms consisting of Hidroservice, Louis Berger, and EIH (HLBE) conducted an economic evaluation for a total of 21 scenarios for improving navigation on the Paraguay and Paraná Rivers.

HLBE concluded that several scenarios are economically feasible. From these the Intergovernmental Committee on Hydrovia (CIH) selected a scenario that would accommodate four-by-five barge trains on the Santa Fe-Asunción reach with a three-meter deep channel, and four-by-four barge trains on the Asunción-Corumbá reach with a 2.6-meter deep channel.

Photo 6. Barge loaded with iron ore that will eventually be shipped to Europe. Near Corumbá, Brazil.
Photo: André Leite/WWF Canada

HLBE also evaluated alternative scenarios for the Corumbá-Cáceres reach of the river. A scenario which would accommodate one-by-two barge trains with a 1.8-meter deep channel was concluded to be economically feasible, if the Ferronorte railroad from Cuiabá to Santos is not completed.

However, regardless of which scenario is being recommended, the analysis of this report indicates that the economic feasibilities of all of HLBE's scenarios are highly doubtful. There are numerous errors in HLBE's evaluation, which when corrected, indicate that none of the scenarios meet the minimum economic requirements of the Inter-American Development Bank (IDB).

More importantly, when HLBE's errors are corrected, the scenarios do not even produce positive net economic returns to society. HLBE's errors systematically contribute to overestimating benefits of the project while underestimating costs. Among the most important errors in the HLBE evaluation are the following:

a) HLBE over-estimates the probability of a collapse in navigation and, as a result, the benefits that would be produced by avoiding such a collapse. HLBE's method of calculating the probability of a collapse is disputed by experts in hydrologic engineering. Furthermore, HLBE's predictions are contrary to accepted estimates of risk by barge operators on the river.

b) HLBE ignores competition from alternative forms of transportation, with the exception of Ferronorte railroad. Other modes of transportation are also being improved and constructed in the region. For example, it now seems clear that the Ferronorte railroad will be completed and that, as a result, construction on the Corumbá-Cáceres reach of the river is not economically feasible. While HLBE recognized this possibility, improvements to and construction of other transportation routes in the region were completely ignored.

c) HLBE likely overstates the growth in shipments from the region, particularly soybean. It assumes past growth trends will continue into the future, when evidence from research groups such as the Fundação Centro Brasileiro de Referências e Apoio Cultural (CEBRAC) indicates that past trends are not likely to continue. As a consequence, HLBE estimates cargo loads that are not likely possible or sustainable.

d) HLBE omit relevant construction costs when evaluating other scenarios. HLBE assumes that a large portion of the basic costs of the Project, i.e., the base case, are not attributable to the Project at all. The base case, however, is an integral part of the Project and ignoring these costs is pure nonsense.

e) HLBE assume that there will be no significant impacts to the environment, even in the Pantanal. The only environmental costs included in the economic analysis are to commercial fishing, and the values used for losses are insignificantly small. HLBE fails to include economic values for the broad range of environmental impacts identified by previous studies (Bucher & Huszar, 1995). HLBE's identification and measurement of environmental costs of the project are unacceptable by any professional standard.

The analysis of this report shows that correcting these errors, either singularly or in concert, leads to an economic evaluation that does not support the Hydrovia Project as proposed by HLBE. A corrected evaluation of the scenarios identified by HLBE shows negative net economic returns.

As a development project, the Hydrovia Project should contribute to improving the general welfare of the population of the region. IDB recognizes this as one of its criteria for providing funds, but HLBE ignores the issue of the distribution of benefits and costs from the Project.

Evidence exists that the Project will not produce a fair distribution of benefits and costs. Benefits will be distributed to a relatively small number of already wealthy interests, while the costs will be spread more thinly over a relatively poor population. In particular, big companies involved in the construction of the Project and major shippers such as large-scale soybean producers are likely to gain, while small landholders and indigenous peoples are likely to lose.

Because of the flaws in HLBE's economic evaluation, it should not be used as a basis for judging the economic feasibility of the Project. HLBE takes such a narrow view of the Project that it fails to correctly identify and measure the relevant benefits and costs of the Project. Even within this narrow perspective, the many mistakes in the evaluation lead to results that are not credible.

Finally, it should be mentioned that the political economics of the decision process are heavily weighted in favor of the Project. Even if the benefits of the Project do not exceed the costs, strong special-interest groups will continue to press for the Project. Unless organizations such as World Wildlife Fund continue to monitor and balance these groups, it is likely that a socially undesirable form of the Project will be implemented.

SECTION II:

REVIEW AND CRITIQUE OF THE ENVIRONMENTAL IMPACT ASSESSMENT OF THE HYDROVIA PARAGUAY-PARANÁ PROJECT

Photo 7. Aerial view of the Paraguay River near Cáceres, Brazil.
Photo: André Leite/WWF Canada

INTRODUCTION

by André Leite

This review focuses on the Environmental Impact Assessment (EIA) for the Hydrovia Paraguay-Paraná Project produced by a consortium of consulting firms: Taylor Engineering Inc., Golder Associates Ltd., Consular Consultores Argentinos Asociados S.A., and Connal Consultora Nacional (collectively TGCC).

Photo 8. Girls from Corrientes (confluence of the Paraguay and Paraná Rivers), Argentina.
Photo: André Leite/WWF Canada

The conclusion from the EIA for the Hydrovia Project states that environmental consequences are negligible and that the Project is feasible from an engineering and an economic standpoint. The results were accepted by the Intergovernmental Committee on Hydrovia (CIH) — a multilateral body of the governments of Argentina, Bolivia, Brazil, Paraguay, and Uruguay — in December 1996 and were sent for the approval and commitment to begin construction of the Project. Although formal approval of the EIA has yet to be given, Argentina, Brazil, Bolivia, and Paraguay have begun the first steps of dredging for the Project.

When the EIA was released in December 1996, WWF commissioned a review through a multidisciplinary group of international experts. Two teams were formed: a regional team with experts from the countries directly affected by the Project and an international team, with experts on river ecology and hydrology. Teams examined a complete set of volumes comprising the Final Report of the EIA — an enormous document of 13 volumes, some 3,300 pages, and hundreds of tables and figures. They worked independently under the same methodological guidance, travelling in the region. During a week-long meeting, all the consultants shared their findings, conclusions and recommendations. The review began in March 1997 and finished in August 1998. One paper was produced: A Review of the Environmental Impact Assessment. Great effort has been taken to avoid repetition in material, presented in the earlier critiques; therefore, this present review should be seen as a sequel to the earlier publications expressing concern over the Hydrovia Project.

WWF's review is based on seven different concerns and impacts of the EIA: 1) legal, conceptual and procedural aspects of the EIA, 2) hydrological impacts, 3) impacts relating to landscape feature, vegetation, and flora, 4) impacts on terrestrial fauna, 5) impacts on the aquatic invertebrate fauna, 6) impact on water and sediment quality, and 7) impacts on fish and fisheries.

It should be emphasized here that the EIA report itself does not lend support to any attempt to analyze it. The main conclusions are optimistic regarding the potential impact of the Hydrovia Project. As this contradicts many earlier findings (e.g. Bucher et al., 1993), a careful study seems warranted.

Even a superficial examination reveals that errors occur in typing, calculation, logic, facts, conceptualization, methodology, omissions, and so on. A large number of any one of these types of errors can be found in the EIA.

The EIA attempts to apply ecological methods in its assessment process; for example, the concept of indicator species, ecological land classification, and hydrological computer models. These attempts, however, continually failed to produce any useful and informative results. For instance, 50 species of fishes are selected as "bio-indicators," but due to their large number, and the effort required to monitor them, they may not serve as useful indicators. On the other hand, of the hundreds of bird species available for monitoring the Project, just one, the great white egret, was selected as the indicator species for all the changes that might result. It was chosen for its cosmopolitan distribution and great adaptability, although these traits suggest it may not be useful as an indicator species.

This review does not attempt to produce an alternative EIA. It will show, however, that the attempt to produce an EIA has failed, and will make recommendations for further planning under the circumstances.

CHAPTER I DESCRIPTION OF THE HYDROVIA PROJECT

By Peter Petermann and André Leite

The following sections provide a brief description of the Hydrovia Project, for which the EIA was undertaken. Relevant chapter and page references to the EIA report are provided in the appendix.

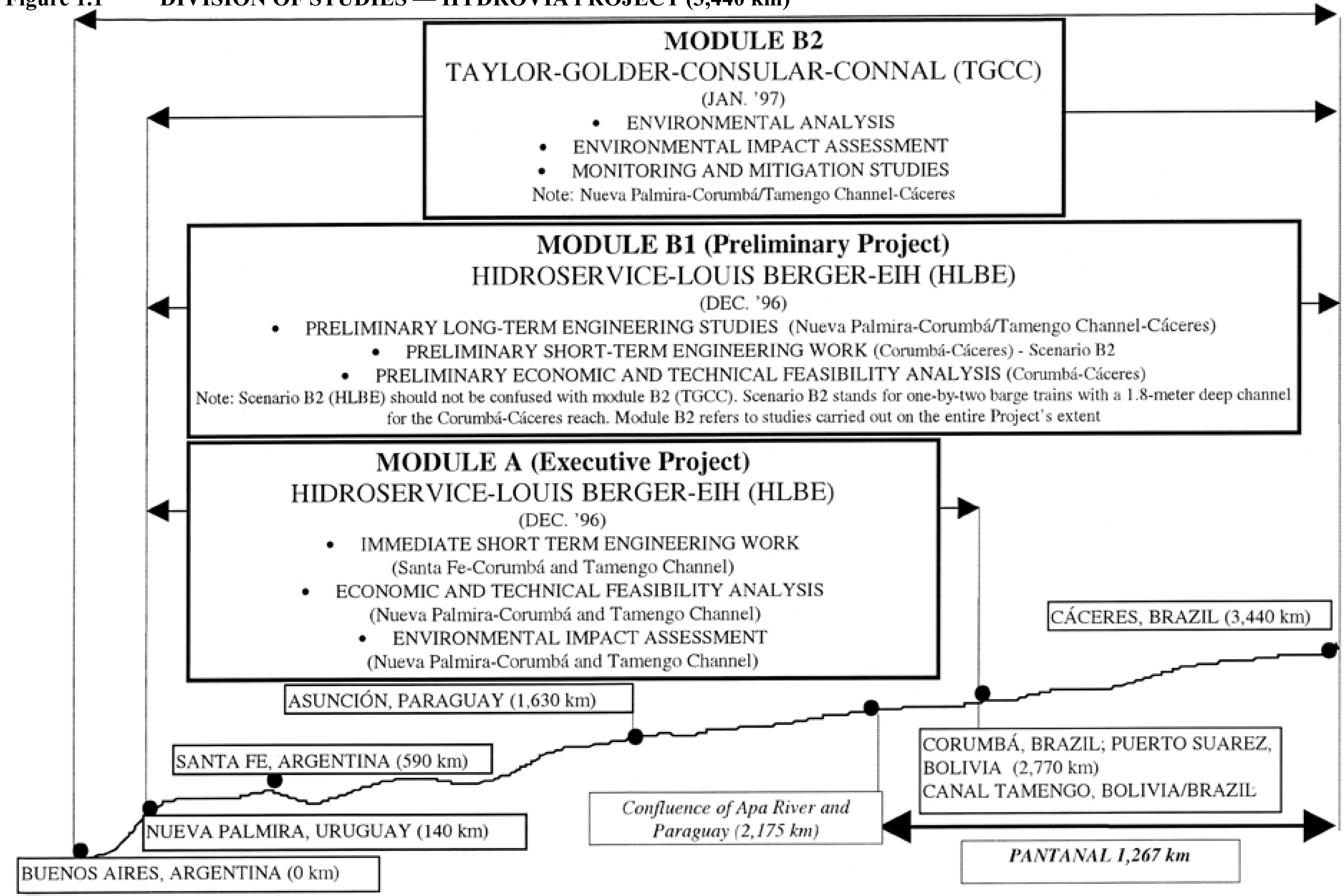
Photo 9. Aerial view of the Paraguay river, near Cáceres, Brazil.
Photo: André Leite/WWF Canada

1.1 Subdivisions of the Project

In planning the Hydrovia Project, several divisions of the Paraguay-Paraná River system have been developed.

a) Planning units: The Project was divided into three sections: Module A, from Nueva Palmira (Uruguay) to Corumbá and Tamengo Channel (Brazil/Bolivia); Module Bl, from Nueva Palmira to Cáceres (Brazil), including the Tamengo Channel; and Module B2 which refers to environmental analysis, environmental impact assessment, and monitoring and mitigation studies carried out on the entire Project's extent (Figure 1.1).

Figure 1.1 DIVISION OF STUDIES — HYDROVIA PROJECT (3,440 km)



The Project was divided into three sections: Module A, from Nueva Palmira (Uruguay) to Corumbá and Tamengo Channel (Brazil/Bolivia); Module BI, from Nueva Palmira to Cáceres (Brazil), including the Tamengo Channel; and Module B2 which refers to environmental analysis, environmental impact assessment, and monitoring and mitigation studies carried out on the entire Project's extent. Note that since only signalization will be necessary on the stretch from Nueva Palmira to Santa Fe, Module A details only the necessary, immediate, short-term engineering interventions (dredging and signalization) from Santa Fe to Corumbá. Module A also includes an environmental impact assessment of the Nueva Palmira-Corumbá and Tamengo Channel reach. Module B1 refers to the preliminary, short-term engineering work and preliminary economic and technical feasibility analyses for the Corumbá-Cáceres reach. Module B1 also refers to the preliminary long-term, engineering studies for the Nueva Palmira-Cáceres reach. The temi "preliminary" is used because if any of these planned interventions is undertaken, the studies will have to be completed.

The Tamengo Channel provides the only link for Puerto Suarez and Puerto Aguirre, the main Bolivian transportation ports. The Channel is the only link from Bolivia to the Paraguay River across die Brazilian border.

Source: André Leite, WWF Canada

b) Navigation units: Decisions were made for each module concerning the future minimum size of the waterway. The greatest convoy size would travel from Santa Fe to Asunción (four-by-five barges per convoy), while the size would be reduced between Asunción and Corumbá, including the Tamengo Channel (four-by-four barges per convoy) — scenario F2E1 (HLBE). Smaller one-by-two barges per convoy would be used from Corumbá to Cáceres — scenario B2[4]. This would imply that all greater convoy sizes would show even less tolerable ecological impacts, without any economic benefit. HLBE's recommendation, however, is clearly not to implement scenario B2 if the Ferronorte is built.

c) Ecoregions: Based on Bucher et al. (1993), the river basin was subdivided according to hydrological characteristics: Pantanal/Upper Paraguay (Cáceres to Apa River); Lower Paraguay (Apa River to Confluencia/Paraná River); Lower Paraná (Confluencia to Santa Fe); and Delta (Santa Fe to Nueva Palmira). These ecoregions are not ecologically homogeneous and therefore are not entirely satisfactory subdivisions. For example, the Rio Bermejo and the Rio Pilcomayo are significantly different from other rivers in the basin in their physical and chemical characteristics, but are not distinguished in the EIA accordingly.

1.2 Goals for the Improvement of the Paraguay-Paraná River System

The planned improvement of the Paraguay-Paraná waterway consists of several parts:

a) modifications of the river channel morphology to make it suitable for year-round traffic and larger convoys than present;

b) signalization of the river channel to permit 24-hour traffic and to improve safety;

c) implementation and improvement of harbor facilities and other infrastructure;

d) building of port and other facilities to service the increased shipping capacity of the new river channel.

Only the modifications and signalization of the river channel are part of the EIA, although improvements for the harbor facilities and shipping should have been included in the studies since they, too, could cause environmental impacts.

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[4] Scenario B2 (HLBE) should not be confused with module B2 (TGCC). Scenario B2 stands for one-by-two barge trains with a 1.8-meter deep channel for the Corumbá-Cáceres reach. Module B2 refers to studies carried out on the entire Project's extent.

There is little environmental concern about signalization improvements, as they could potentially reduce the risk of accidents. However, analysis of the consequences of improved signalization might conclude that increased traffic at night would actually increase the risk of accidents. Regardless, the main problem of the Hydrovia Project is certainly the intervention in the riverbed morphology. Signalization, therefore will not be treated in detail in this independent review.

It must be emphasized here that the engineering plans for the modifications of the river channel are still very incomplete. This is true for both Modules A and B1. For example, there are only general recommendations for the disposal of dredged material, but no definite plans. Except in the case of the Tamengo Channel, plans for the disposal are very different from the recommendations. There is no indication in the assessment about how many other sites along the river may not be able to meet the general recommendations for disposal of dredged material.

Dredging plans for Module A are probably complete, but specific plans cannot be found in either the engineering study by HLBE or in the EIA. A detailed judgement about their immediate impacts is thus precluded. Plans for Module B1 are still incomplete, but again the EIA does not even reveal the existing parts of these plans. For both modules the basis for the calculation of the amounts of sediments to be dredged is not explained, though this information is crucial for both the economic feasibility analysis and the EIA.

1.3 Adaptation of the River Channel

The proposed plan of the Hydrovia Project is to create and maintain a navigation channel in the Paraguay and Paraná Rivers that is sufficiently deep and wide to guarantee (one-way) navigation for most of the time. The plans are based on the assumption that navigation should be possible for at least 90 percent of the year, even under the conditions of a low water stage of 10-year recurrence time. The minimum size of the waterway channel is determined by the configuration of the convoys of barges.

Depending on the size of convoys, varying widths and depths of channels within the river system will present problems for navigation. In such problem areas, the required depth and width of the river channel would be achieved through dredging predominately sandy sediments, but also some areas of hardpans or rocky sills, and by widening the channel in narrow curves.

Necessary channel depth was determined by interpolation of the water level between neighboring river gauges (HLBE, chap. 9). Given the large distances between gauges along the rivers, obtaining reliable values will be difficult, but under the circumstances more accurate methods are not available.

Although the engineering studies included investigations of critical sites within the waterway, and numerous lists of these sites were cited, the results are not documented in the engineering studies or in the EIA.

1.3.1 DISPOSAL OF DREDGED MATERIAL

Disposal plans of dredged material exist in the form of recommendations for the contractor entrusted with the dredging operations. These recommendations are found in chapter 9.3.4 of the HLBE report, with additional information in chapter 12.3.1.2.

The sites for disposal and treatment of dredged material are determined principally through economic considerations. Although environmental reasons are given for the recommendations, they are usually secondary to the economic ones.

The EIA assumes that as long as the recommendations are followed, the dredged material can be returned to the river without causing any impact on the environment. The EIA, however, did not analyze whether this assumption was realistic, nor did it assess how many dredging sites would make it impossible to follow these recommendations. It is an unacceptable approach for an EIA to consider an impact (or source of impacts) as non-existent simply because the impact is not considered adequately in the engineering plans. The quantity of sediment to be dredged indicates that disposal is a problem of considerable magnitude and, therefore, a problem that cannot be disregarded.

Disposal Recommendations in the EIA

a) Dredged material will be deposited no greater than two kilometers from the dredging site in the Santa Fe-Corumbá reach (HLBE, pp. 9-8), and no greater than one kilometer in the Corumbá-Cáceres reach (TGCC, pp. 1-20), due to economic and technical reasons.

b) For economic and ecological reasons material will be returned to the riverbed, below the water line, along the margins of the banks or in side branches, and downriver from the site dredged (HLBE, pp. 9-8).

c) Wherever possible sediment deposition in the river channel will influence the current and erosive force of the river so that the form of the channel as created by the dredging is maintained (HLBE, pp. 9-8). The river current at the chosen disposal site will have low (TGCC, pp. 1-20) or intermediate energy (HLBE, p. 12) to avoid immediate erosion and the formation of banks downriver (HLBE, p. 9-9).

d) Height of the deposits should not exceed 2.5 meters, and on average must be between 1.0 and 1.5 meters (HLBE, p. 12-12).

e) Disposal on the banks or in neighboring wetlands is not recommended (HLBE, p. 12-12), but is definitely not excluded (HLBE, pp. 9-19; TGCC, pp. 11-13, 14-37). The possibility of a “beneficial use” of the dredged material is mentioned, for instance to stop erosion at the ecological station Taiamã in the Pantanal (TGCC, pp. 10-49).

f) Contaminated sediments will be specially treated and deposited on higher ground (TGCC, pp. 1-20).

Impression of the Magnitude of the Impact by Disposal of Dredged Material

For the Santa Fe-Corumbá reach (scenario E2E1[5]) and the alternative adopted by CIH (scenario F2E1[6]), the total quantity of dredged sediment (without rocky material) is 19.7483 million cubic meters (TGCC, Table 1.5.3). An area of about 20 square kilometers of river bottom would thus be covered to the depth of one meter by dredged sediments.

For Corumbá-Cáceres reach (scenario B2[7]), the quantity of dredged sediment varies between 6.575 million and 2.956 million cubic meters, depending on the alternative considered (TGCC, Table 1.5.4). This results in up to 6.5 square kilometers of river bottom covered to the depth of one meter by dredged sediment.

1.3.2 MODULE A: SANTA FE TO CORUMBÁ/TAMENGO CHANNEL

Several sizes of convoys were defined, ranging from three-by-three to four-by-five barges of 60-meter length, 12-meter width, and variable draft from two to four meters.

A total of 92 critical passes with sedimentary river bottoms, and an additional 23 passes consisting of harder material can be found between Asunción and the mouth of the Apa River and along the Tamengo Channel (Figure 1.2). For one of the rocky passes, Remanso Castillo (near Asunción, 1,630 km), use of explosives is recommended by HLBE. Additionally on the Hydrovia up to Corumbá, there are 12 curves with a radius too narrow for the convoy sizes chosen by CIH. The EIA defines critical curves as those with a radius of less than 920 meters for convoys of four-by-five barges or 610 meters for convoys of three-by-four barges (TGCC, pp. 1- 17). It does not mention the radius of critical curves for convoys of four-by-four barges, which is the convoy size chosen by CIH for the Hydrovia between Asunción and Corumbá.

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[5] Scenario that would accommodate four-by-four barge trains on the Santa Fe -Asunción reach of the Paraguay-Parand Rivers with a three-meter deep channel, and four-by-four barge trains on the Asunción-Corumbá reach of the Paraguay River with a 2.6-meter deep channel.

[6] Scenario which would accommodate four-by-five barge trains on the Santa Fe-Asunción reach with a three-meter deep channel, and four-by-four barge trains on the Asunción-Corumbá reach with a 2.6-meter deep channel.

[7] Scenario that would accommodate one-by-two barge trains on the Corumbá-Cáceres reach with a 1.8-meter deep channel. Scenario B2 (HLBE) should not be confused with module B2 (TGCC). Module B2 refers to studies carried out on the entire Project’s extent.

The CIH did not consider convoy with the configuration of three-by-four. It thus remains unclear, whether the correct convoy size was used in the calculation of the costs concerning the dredging of critical curves.

HLBE has estimated the amount of material to be removed for every alternative and critical pass considered (HLBE, appendix 9.2, vol. 7). These numbers are crucial for the calculation of the implementation costs for the Project, which depend greatly on dredging costs. The tables of results contain numerous errors, which influence the total costs of the respective alternatives; however, the differences between the total costs calculated and the correct values are in the order of magnitude of one to 10 percent, and would probably not have decisive influence on the economic comparisons. Still, they shed light on the quality and reliability of the technical studies.

Calculation of the 100 meter by 4.0 meter variant erroneously ignored the dredging of pass 15 (Santa Helena). The dredging of this pass would result in 78,603 cubic meters of sediment (extrapolated from the number of the 125 meter x 4.0 meter variant). The time required for the dredging was also miscalculated, by assuming a 16 hour working day instead of 14 hours as for the other variants (except 100 meter by 3.6 meter variant, which contains the same error). These two mistakes in one river segment (Santa Fe-Confluencia) account for a difference of U.S. $ 571,566, which is 8.5 percent of the cost in this river segment, but only 0.4 percent of the total cost of this variant.

In addition to these calculation errors, comparisons of the different alternatives are founded on very simple assumptions that seem insufficient in their characterization of the river system. Considering here only critical passes with sedimentary bottom (not rocky), the basic variables for each site were the length and average water depth before dredging. Between alternatives of different channel draft or width, simple linear relationships were assumed. Thus the amount dredged for a 125-meter wide channel would be 1.25 times the amount of a 100-meter wide channel (HLBE, Fig. 1.3). This conceptual approach is likely to underestimate the dredging effort for the greater channel sizes. When the width of the dredged channel is increased, the amount of material to be removed does increase linearly, as assumed by HLBE, because there will be more shallow areas to be dredged meaning more material dredged, and consequently higher costs. This might not be so at every single pass, but summing up the dredged material from all passes, it will logically be so. The same is true when the depth of the dredged channel is increased: as the resulting channel is not rectangular so the area affected by dredging will also increase, including more shallow areas.

Similarly, dredging costs were overestimated for the smaller altematives. The size of dredgers was chosen to meet requirements of the large-scale dredging scheduled for the greater channel alternatives. The fixed cost for transportation of super-dredgers from pass to pass is much too high to justify their use in the small-scale dredging necessary for the smaller alternatives. More realistic assumptions would thus show possibilities to economize on dredging costs in the smaller alternatives. The economic feasibility studies are thus biased toward the greater altematives.

The configuration (F2E1) adopted by CIH for Module A is as follows (HLBE, pp. 2-65; TGCC, Table 1.5.2):

a) Santa Fe-Asunción: four-by-five barges, three-meter draft (0.6-meter overdepth), 100-meter channel width;

b) Asunción-Corumbá: four-by-four barges, 2.6-meter draft (0.6-meter overdepth), 90-meter channel width;

c) Tamengo Channel: four-by-four barges, 2.6-meter draft (0.6-meter overdepth), 90-meter channel width.

It must be emphasized that HLBE recommended a slightly smaller variant (four-by-four barges), based on the economic study (HLBE, pp. 2-63), but this was not adopted by CIH.

In the ULBE and EIA reports, there is confusion about the size of the channel, as different sizes are cited throughout.

After the CIH decided on size of the waterway, analysis of dredging costs was repeated with modified assumptions (Figure 1.4). In a later version of the report, the modified calculations are only available for the chosen alternative (HLBE, appendix 16.3, vol. 16).

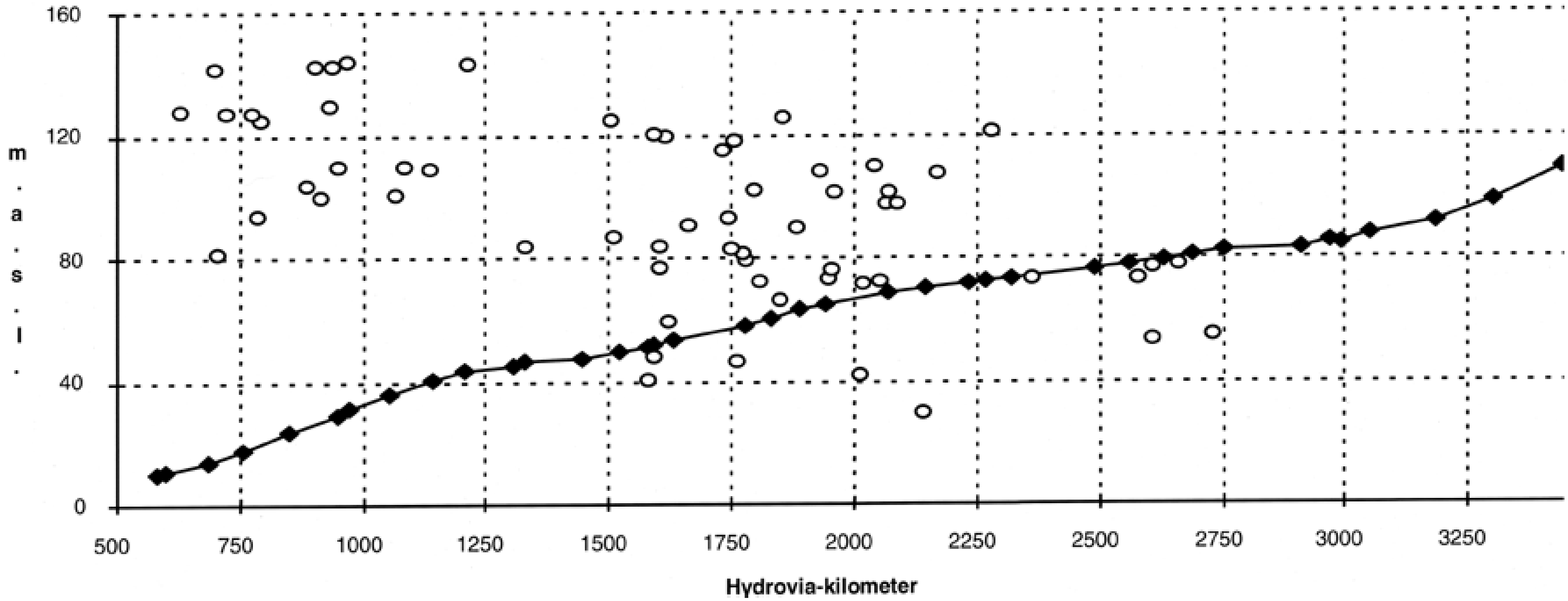
Comparison between the preliminary estimation of dredging costs and the final project shows several discrepancies:

a) Estimates of the total amount of sediment to be dredged was reduced by 30 percent from 21,879,306 cubic meters to 16,751,643 cubic meters (without Tamengo Channel).

b) Estimates of the amount to be dredged for individual passes was changed. The total sum of differences between both estimations for the passes is more than 10 million cubic meters. While most passes in the later version have lower values than in the earlier report, some have higher values, and some passes have even been added.

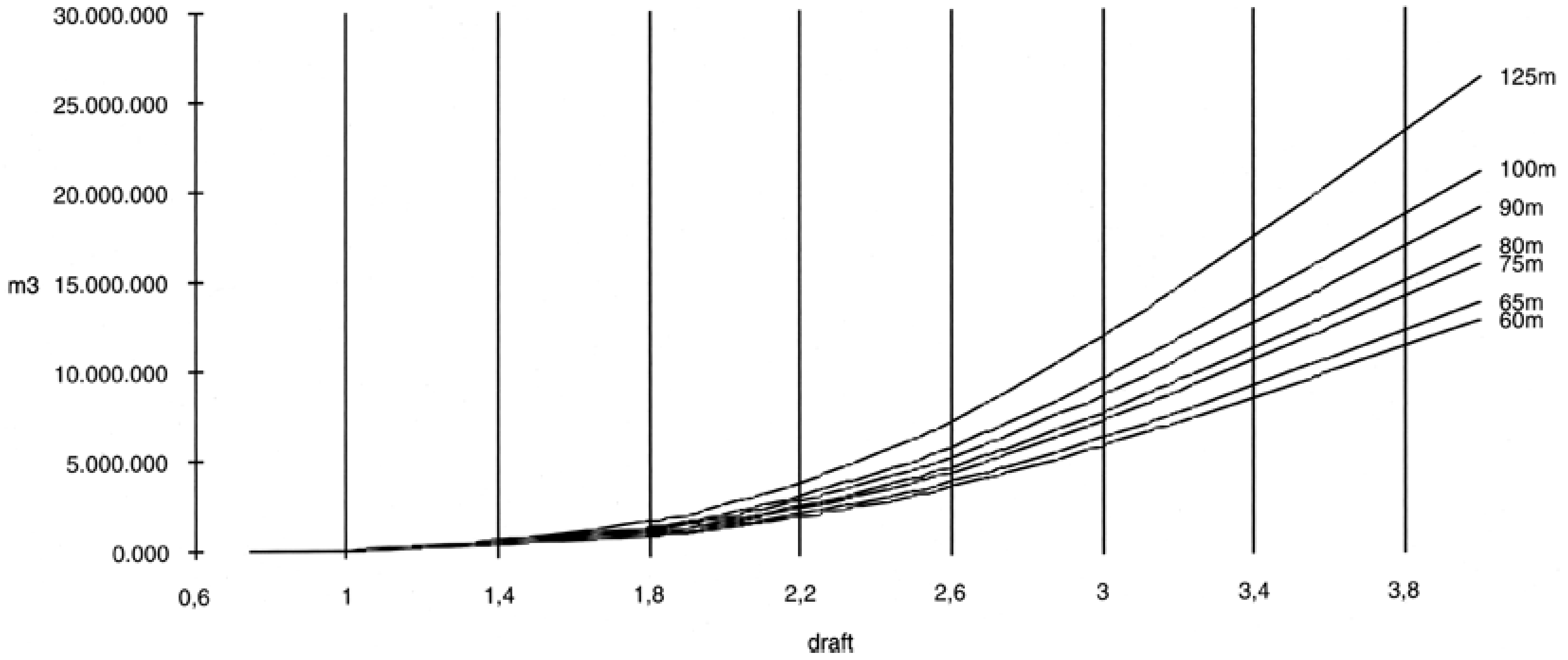
As no explanation is given for these important changes, it must be assumed that estimates for the effort of dredging, and consequent costs for implementation of the Hydrovia Project, are not reliable. The same must be said for the maintenance dredging. Thus, the information upon which the economic decision about the alternatives was based contained great uncertainties. As the modified calculations were done exclusively for the chosen alternative, there is no possibility to verify the comparison of the economic feasibilities for the alternatives, which is the critical analysis necessary in evaluating options in an EIA.

Figure 1.2 Depths of Critical Passes Below the Reduction Level in Comparison to Slope of the Hydrovia Rivers



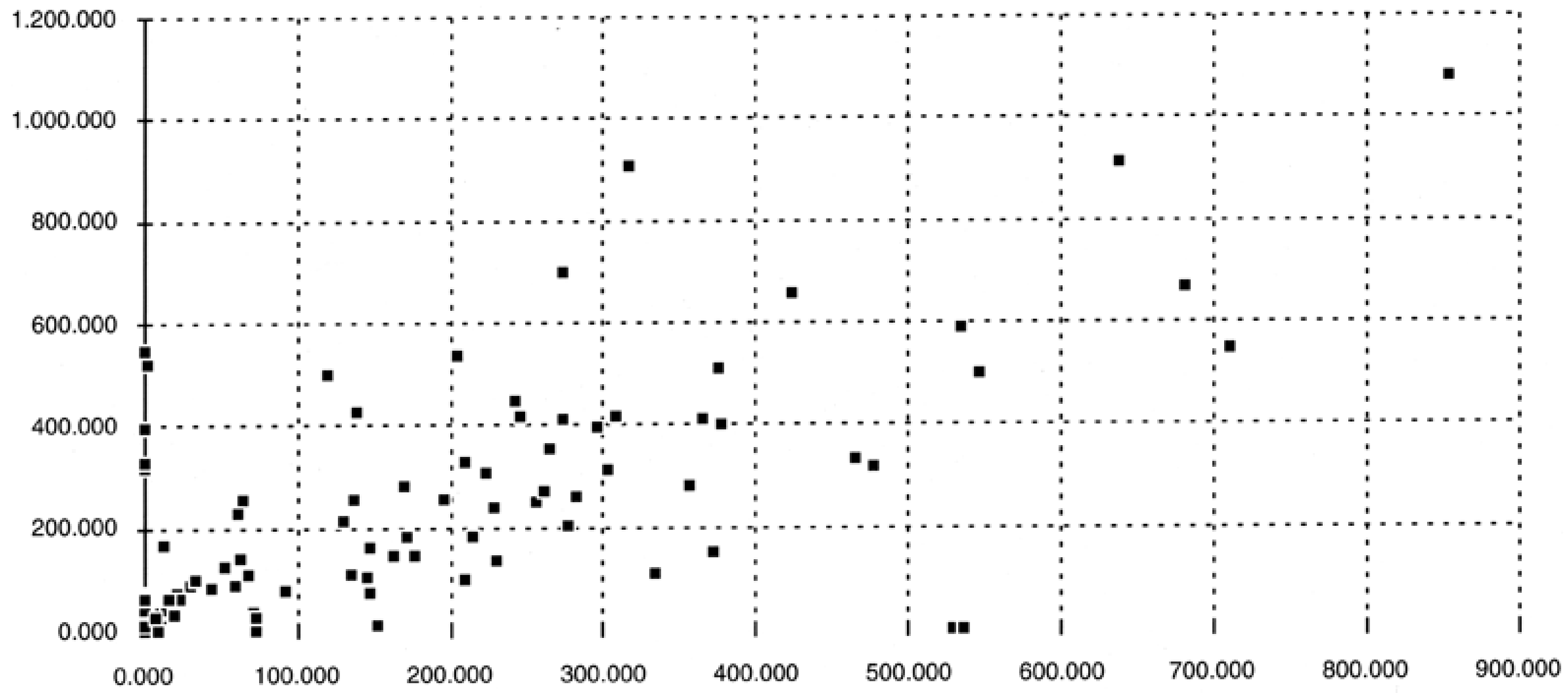
Source: HLBE (1996a). appendix 9.2.
note: m.a.s.l. = meters above sea level

Figure 1.3 Quantities of Sediment Scheduled for Dredging Under Different Alternatives of the Size of the Hydrovia



* Only dredging of soft material from the river bottom; without Tamengo Channel.
† The rising slope is due to the increase in the numbers of critical passes, while the quantities of dredged material for each pass is assumed to rise linearly with the draft.
Source: HLBE (1996a), appendix 9.2, with corrections of errors

Figure 1.4 **Comparison of the Quantities of Material to be Dredged for the Improvement of the Hydrovia Project According to Two Different Calculations (without Tamengo Channel)**



Source: HLBE (1996a), appendix 9.2 and 16.3.

Note: x-axis: modified estimation, only available for the chosen alternative.
y-axis: first estimation, on which the decision on the channel size in Module A was based.
The reasons for the differences are not explained.

1.3.3 MODULE B1: PRELIMINARY SHORT-TERM ENGINEERING WORKS BETWEEN CORUMBA TO CACERES (ALSO REFERRED AS SCENARIO B2) AND PRELIMINARY LONG-TERM ENGINEERING WORKS BETWEEN NUEVA PALMIRA-CORUMBÁ/TAMENGO CHANNEL-CÁCERES

The EIA contains only fragmentary information about the engineering actions planned for Module B1 (Table 1. 1).

The EIA did not identify passes with rocky bottoms between the Apa River and Cáceres, in contradiction to the study of Ponce (1995). The EIA recommends cutting though one meander, without further details about this drastic intervention. Apparently there are no detailed plans for site selection for the disposal of dredged material, except for the general recommendations (TGCC, pp. 1-19f; and see above). It will be much more difficult to follow those recommendations in Module B1, since the Paraguay River in the Pantanal is, in many sections, rather narrow or shallow or both, especially in the section most heavily affected by dredging.

Potential impacts of hydraulic control structures (like groynes) to reduce maintenance dredging have not been studied (TGCC, pp. 1-16). The available model study of Ita Piru shows they do cause hydrological impacts (TGCC, pp. 10-11), but it is not possible to evaluate their impact on the environment without any information about the number, location, and kind of structures involved.

Alternatives with the greatest impacts were considered for the EIA; i.e., two-by-two, 1.8-meter draft for dredging actions, but one-by-two, 1.8-meter draft for the increase in traffic (TGCC, pp. 9-21). The opportunity to compare the impacts of different altematives, however, was not undertaken.

Table 1.1 Configuration of Convoys, Number of Passes and Quantity of Sediment to be Dredged in the Corumbá-Cáceres reach

Convoy Design Draft	**2×2 1.8 m**	**2×2 1.5 m**	**2×1 1.8 m**	**2×1 1.5 m**	**1×2** 1.8 m**	**1×2** 1.5 m**	**1×1 1.8 m**	**1×1 1.5 m**
Number of critical passes:								
Segment B (Paraguay)	69	?	18	?	?	?	4	?
Segment C (Bracinho)	9	?	2	?	?	?	0	?
Segment C	64*	68*	?	?	?	?	?	?
Material to be dredged (thousands m^3):								
Segment B	1,200	1,080	310	280	310	280	62	56
Segment C	5,375	4,110	5,375	4,110	4,300	3,240	3,745	2,900
Total	6,575	5,190	5,685	4,390	4,610	3,520	3,807	2,956
Maintenance dredging (thousands m^3):								
Segment B	200	180	52	47			10	9
Segment C	1,035	823	760	606			760	606

* There seems to be a mistake in the number of passes in segment C: the number of passes to be dredged is higher with lower draft (1.5 meters instead of 1.8 meters), which seems counterintuitive. **Convoy dismembered in segment C. Source: TGCC (1997).

1.4 Navigation: Number of Vessels

The total number of loaded convoys expected to use the Project in the future is shown in Tables 1.2. and 1.3, which show there will be a considerable increase in the traffic on the waterway, except when the Ferronorte railroad is built. Unfortunately, the EIA presents no data on the seasonal distribution of traffic. This would be significant information, since most of the cargo (e.g., soybeans) will be transported only during a few months of the year.

Table 1.2 Number of Loaded Convoys Using Different Reaches of the Hydrovia Project

Year	**1997***	**1997**	**2020**	**2020**	**2020**	**2020**
Case	without Hydrovia Project	with Hydrovia Project	without Hydrovia Project	with Hydrovia Project without Ferronorte	with Hydrovia Project with Ferronorte	without Hydrovia Project with signalization
Cáceres-Corumbá	20	487	0	1766	0	20
Corumbá-Pto. Murtinho	104	168	290	532	312	291
Pto. Murtinho-Concepción	134	188	352	577	357	353
Concepción-Asunción	150	200	375	593	373	376
Asunción-Formosa	182	222	396	575	399	397
Formosa-Rosario	228	254	512	659	483	513
Rosario-Nueva Palmira	177	213	391	561	385	392

*Refers to the first year after the completion of the Hydrovia.

Source: TGCC (1997), Summary Table 3.5.

Table 1.3 Percentage Increase in the Number of Loaded Vessels Using the Hydrovia Project

Year	**1997**	**2020**	**2020**	**2020**
Case		without Ferronorte	with Ferronorte	with signalization
Cáceres-Corumbá	2335%	*	*	*
Corumbá-Pto. Murtinho	62%	83%	8 %	±0%
Pto. Murtinho-Concepción	40%	64%	1 %	±0%
Concepción-Asunción	33	58	–1	0
Asunción-Formosa	22	45	1	
Formosa-Rosario	11	29	–6	0
Rosario-Nueva Palmira	20	43	–2	0

*Infinite increase.

Source: TGCC (1997), Summary Table 3.5.

1.5 Risk of Accidents

The EIA does not expect an increase in the number of accidents nor accidental release of pollutants, even though the increase in traffic is acknowledged (TGCC, pp. 10-74). Rather, the EIA seems to imply that the number of accidents will actually decrease.

This misconception of accident risk is derived from misinterpreted statistics of accidents along the Mississippi River (HLBE, appendix 12.4). These statistics prove two facts:

a) The number of accidents along the Mississippi River is several orders of magnitude greater than the Paraguay-Paraná River system, despite the more sophisticated measures of security. This leads to the logical conclusion that greater traffic means greater probability of accidents.

b) The number of vessels on a waterway is not the only factor to influence the number of accidents. Training and experience of shipping crews, signalization, and state of equipment on board ships, among other factors (e.g., water stage, weather) contribute to vary the probability of accidents. From this it cannot logically be concluded that a greater number of ships automatically means greater security, as HLBE and the EIA imply. It is unreasonable to expect the number of accidents to diminish when the traffic increases from 20 to 1,766 vessels per year!

CHAPTER 2 LEGAL AND CONCEPTUAL ASPECTS OF THE EIA

by Luis Carlos García Lozano and Peter Petermann

The following sections provide a brief description of the legal, and conceptual aspects of the Hydrovia Project. Relevant chapter and page references to the EIA report are provided in the appendix.

Photo 10. Jabiru stork *(Jabiru mycteria)* in the Brazilian Pantanal.
Photo: André Leite, WWF Canada

2.1 Conclusions

The legal, and conceptual bases of the EIA are insufficiently defined. The descriptions of impacts contain contradictions and misconceptions in use and classification of technical terms, and in the influence of the EIA on the decision-making process.

As well, access to the document is impossible for the majority of the population involved. The EIA document is of enormous length (greater than 3,300 pages), making its distribution to the interested public impractical and prohibitively expensive (more than U.S. $1,000 per copy).

2.2 Recommendations

a) Based on the experience with this EIA document, future EIAs must require better terms of reference, and subsequent oversight to ensure the terms of reference are properly met.

b) The legal basis for the EIA should be developed and made consistent in the MERCOSUR countries.

c) Public participation of regional institutions and NGOs devoted to environmental research and planning should become a central part of the EIA process.

2.3 Legal Foundation and Formal Requirements of the EIA

The Hydrovia Project concerns the legislation of five different countries with somewhat differing laws on EIA. The EIA gives a brief review of the legal situation (TGCC, pp. 1-6ff). However, the EIA on the Hydrovia Project is based on the terms of reference of the United Nations (UNEP, 1987) and the World Bank (TGCC, pp. 1-1; 1-6). No details of the legal and conceptual requirements for the EIA are given, nor is there much explanation about the concept of the environmental impact assessment.

2.4 Some Conceptual Problems of the EIA

Here only some aspects, which penetrate greater parts of the EIA, will be briefly analyzed. It must nevertheless be one of the recommendations of the review that precautions be taken not to repeat this experience. Besides the waste of money, the entire institution of impact assessment could be compromised. EIAs can, and should, be done more efficiently.

2.4.1 THE SIZE OF THE EIA DOCUMENT

The final EIA contains more than 3,300 pages, including figures, tables, and appendices. This excessive size is not due to the wealth of information necessary for the assessment process, as only a small part presented is actually used. Most of the complexity and size is due to poor organization of chapters, tables, and figures, and to many repetitious presentations.

Though some tables are presented in such a condensed form that they are hardly readable, most are needlessly extended over several pages in the EIA. Often, instead of creating one table with several columns, several similar tables are produced, making comparisons very difficult. Several times entire tables are repeated with just some minor details added. Tables 3.5 and 3.6 illustrate the more appropriate and proposed versions of presenting the data.

Illustration of the EIA with figures does not follow any system. Most figures are graphs (e.g., of climatic factors) that do not contain much or any relevant information. Many figures are presented in an awkward form, or do not contain the full information required (e.g., lacking scales or units). The figures do not facilitate the understanding/interpretation of the EIA.

However, some of the graphics are of a much higher quality than the rest, such as the diagrams of the landscapes (TGCC, Figs. 7.6aff).

The enormous size and the extensive use of colored graphics make the document extremely expensive. Considering the level of income, especially of the rural and indigenous populations, the document would be inaccessible by its price alone. Therefore, it cannot be considered a document adequate for public distribution and use.

2.4.2 THE ROLE OF THE IMPACT ASSESSMENT IN DECISION MAKING

Though there is no unique international standard for an EIA, the common base for all systems is that it is a tool in the decision-making process (e.g., Erickson, 1994; Wood, 1995). The purpose of an EIA is to provide the public, politicians, and planners with the best possible predictions of the consequences of various alternatives before irreversible decisions are made.

Ideally, several alternatives for the Project in question should be compared, including the option of not proceeding with the Project.

In several of the countries affected by the Hydrovia Project, an EIA is mandatory; therefore, approval of the EIA should be given separately for every country (TGCC, chap. 1.4).

There is no information in the EIA about how its conclusions will influence the decisions on the Hydrovia Project. The decision by CIH to choose one of the alternatives for Module A was apparently taken before the conclusion of the assessment, based exclusively on economic feasibility studies that have been challenged by many experts.

For the Corumbá-Cáceres reach, the EIA does not compare the different alternatives for the size of the Hydrovia Project in this area of the river, though this would have been rather simple and failure to do so violates EIA principles. Instead only one “worst case” scenario was investigated.

The final intention of the EIA remains somewhat unclear. The only proposals resulting from the EIA appear weak and partially unrealistic in their recommendations for the monitoring and mitigation of impacts. The consultants found an adequate way to express the indecision of this EIA: “The intention ... is that this report [EIA] might serve as a base for the organizations and persons to take decisions about the nature and extent of the impacts which result from the project” (TGCC, pp. 1-2, emphasis added).

2.4.3 THE ASSESSMENT PROCESS AND THE ROLE OF “KEY QUESTIONS”

The process of the EIA is illustrated in the Figure 2.2.1 of the report, and represented here as Figure 2.1 a. Unfortunately, this illustration is quite different from the process that took place. The process, derived from the EIA documents, is more correctly shown here in Figure 2.1 b. Evaluation of the impacts is given in the form of answers to several “key questions”, which are derived from concerns expressed in publications and at public hearings. It must be emphasized that the key questions are independent from attempts in the EIA to quantify the impacts. The use of key questions produces the impression that all relevant aspects were taken into consideration in the EIA.

The assessment process, which used ecological land classification and identification of potential indicator species, contributes only some data to the assessment, and didn’t provide answers to all key questions. Most of the key questions are answered without any investigation of the impacts suggested. Instead, they represent the subjective, personal opinions of the consultants.

Certainly, the subjective opinion of an experienced, competent expert must not be dismissed, but there is the potential for consultants to judge the impacts incorrectly:

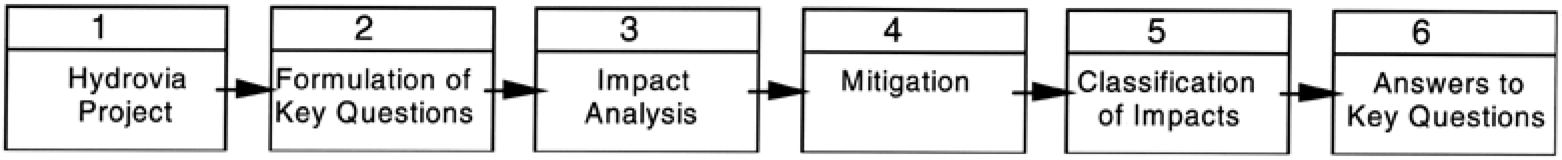
a) There is a misconception about the magnitude of impacts for the implementation of the Hydrovia Project. The EIA attempts to evaluate the impact from dredging in a zone of “intensive influence” around the dredging site. Beyond this zone, the impact was believed to be only “extensive,” or widely dispersed. The zone of “intensive influence” is assumed to cover an area with a radius of only 30 meters or about 2,800 square meters. This is only about 10 percent of the dredging area itself, and it highlights drastically how the consultants underestimated the zone of impacts.

b) The consultants did not show familiarity with the natural resources potentially affected by the impacts. They were unable to identify synonymous names in the list of plant species, used incorrect scientific names of fish (TGCC, pp. 11-131), and produced a list of bird species containing many species not found in the Hydrovia Project region.

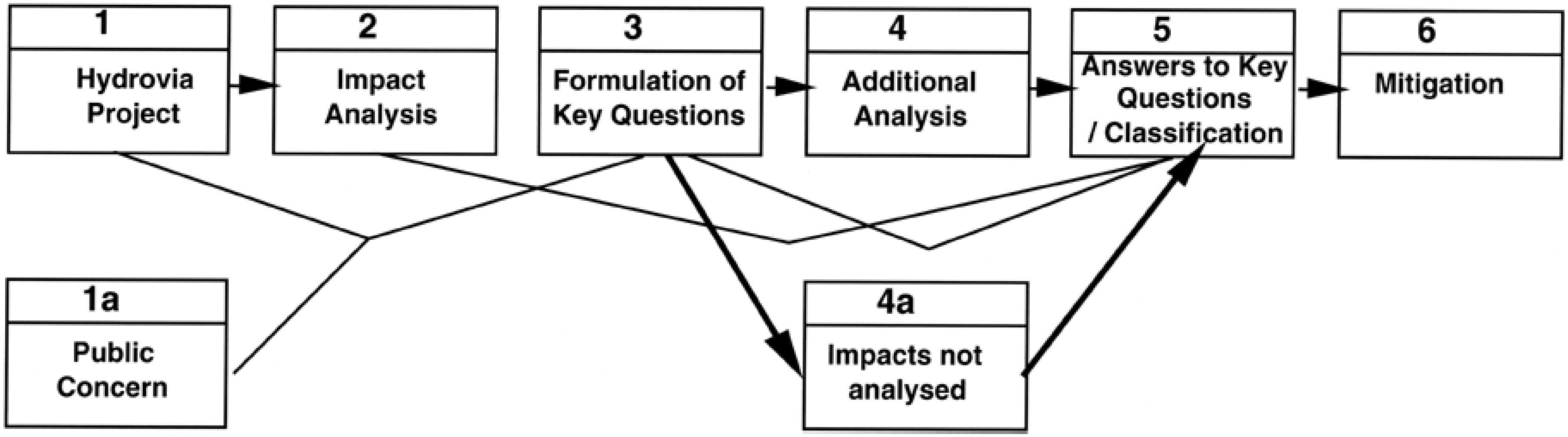
c) In summary, the “key questions” camouflage the fact that most impacts are not assessed or only partially assessed in this EIA, or treated with poor-quality data.

Figure 2.1 Intended and Actual Process of the Impact Assessment for the Hydrovia Project

a. Intended Process (source: TGCC, Figure 2.2.1)



b. Actual Process



2.4.4 BIO-INDICATORS

In the assessment of impacts on vertebrates (fish, birds, mammals, and reptiles amphibians were omitted because of lack of information), bio-indicators were selected.

Normally, indicators are employed to detect changes in the quality of the environment. To do this, parameters of the population of indicator species (e.g., distribution, abundance, demographic structure, and health) are recorded repeatedly. Observed changes in the population parameters can either reflect natural variability or indicate human-caused changes in the environment. Only a limited number of species, the indicator species, are used, since it is not possible for practical and economic reasons to survey all known species. The indicators should ideally indicate environmental trends, which are relevant to more species than can actually be monitored.

In the EIA, indicators are used in the opposite sense: for an expected change in the quality of the environment (the expected direct and indirect impacts of the Hydrovia Project), the resulting impact on the indicator species was estimated. The basic information on the habitat requirements used for this was available for all species of the respective animal classes, since that information was available in the selection process of the indicator species. Indicators, therefore, were employed inappropriately in the EIA, and the potential impacts could have been calculated for all species. The flawed attempt to select the indicator species objectively, could have been avoided.

In summary, the EIA incorrectly selected and used indicator species such that, in the end, they could not be used to indicate any environmental trend.

2.4.5 TYPES OF IMPACTS: DIRECT, INDIRECT, CUMULATIVE

Clear and logical definitions for direct, indirect, and cumulative impacts are given by Erickson (1994: p. 9):

> a) Direct impacts are changes in environmental components and processes that result immediately from a project-related activity or action.
>
> b) Indirect impacts are changes in environmental components and dynamics that are consequences of direct impacts.
>
> c) Cumulative impacts are the aggregates of direct and indirect impacts resulting from two or more projects in the same area or region.

Sources of direct impacts would be all activities related to the dredging and disposal of dredged material. The "project-related activity" undoubtedly includes operation of the Project, so the navigation as well as maintenance dredging should also be sources of direct impacts. Examples of direct impacts of the

Hydrovia Project would thus include the changed hydrology of the river, increased turbidity of river water due to dredging and navigation, destruction of gallery forests, disturbance of animals around the sites of dredging, and erosion of riverbanks due to wave action caused by barge convoys.

Indirect impacts would include the changes of vegetation due to eventual hydrological changes, changed land use patterns due to the economic impact of the Hydrovia Project, decreased populations of wildlife due to destruction of gallery forests, increased poaching due to easier access to nature, as well as the influence of a changed hydrology and vegetation on the regional climate.

Cumulative impacts would include the joint impacts of the Project and factors such as the gas pipeline from Bolivia to São Paulo, which crosses the Paraguay River.

In the EIA, several conflicting definitions for direct and indirect impacts are given. Definitions similar to the ones by Erickson (1994) are given in the EIA (TGCC, pp. 2-18), except that direct impacts that do not occur in the immediate vicinity of the dredging are classified as indirect.

Further examples of confused definitions abound. For the ecological land classification, only the dredging itself was considered a direct impact; while even areas a short distance away (less than 30 meters) are believed only indirectly affected (e.g., by turbidity, human access, noise, and light) (TGCC, Fig. 11. 1.6.2). For the terrestrial vertebrate fauna, an indirect impact would be one that could occur more than 10 kilometers from the river (TGCC, pp. 11-89). In the chapters on water quality, direct impacts would be those related to the construction, while indirect impacts would be those related to the operation of the Project (TGCC, pp. 10-20). Cumulative impacts were considered to be the combined effects of construction and operation of the Project (TGCC, pp. 11-57). Further confusion is created by the terms "direct" and "indirect" influence (TGCC, pp. 1-24), which seem to refer to the area of potential impacts.

Thus, by inflating the term indirect impact, the EIA hides the fact that truly indirect impacts are either ignored or downplayed in the EIA. Worse still, truly cumulative impacts resulting from other existing or planned development projects are not considered.

2.4.6 DETECTION OF SIGNIFICANT IMPACTS IN A VARIABLE ENVIRONMENT

The magnitude of an impact was classified in the EIA as follows (TGCC, pp. 2-18):

a) High impacts are those affecting more than 15 percent of a resource.

b) Moderate impacts are those affecting five to 15 percent of the resource.

c) Low impacts are those affecting less than five percent of the resource.

A slightly different definition is given, however, in the EIA (TGCC, Table 10. 1.4):

a) High impacts affect more than 15 percent of the natural variation (of the resource).

b) Moderate impacts affect six to 15 percent of the natural variation.

c) Low impacts affect one to five percent of the natural variation.

d) Negligible impacts affect less than one percent of the natural variation.

These definitions are in contradiction to the repeated statement found in the EIA that certain impacts are insignificant because the natural variation of the resource was greater than the changes caused by the Project.

There is also no clear definition what these numbers actually mean, and the ways they are applied are often ambiguous. For instance, the reduction of the area flooded in the Pantanal is expected to be up to four percent (TGCC, Table 9.4.3), but this is related to the total area flooded and not to the enormous natural variation of the flooded area over the season and from year to year.

Another problem in the EIA is the classification of impacts as insignificant before their indirect impacts are analyzed. Hydrological changes, for instance, are considered to be direct impacts only when they cause problems with flood control, water supply, or navigation. These direct impacts can be estimated using only the hydrological data. The indirect impacts, such as the distribution of plant species in the floodplain, cannot be derived from the magnitude of hydrological changes alone. Consequently, declarations of insignificance of impacts, especially hydrological impacts, are quite premature.

These few examples serve to show there are fundamental flaws in the use of the EIA.

CHAPTER 3 HYDROLOGICAL IMPACTS OF THE HYDROVIA PROJECT

by Peter Petermann, Fernando 0. de Francesco, Enrique J. Schnack, Raul Pedroni, Georg Rast, and Helmut Friedrich

The following sections provide a brief description of the hydrological aspects of the Hydrovia Project. Relevant chapter and page references to the EIA report are provided in the appendix.

Photo 11. Dredge operating in the Tamengo Channel, Bolivia.
Photo: André Leite/WWF Canada

3.1 Conclusions

The hydrological model, meant to simulate the hydrological changes that the Project might cause, has been unable to produce realistic information. A comparison with real, observed hydrological parameters shows that the model simulations failed to produce near-real values for all relevant parameters, such as water discharge, water levels, seasonal variation of low and high water, and flooding of the Pantanal.

This is certainly due to the inadequate use of the data base for variables such as precipitation and vegetation cover, but also due to the inability of the model to simulate the water retention in the Pantanal floodplain and to insufficient consideration of the planned interventions in the riverbed. These problems lead to an underestimation of impacts.

Performance of the Model

The EIA contains comparisons of the observed hydrological data for seven years (1984 to 1990), with two different model simulations for the same years. For the second simulation, the original model parameters were modified to include additional information on the riverbed. The EIA claims that it showed better agreement with the observed data. This is questionable, as the following comparisons from Corumbá/ Ladário show:

a) Flood peak discharge: Simulated values are 74 to 116 percent of those observed for the first simulation (mean difference: ±12 percent), and 64 to 99 percent for the second (mean difference: ±15 percent). EIA calculated average peak discharge for the seven years used for comparison, and found it to be only 1.7 percent different from error calculations from the observed average peak discharge in the first simulation. The second simulation, when compared with the observed average peak discharge, had a difference of 13.9 percent. The EIA seems to have used the poorer performing model.

b) Low-water discharge: Simulated values are 93 to 153 percent of those observed for the first simulation (mean difference: ±15 percent), and 90 to 151 percent for the second (mean difference: ±14 percent).

c) Timing of the peak flood: The simulations miss the observed date of the peak flood for up to four months in both simulations. The real hydrological data from Ladário show a very peculiar relation between the height and the date of occurrence of the peak flood, reflecting the temporal retention of the flood wave by the Pantanal. The simulated values, however, do not fit into this characteristic pattern.

d) Water level: The simulated water level is about 3.2 meters too high at Corumbá and increases downriver. At Corrientes, the simulated water level, independent of the Project or land use changes, is projected to be about six meters too high.

e) Pantanal flooding I: When the simulated and real water discharge data are used to estimate the corresponding areas inundated in the Pantanal, the differences become even greater. Based on estimations of the maximum area inundated for a period of seven years using the simulated data, values are between 57 and 120 percent for the first simulation (mean difference: ±16 percent; maximum area flooded in a year of low rainfall), and 41 to 99 percent for the second simulation (mean difference: ±21 percent).

f) Pantanal flooding II: The values yielded through simulations of the flooding of the Pantanal are too great. Maximum discharge in a low water year should have a corresponding inundated area in the Pantanal less than 30,000 square kilometers, yet the EIA estimates 50,000 square kilometers. The minimum area in a low water year would be less than 6,770 square kilometers; the EIA calculates more than 15,000 square kilometers.

For these reasons, the model cannot be expected to produce realistic, reliable results.

<u>EIA:</u>

The simulations of the hydrology for the cases “without/with Hydrovia Project” show additional shortcomings:

a) Differences between preliminary and final version of the EIA: A preliminary version of the EIA (TGCC, 1996) stated much greater changes in the hydrology, for unexplained reasons. Input parameters of the model representing changes in the riverbed morphology are not documented in the EIA. Input parameters were incorrectly used, leading to an underestimation of impacts.

b) River bed morphology: For the case “with Hydrovia Project,” only the dredging of the riverbed was taken into consideration. This, however, is only one of several impacts the riverbed would suffer as a consequence of the Project. Disposal of dredged material from increased riverbed erosion resulting from removal of geomorphological control points was not considered.

c) Interpretation and evaluation of results: Only a 100 percent reduction of the flooded area is considered an impact. For the evaluation of impacts, however, the EIA regards an impact greater than 15 percent of the natural variation as being of “great magnitude.” This is because when the general water level in a floodplain is reduced, it is not only the borders of the floodplain that are affected, but the entire ecosystem. Some areas may experience a lower water level for greater periods than before the implementation of the Hydrovia Project. An area that suffers a “great impact” of reduced flooding would therefore be several times greater than maintained in the EIA. Even the optimistic results produced by the simulations of the EIA would thus have to be regarded as impacts of “great magnitude” instead of “low or negligible.”

Clearly the interpretation of the hydrological impact assessment does not follow the EIA criteria for the evaluation of impacts. As well, important sources of impacts seem to have been ignored.

Changes in the hydrology of the region must raise great concern, as they could have disastrous consequences for the human and natural environment.

3.2 Recommendations

a) The assessment of hydrological impacts must not be used as a basis for decisions on the Project.

b) Plans for large-scale dredging in the Paraguay River (Corumbá-Cáceres reach) must be abandoned until a more comprehensive EIA is done, as the hydrology is highly sensitive to interventions, and consequences could be very serious for the human and natural environment.

c) No decision on the Project should be taken before a realistic, objective assessment of the impacts has been made. In particular, no irreversible interventions should be allowed.

3.3 Importance of the Hydrological Aspects for the EIA

Landscapes in the Paraguay and Paraná River basins are characterized by low altitudes, mainly below 100 meters above sea level (m.a.s.l.). Vast areas are covered by wetlands, mostly floodplains, which are more or less directly influenced by the water levels of the main rivers. Vegetation and land use are to large degrees determined by the local hydrological situation. Relatively small variations in the local topography, in the order of magnitude of decimeters rather than meters, can lead to significant hydrological differences with corresponding ecological consequences.

Due to the enormous floodplain, most rainfall over the two river basins returns to the atmosphere by evapotranspiration. Seasonally, the river basin serves as a net source of atmospheric vapor, when evapotranspiration is higher than precipitation. In a generally semi-arid region, especially west of the Paraguay River, the importance of evapotranspiration to regional climatology must not be underestimated.

At the same time, high evapotranspiration rates serve as a flood control mechanism. Assuming that 90 percent of the precipitation is returned to the atmosphere by evapotranspiration, then 10 percent is discharged through the basin. A reduction in the rate of evapotranspiration by only five percent increases the water discharge of the basin from 10 to 15 percent, an absolute increase of 50 percent.

Normally, evapotranspiration rates are dependent upon retention time of floodwaters in the floodplain, and retention time increases with floodplain area. Therefore, a loss of floodwater retention area increases the danger of flooding downriver. Similar effects have been extensively studied in European systems such as the Rhine River.

Large parts of river basins are sparsely populated, especially in the Paraguayan and Bolivian Chaco. Population centers are found close to rivers, where intact floodplain rivers provide for many resources and natural services, such as drinking water, food (fish), flood control, wastewater disposal, and transport.

Deterioration of the ecological quality of the Paraguay and Paraná Rivers and their floodplains can therefore, have serious consequences for a large part of the region's population. This is especially true for indigenous communities, which for the most part live along the river.

The hydrological system has a high natural variability, as it depends on the amount of precipitation, which varies from year to year. Prolonged droughts, which have occurred repeatedly in the region, have led to great economic and ecological damage. Under natural circumstances, the system has a great capacity to recover as long as the variability remains in the historical order of magnitude. Additional stress at critical times or places could exceed the system's capacity to recover.

There are other environmental risks connected to the Project, such as the increased turbidity of the river, loss of riparian habitat (especially gallery forest), and increased risk of the introduction of exotic species, shipping accidents, and accidental spills of pollutants. Hydrological changes, however, probably have the greatest potential for irreversible negative change to the environment, which might even reach beyond the river basins if regional climatic parameters are also affected.

3.4 Procedure of the Hydrological Impact Assessment in the EIA

The EIA employs two combined computer models to calculate the water discharge, river levels, and their seasonal variation (TGCC, p. 88ff). In the first model, simulations are based on the amount and seasonal distribution of rainfall (model SWAT), but also take into account temperature and evapotranspiration, soil type, vegetation, land use, and topographical and geometric features of the river basins.

Flood-wave propagation along the river is calculated by the second model (UNET), which is based on information about the riverbed morphology such as transects, slope, friction, and retention time.

Additionally the flooded area of the Pantanal was estimated using an empirical formula from Hamilton et al. (1996). This formula relates the total area inundated in the Pantanal floodplain to the water level of the Paraguay River gauge at Ladário (near Corumbá, Brazil) one to two months later. It was based on an investigation of the Pantanal flooding from 1979 to 1987. In this span of time, no drought year occuffed, so the formula is only reliable for water levels corresponding to 1.3 meters or higher at the Ladário gauge. For lower water levels, Hamilton et al. estimated the flooded area to be less than 6,770 square kilometers.

For the EIA, the formula was modified to include information from the water gauge at Descalvados, Brazil, in the northern Pantanal. Thus, it was hoped to get a better representation of changed river morphology in the Pantanal. How this was done is not explained in the EIA, though a description was promised for the impact analysis (TGCC, pp. 3-99; chap. 9.4).

The Ladário station was found by Hamilton et al. (1996) to be appropriate for the estimation of the flooded area in the Pantanal because the greater part of the floodplain lies upriver from this point. The same is not true for Descalvados, which makes the inclusion of this station questionable.

Besides the Pantanal, there are further vast areas of floodplains along the Paraguay and Paraná Rivers; but hydrological impacts on these areas were not addressed.

The effectiveness of the hydrological model was optimized by a calibration of its parameters so that there was maximum agreement between the model simulations and observed discharge values. The modified parameters include channel friction, runoff coefficient, soil characteristics, and area of floodplain (TGCC, pp. 3-94). The reliability of the calibrated model was assessed in the EIA by a comparison of the model simulations with observed water discharge curves for seven additional years (Laddrio: TGCC, Table 3.5.12, Fig. 3.5.24; other stations: TGCC, Figs. 3.5.25ff).

With these adjustments, the model could simulate the water discharge and corresponding water levels for years of low, middle, or high precipitation for the actual land use or for future land use scenarios. It could not, however, simulate the hydrological impacts of riverbed dredging, since it considers only a very limited number (20) of river transects along the entire Project (TGCC, pp. 3-94).

For a proper assessment, the model required four additional river transects at each of the 231 critical passes: two immediately outside each dredged zone and two inside (TGCC, Fig. 9.4. 1). For the simulation of the hydrology "without/with Hydrovia Project", the two "inside" transects would be adjusted to the form of the riverbed before and after the dredging. How this was accomplished for the Corumbá-Cáceres reach, given that no detailed plans for the dredging seem to exist, remains unexplained. Details of the river transects are not documented anywhere in the EIA, despite the fact that they are crucial for the assessment.

With this additional information, the model was once more calibrated as described above, and again compared to observed water discharge curves. The EIA found the performance of the changed model better, but this is questionable, as will be shown in the next section.

The modified model was finally used to calculate the hydrological impacts due to land use changes and/or the implementation of the Project.

3.5 Analysis of the Data Base

The hydrological models require long-term data on climate, topography, soil characteristics, vegetation, land use, river morphology, and so on. In a region as vast, and in parts as sparsely populated, as the basin of the Paraná and Paraguay Rivers, deficiencies in the data base must be expected. Nevertheless, proper use of the available data, complemented by field surveys, would probably have allowed reasonable estimates about the potential hydrological impacts.

In this chapter it will be shown that:

a) the data base was insufficient because not all available data were used;

b) handling of the data was faulty;

c) presentation and documentation of this part of the assessment is neither clear nor consistent.

3.5.1 PRESENTATION OF THE DATA BASE

The insufficient documentation of the data base makes it impossible to analyze it completely. The information on area, soils, and vegetation is split into several tables (TGCC, Tables 3.5.2, 3.5.4, 3.5.5, 9.4. 1) (see Tables 3.1 and 3.2).

As geographical base units for the models, 30 HRUs (hydrological response units) were delimited, each of which contains the basin of one or several tributaries (TGCC, Fig. 3.5.4).

Table 3.1 Area, Actual and Future Land Cover of Each HRU

Note: The contents of this table were spread over five pages in two distant chapters in the EIA.

			Soil Coverage				**% Area**		**% Area**	
			Grasslands		Forest/Shrublands		Water/Wetlands		Agriculture	
HRU	Area (km2)	(%)	Actual	Future	Actual	Future	Actual	Future	Actual	Future
Cuiabá Superior	71,016	2.7	42	37	24	19	1	1	33	43
Paraguay Superior	35,416	1.4	41	36	27	22	1	1	31	41
Jaurú	10,891	0.4	54	40	5	5	17	17	24	38
Jacobina	1,216	0.O	69	45	16	15	9	9	6	31
Cassanje Superior	10,599	0.4	78	74	2	1	16	16	4	9
Corixo Grande	40,157	1.5	15	14	46	46	38	38	1	2
Cuiabá	38,221	1.5	26	21	28	24	39	39	7	16
Cassanje	10,460	0.4	18	10	5	5	75	75	2	10
Corixo Grande Superior	20,501	0.8	28	27	60	60	3	3	9	10
Taguarí I Miranda Sup.	68,459	2.6	39	34	30	28	8	8	23	30
Abanico Fl. Taguari Norte	18,146	0.7	41	40	12	12	44	44	3	4
Negra	1,583	0.1	14	14	52	52	25	25	9	9
Verde	187,247	7.2	8	8	89	88	1	1	2	3
Jordán	10,998	0.4	7	7	89	89	4	4	0	0
Branco	24,410	0.9	45	44	10	10	36	36	9	10
Taguarí / Miranda	44,874	1.7	45	42	5	5	47	47	3	6
Pilcomayo	164,531	6.3	33	27	56	53	8	8	3	12
Ypané	77,299	3.0	50	46	26	24	4	4	20	26
Bermejo	141,541	5.5	21	18	62	61	9	9	8	12
Monte Lindo	117,792	4.5	28	28	60	59	5	5	7	8
Salado	158,212	6.1	16	16	39	39	6	6	39	39
Tebicuary	42,190	1.6	54	45	3	2	13	13	30	40
Negro	50,014	1.9	25	17	61	59	1	1	13	23

			Soil Coverage				**% Area**		**% Area**	
			Grasslands		Forest/Shrublands		Water/Wetlands		Agriculture	
Tapenaga	93,027	3.6	39	34	19	19	14	14	28	33
Carcarañá	108,399	4.2	1	1	8	8	2	2	89	89
Ñembucú	2,848	0.1	62	62	1	1	37	37	0	0
Empedrado	5,059	0.2	57	57	10	10	30	30	3	3
Corrientes	46,894	1.8	40	40	20	20	29	29	11	11
Gualeguay	43,845	1.7	40	40	29	29	16	16	15	15
Paraná Superior	949,639	36.6								

Source: TGCC (1997), Tables 3.5.2, 3.5.5, and 9.4.1.

Table 3.2 Soil type of Each HRU (% of Area) (The contents of this table were spread over three pages in the EIA.)

Soil type	Inceptis.	Entisols	Ultisols	Aridisols	Alfisols	Mollisols	Histosols	Vertisols
HRU	A/D	B	B	B	C	C	D	D
Cuiabá Superior		76.41	0.23		17.24	6.12		
Paraguay Superior		70.38	19.62		0.59	9.41		
Jaurú		28.60	45.33		21.39	4.68		
Jacobina			24.82		64.51	10.67		
Cassanje Superior			24.82		64.51	10.67		
Corixo Grande		2.50	88.10		8.68	0.72		
Cuiabá		8.50	75.99		15.28	0.23		
Cassanje			95.48		4.52			
Corixo Grande Superior		15.59	35.57		48.84			
Taquarí / Miranda Sup.		61.43	1.71		33.80		3.06	
Abanico Fl. Taguari Norte		0.98	99.02					
Negra		4.24	16.46	19.21	17.95	42.14		
Verde		4.24	16.46	19.21	17.95	42.14		
Jordán		21.35	78.65					
Branco		1.20	40.11		3.42	2.81	0.89	51.55
Taguarí/Miranda		1.20	40.11		3.42	2.81	0.89	51.55
Pilcomayo	0.75		1.91	10.26	8.67	78.41		
Ypané	13.77	15.16	18.57		42.41	3.76		6.32
Bermejo				32.04	5.63	62.33		
Monte Lindo	0.22		47.95	10.71		37.59		3.53
Salado			0.11	16.53	15.80	54.55	13.01	
Tebicuary	0.45		44.99		49.94	4.62		
Negro				19.25		80.72	0.02	
Tapenaga			0.07	5.64	22.97	50.91	20.40	
Carcarañá			0.70			29.20	10.90	59.00
Ñembucú				25.76		48.47	25.77	
Empedrado			60.00			40.00		
Corrientes	3.63		59.00		10.00	27.00	0.20	
Gualeguay	3.50		74.30			3.10	8.70	10.30
Paraná Superior	0.22	68.70	4.22		17.00	8.60	1.15	

Source: TGCC (1997), Table 3.5.4.

3.5.2 PRECIPITATION

a) Sources of data: Precipitation data were taken from one source only: World Meteorological Organization (WMO) data contained in the annual weather records of the National Oceanic and Atmospheric Administration /U.S. Department of Commerce (NOAA) (TGCC, pp. 3-73). This source is neither well identified in the EIA nor contained in the references. Figure 3.1.5 in the EIA shows data from the Food and Agricultural Organization (1985). This information was ignored, though it could have helped to fill gaps in the network of meteorological stations used in the EIA. Apparently, no attempt was made to obtain data directly from meteorological stations in the region.

b) Selection of meteorological stations: The EIA excludes all stations that are not exactly situated in the basin of the Paraguay and Paraná Rivers. There is no logic in this, as the climate extends beyond continental divides, and stations in neighboring regions could be important for recognition of regional climatic trends. Headwater regions along the perimeter of the basin are especially important and inadequately represented.

The EIA selected those stations with rainfall records of more than 10 years, attempting even to demonstrate mathematically that this would be sufficient to cover the variability of precipitation over the long term. For the Project region, however, this is not true: during the 30-year period (1963-92), the 10-year mean precipitation of Cuiabá varied from 1,219 to 1,473 millimeters (a difference of over 20%), a striking variation for 10-year averages.

c) Spatial distribution of stations: The total number of stations in the region (24) seems quite impressive, but they are very unevenly distributed (TGCC, Figs. 3.5.5, 3.5.6). This is most apparent for one of the key hydrological regions: the greater part of the Upper Paraguay basin, that includes most of the Pantanal and is covered by only one station, Cuiabá. The “area of influence” of this station is more than 180,000 square kilometers (TGCC, Table 3.5.7) — an area greater than Uruguay, Florida, or England with Wales. While mean precipitation at Cuiabá is 1,369 millimeters (TGCC, Table 3.5.9), regional precipitation in this area ranges from less than 1,000 millimeters in the Pantanal to more than 2,000 millimeters in the headwater regions (Ponce, 1995).

d) Spatial representation: Precipitation varies in space and time but rainfall records are measurements from a single point in space. For hydrological modelling, these measurements have to be transformed into spatial representations. In the EIA, the region of the Project was divided into “areas of influence” around every selected station. A purely geometric approach was chosen for this, using the equidistances between neighboring stations as borderlines between the “areas of influence”, which take on the form of polygons (Thiessen-polygons) (TGCC, pp. 3-84, Fig. 3.5.6; Ponce, 1989). Due to the great distances between stations and variability of precipitation over space and time, this method seems inadequate to simulate the actual spatial distribution and averages of precipitation.

The EIA assumes that any precipitation record must always be higher than the real, average precipitation in the region. There is a formula to calculate the difference; but as the information needed to apply the formula was not available, a general 10 percent reduction of the recorded precipitation sums was decided (TGCC, pp. 3-85). This might have been reasonable, if only individual rainstorms were analyzed. As this is not the case, the reduction of the recorded precipitation serves as a 10 percent error in the data base.

e) Daily precipitation: The SWAT model requires daily precipitation data. NOAA reports give only monthly data, though EIA claims that daily data were obtained for shorter periods from EVARSA and Centro de Ecologia Aplicada del Litoral (CECOAL), (TGCC, pp. 3-73). No information, however, is given about their quality and use. Apparently, monthly data were used to create fictitious daily distributions of rainfall, based upon a formula from empirical records from the U.S. (TGCC, pp. 3-85). It is questionable whether this information is valid for the region of the Project.

f) Documentation and presentation of data: The EIA illustrates the information on precipitation in numerous tables and figures that are poorly organized, repetitious and contain many omissions and errors (TGCC, 1997). For example:

- Tables 3.5.7 and 3.5.8 are practically identical;
- Table 3.5.9 shows precipitation for 45 stations, with some obvious errors;
- the stations are identified only by their WMO number, but the names of 43 of them can be found in appendix 3E, which contains a total of 65 stations;
- Figure 3.5.5 shows 66 and Figure 3.5.6 only 31 stations, but several of these are missing in Figure 3.5.5;
- seasonality of rainfall is illustrated in chapters 3.1.1 and 3.5.3 in different forms of diagrams, mostly difficult to read;
- Corumbá is shown three times, and six other stations twice;
- Ciudad del Este is sometimes called “Pto. Pres. Stroessner.”

There are many other examples.

According to Ponce (1995), precipitation in Chapada dos Parecis it is about 1,800 millimeters per year, but in the EIA it belongs to the “area of influence” of Cuiabá, with 1,369 millimeters per year. This would be reduced by 10 percent to 1,232 millimeters. Therefore, the EIA uses a value that is 68 percent of the actual one. As mentioned previously, monthly records were then transformed to a fictitous daily rainfall pattern, which has been recorded in a different climatic zone in North America. After all these manipulations, it is unlikely the “daily precipitation” used in the hydrological model has much to do with reality.

3.5.3 SOIL TYPES, VEGETATION, AND LAND USE

Two different data sets were used to describe the vegetation of the Hydrovia Project region:

> a) Satellite imagery: The ecological land classification was based on the interpretation of satellite images restricted to a zone just 10 kilometers wide along the main rivers (see section 3.6). A total of 16 types of vegetation were distinguished (TGCC, pp. 4-13).
>
> b) Geographical Information System (GIS): The hydrological model was based on a map of the vegetation published in 1970 by the Organization of American States, but no reference is given in the EIA, nor is there a scale for the map. A total of 24 types of soil cover were identified (TGCC, pp. 3-74) and lumped into four categories for use in the GIS (TGCC, pp. 3-81): woodland/forest, grassland, wetland/water, and agricultural land. Even those categories, however, could not be "separated adequately" (EIA-page 3-82) by the GIS, so that it was necessary to use additional sources of information to refine the vegetation map.

The expected land use change was based on the assumption that 50 percent of the woodland/forest and grassland vegetation on soils suitable for agriculture would be transformed into agricultural land (TGCC, pp. 3-9 to 3-37). Despite an extensive and superfluous discussion of different systems of soil classification (TGCC, pp. 3-64 to 3-70; appendix D), there is no information on which types of soils were assumed to be suitable for agriculture.

The land use changes expected by the EIA for the different sub-basins (HRUs) can be calculated by comparing Table 3.5.5 and Table 9.4.1 of the EIA. To improve clarity and transparency (TGCC, pp. 217), both tables should have been combined, giving each of the types of soil cover a separate column.

The EIA provides a lot of information about soil classification, geology, and vegetation, described in extensive chapters and illustrated in several maps. But there is almost no information about what kind of data were used in the model, e.g., the hydrological properties of soil types or of the vegetation.

3.5.4 HYDROLOGICAL DATA

The EIA maintains that there are 4 "numerous" water gauges (TGCC, pp. 3-74; HLBE, pp. 7-2ff), but only eight have been used for the hydrological model. All are on the Paraguay and Paraná Rivers; none on the tributaries (TGCC, Fig. 3.5. I.a). Most of the subregions (HRUs) have no river gauges, and the river gauges at Cáceres and Porto Murtinho appear not to have long-term records (Cáceres is missing in Table 3.5. 1); leaving only one gauge at Ladário along the Upper Paraguay River.

Only four gauges in the river basin have records of water discharge (TGCC, Table 3.5. 1) for differing spans of time (1, 14, 15 and 95 years). For Ladário, an empirical formula was used to calculate water discharge from water levels: $Q = 20h^2 + 210h + 600$, where Q = water discharge in cubic meters per second, and h = water level in meters. For the Ladário station, only data for water levels below 1.30 meters are available. The extrapolation for higher water levels will probably give unreliable values.

3.6 Reliability of the Hydrological Model

Before the model was applied to assess impacts of the Project, the ability of the model to produce realistic simulations was tested. As indicated below, the simulations of the model do not come close to reality.

3.6.1 THE HAMILTON FORMULA AND PANTANAL FLOODING

The formula used to estimate the area flooded in the Pantanal is based on the positive empirical relationship between the magnitude of flooding and the water level at Ladário recorded one to two months later (Hamilton et al., 1996). The water discharge at Ladário is determined by the extent of flooding and by the river morphology (while the water level additionally depends on the form of the river transect at Ladário). The Hamilton formula, however, is valid only for the geomorphological situation of the Paraguay River during the years of investigation (1979-1987). Changing the river morphology to yield a more efficient drainage of the floodplain would change the relationship of water level to flooded area: the same water level would mean less area flooded. This could be achieved by straightening, deepening, or widening the river channel, as planned for the Hydrovia Project.

Consequently, the formula would show only one part of the impact on the Pantanal. This weakness cannot be remedied simply by including the Descalvados River gauge in the formula.

3.6.2 COMPARISONS OF SIMULATED AND REAL HYDROLOGICAL DATA

As described above, the EIA contains two different sets of comparisons between model simulations (with and without transects of passes) and real, observed hydrological data. Those comparisons were made to test the reliability of the model simulations. However, no threshold value for the reliability of the simulations was defined, so it is unknown how great an error the EIA would regard as intolerable.

The results of the first comparison are given in Figures 3.5.24ff of the EIA for Ladário and other river gauges, and in Table 3.5.12 for Ladário only. For the second comparison results are given only graphically (TGCC, Figs. 9.4.2 to 9.4.6), but not in numerically. The result is further discussed in the text (TGCC, pp. 3-95).

The EIA concludes there is a good concurrence between the real and simulated data. Although the difference in the peak flood was 27 percent in one year, the average difference was only 11 percent, and the difference between the mean peak flood for all seven years was only 1.7 percent.

In the independent review, a more complete analysis of the differences between the simulated and observed hydrological data was attempted. It must suffice here to illustrate the comparisons for the station Ladário. The meager information in Table 3.5.12 of the EIA was complemented by the calculation of the respective numbers for minimum discharge and for the second simulation from the Figures 3.5.24 and 9.4.2. The date of occurrence of the peak flood for Ladário was calculated for the second simulation using the information from Ponce (1995, Table 13) for the observed dates of the peak flood, and calculating the distance to the simulated dates in Figure 9.4.2.

Discharge: Table 3.3 shows the results of the comparison. The wrong number for 1984 in Table 3.5.12 of the EIA was corrected (2,520 instead of 1,920 cubic meters per second). The main results are as follows:

a) The average errors for maximum and minimum discharge for both simulations are greater than 10 percent.

b) The second simulation yields a greater difference in the maximum discharges, but a slight improvement in the minimum discharges.

c) The differences of values for single years range from –36 percent to +53 percent.

d) If instead of simulated values, the 7-year-mean discharge was taken for comparison, the difference in the observed maximum discharges was on average only 14.5 percent, and the minimum discharges 10.2 percent (less than for the simulated discharges).

Slope of the river: Slope of the river is a key factor in hydrology, influencing flow velocity, water level, erosive force of the river, and so on (see, e.g., Ponce, 1995, p. 36). This is one of the most important errors in the hydrological model and can only be detected with the help of additional information not given in the EIA. Water levels at most river gauges are several meters too high in the hydrological model, and this error increases downriver. Consequently, the simulated slope of the river is much lower than the real slope, perhaps up to 20 percent in the Pantanal.

Table 3.3 Observed Versus Simulated Maximum and Minimum Water Discharge of the Paraguay River at Ladário

	Maximum Discharge (m^3/sec)						**Minimum Discharge (m^3/sec)**			
Source	(1)	(1)	(4)	(3)	(4)	(2)	(2)	(4)	(3)	(4)
Year	Obs.	Sim.1	% of Obs.	Sim.2	% of Obs.	Obs.	Sim. 1	% of Obs.	Sim.2	% of Obs.
1984	2,168	2,520*	116.2	2,150	99.2	1,240	1,150	92.7	1,120	90.3
1985	2,596	2,395	92.3	2,150	82.8	970	1,030	106.2	990	102.1
1986	1,844	1,353	73.4	1,180	64.0	910	850	93.4	850	93.4
1987	2,124	2,068	97.4	1,740	81.9	940	1,060	112.8	1,100	117.0
1988	2,838	3,238	114.1	2,610	92.0	940	1,440	153.2	1,420	151.1
1989	2,623	2,685	102.4	2,420	92.3	1,120	1,180	105.4	1,120	100.0
1990	1,930	2,197	113.8	1,630	84.5	n.d	n.d		n.d	
Average Difference			11.9		14.8			15.2		14.3
Difference (EIA)**			2.1		-13.9			9.6		7.8

*In Table 3.5.12, erroneously given as 1,920 m3/sec.

**Calculated as in Table 3.5.12, based on the seven-year-mean discharges of observed and simulated values. The value "1.7 percent" given in Table 3.5.12 is wrong, due to the error of the simulated discharge for 1984.

Note: (1) Numbers taken from Table 3.5.12; (2) numbers estimated by graphical interpolation from Figure 3.5.24; (3) numbers estimated by graphical interpolation from Figure 9.4.2; (4) calculations by WWF. Obs.: Data based on recorded water levels at river gauge Ladário/Rio Paraguay. Sim. 1: Data based on the results of the model calculation shown in Figure 3.5.24 and Table 3.5.12. Sim.2: Data based on the results of the model calculation shown in Figure 9.4.2. percent of Obs.: Model calculation data in relation to observed data, in percent. n.d.: annual minimum discharge "not determined," as curve ends at end of year.

Descalvados: No error. Water levels (101.5 to 102.4 meters a.s.l.; TGCC, Fig. 9.4.10) seem to fit to the zero of the river gauge (98.70 meters). The lowest water level observed was 101.0 meters (Ponce, 1995, Table 2).

Ladário/Corumbá: Simulated water level is more than three meters too high. The river discharge can be used to calculate the water level with the empirical formula $Q = 20\mathrm{h}^2 + 210h + 600$, where Q = discharge cubic meters per second, and h= water level in meters (TGCC, pp. 3-95; for the derivation see HLBE, chap. 7.5). The maximum discharge for a low water year at Ladário is simulated as being Q = 1,240 cubic meters per second, and the minimum is Q = 840 cubic meters per second (TGCC, Fig. 9.4.23). The corresponding water levels would be h = 2.468 meters and h = 1.040 meters, respectively:

$$1{,}240 = 20(2.468^2) + 210(2.468) + 600$$
$$840 = 20(1.04^2) + 210(1.04) + 600$$

The zero of the river gauge Ladário is 82.15 meters (HLBE, Table 3.3, Ponce, 1995, Table 2). The water levels would then be 82.15 meters + 2.47 meters = 84.62 meters for the peak flood, and 82.15 meters + 1.04 meters = 83.19 meters for low flow. The simulated water levels are more than three meters higher than this: 87.9 meters and 86.3 meters, respectively (TGCC, Fig. 9.4.11).

Asunción: Simulated water level is almost three meters too high. The peak is 5.550 cubic meters per second discharge (TGCC, Fig. 4.12). The corresponding water level would be about 5.7 meters (HLBE, Fig. 11), or 59.7 meters a.s.l. (gauge zero is 54.04 meters; HLBE, Table 3.3). The difference from Figure 9.4.26 of the EIA is 61.5 – 59.7 = 2.8 meters.

Corrientes: Simulated water level is almost six meters too high. Peak discharge is 23.400 cubic meters per second (TGCC, Fig. 9.4.8). The corresponding water level would be about 5.5 meters (HLBE, Fig. 12), or 47.34 meters a.s.l. (gauge zero is 41.84 meters; HLBE, Table 3.3). The difference from Figure 9.4.46 of the EIA is 53.15 – 47.34 = 5.8 meters.

Pantanal flooding: The simulated maximum discharges were used to calculate the corresponding area flooded in the Pantanal, assuming the maximum discharge was the mean discharge for two months following the peak flooding of the Pantanal.

Results show that the errors become even greater, especially in the second, “better” simulation (see Table 3.4). Differences would be greater still if the simulated minimum water discharge was used.

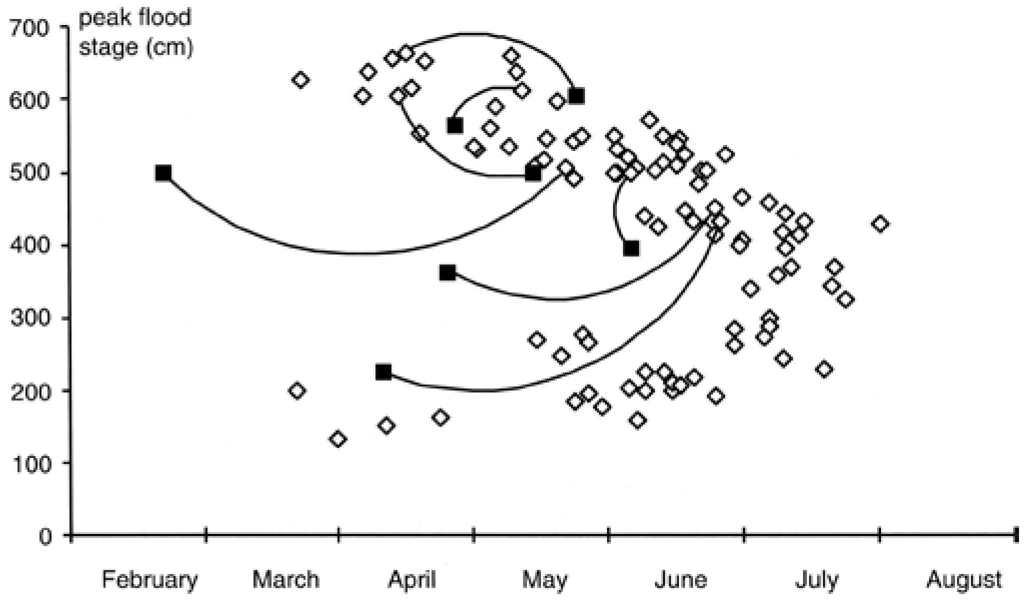
Table 3.4 Estimations of Annual Maximum Area Flooded in the Pantanal, Using Observed Versus Simulated Water Discharge Data of the Paraguay River at Ladário

	Maximum discharge (m^3/sec)			**Pantanal: Maximum area flooded (km^2)**				
Source	(1)	(1)	(3)	(4)	(4)	(4)	(4)	(4)
Year	Obs.	Sim. 1	Sim.2	Obs.	Sim. 1	% of Obs.	Sim.2	% of Obs.
1984	2,168	2,520	2,150	76,102	9,327	120	75,291	99
1985	2,596	2,395	2,150	94,468	86,053	91	75,291	80
1986	1,844	1,353	1,180	60,925	35,018	57	24,746	41
1987	2,124	2,068	1,740	74,113	71,550	97	55,767	75
1988	2,838	3,238	2.610	104,172	119,329	115	95,042	91
1989	2,623	2,685	2,420	95,573	98,088	103	87,119	91
1990	1,930	2,197	1,630	65,079	77,402	119	50,135	77
Average Difference:						16		21

Note: (1) Numbers taken from Table 3.5.12; (2) numbers estimated by graphical interpolation from Figure 3.5.24; (3) numbers estimated by graphical interpolation from Figure 9.4.2; (4) calculations by WWF. Obs.: Data based on recorded water levels at river gauge Ladário/Rio Paraguay. Sim.l: Data based on the results of the model calculation shown in Figure 3.5.24 and Table 3.5.12. Sim.2: Data based on the results of the model calculation shown in Figure 9.4.2. % of Obs.: Model calculation data in relation to observed data, in percent. n.d.: Annual minimum discharge “not determined,” as curve ends at end of year.

Retention effect of floodplain: Floodplains influence the propagation of flood waves by the retention of water. Plotting the peak discharge versus the date of occurrence of the peak flood results in a boomerang-shaped cloud (Figure 3.1). If the hydrological model of the EIA had correctly calculated the peculiar retention effect of the Pantanal floodplain, the data for the seven simulated years would fit into the scheme illustrated in Figure 3.1. The EIA model results do not correspond, however, indicating problems with their data or model, or both.

Figure 3.1 Peak Flood Stage Versus Date of Occurrence at Ladário, 1900 to 1995



Note: Black squares are simulated data from Figure 9.4.2 of the EIA (1984 to 1990), connected to the corresponding observed dates.
Source: Ponce (1995), modified.

3.7 Analysis of the Hydrological Impact Assessment

3.7.1 POTENTIAL SOURCES OF IMPACTS

Interventions in river bed morphology will have several direct and indirect impacts on the hydrology of the region of the Hydrovia Project.

Direct impacts include:

a) localized deepening and widening of the river channel by dredging;

b) localized raising of the river bottom due to disposal of dredged material;

c) localized modifications in the connectivity of the river and its floodplain, due to possible disposal of dredged material on the riverbanks;

d) general straightening of the river channel due to dredging and disposal of dredged material;

e) general increased slope of the river channel due to shortening of the river length;

f) general erosion of the riverbed and banks due to the ship traffic with increasing numbers and/or sizes of vessels, and due to slope increase.

Indirect impacts include:

a) general or localized erosion of the river after the removal of geomorphological control points;

b) general changed patterns of erosion and sedimentation due to dredging, disposal of sediments, and straightening of the river;

c) general modifications of the interchange of river and floodplain, due to other changes in river morphology.

Of all potential impacts listed above, only the first, the localized deepening and widening of the riverbed, has been considered in the EIA (TGCC, pp. 9-43). This is, of course, completely insufficient, since they have already been identified, (e.g., by Ponce, 1995). This is a clear example of how the EIA fails to meet established standards of assessment.

3.7.2 PRESENTATION OF RESULTS

Form of Presentation

For the assessment of impacts, the EIA has simulated the hydrological changes for several cases:

a) for years of low, medium (incorrectly called “typical”), and high precipitation;

b) for the actual and expected future land use patterns in the river basin;

c) for the river with and without the Hydrovia Project.

The results are presented for six sites on the river and the Pantanal (TGCC, pp. 9-37 to 9-57, Tables 9.4.2 to 9.4.4, Figs. 9.4.7 to 9.4.56). An interpretation is given in chapter 10.1 of the EIA.

The text contains data on the discharge, water level, flow velocity, duration of water levels, and the area flooded in the Pantanal, but gives only relative information on the simulated hydrological changes in numbers and percentages. The text is structured improperly, as the different cases (without /with land use change; high/medium/low water year) are explained separately. This information is repeated, quite clearly in three tables (TGCC, Tables 9.4.2 to 9.4.4).

Absolute data are illustrated only in the diagrams. Most figures contain comparisons of curves of discharge, water level, or permanence of water level for the cases “without/with Hydrovia Project” or “without /with land use changes,” or for the changes of the flooded area in the Pantanal. Theoretically, there could be 228 combinations of comparisons, of which 50 are illustrated (TGCC, Figs. 9.4.7 to 9.4.56). To understand the confused order of these figures, it was necessary to prepare an overview (Table 3.5). Most figures cover what appear to be entire years, though the graphs seem to end on the 1st or 13th of December.

Finally, results are given for Corumbá, even though the river gauge referred to is presumably the one situated at Ladário.

Probable Calculation Error

Discharge curves for Corumbá/Ladário (TGCC, Figs. 9.4.23, 9.4.37) contain an error: the rapid decrease of discharge in February is not accompanied by the logical corresponding change in water level. Theoretically, this discrepancy could be explained as a very short-lived backwater effect, but the form of the curve suggests an error of either the computer simulation or the graphical illustration. Whether a remarkable phenomenon or a miscalculation, either casts doubt on the reliability of the entire exercise.

Table 3.5 Hydrological Model Simulations: Summary Table of Comparisons Contained Within the EIA

Level/ Year	Land Use	Hydrovia Project	Descalvados			Corumbá			Porto Murtinho			Asunción		
			Discharge	Level	Perman.	Discharge	Level	Perman.	Discharge	Level	Perman.	Discharge	Level	Perman.
Low	Actual/Future	Without	947*	9.4.10	9.4.13		9.4.11						9.4.121	
Low	Actual/Future	With												
Low	Actual	Without/With	9.4.22	9.4.25	9.4.27	9.4.23		9.4.28			9.4.29		9.4.26	9.4.30
Low	Future	Without/With	9.4.36	9.4.42	9.4.48	9.4.37	9.4.43	9.4.49	9.4.38	9.4.44	9.4.50	9.4.39	9.4.45	9.4.51
Typical	Actual/Future	Without										9.4.15	9.4.16	
Typical	Actual/Future	With												
Typical	Actual	Without/With												
Typical	Future	Without/With												
High	Actual/Future	Without	9.4.18									9.4.19		
High	Actual/Future	With												
High	Actual	Without/With												
High	Future	Without/With												

*Numbers refer to figures in the EIA (TGCC, 1997).

Table 3.5 (cont'd) Hydrological Model Simulations: Table of Comparisons Contained Within the EIA

Level /	**Land Use**	**Hydrovia Project**	**Corrientes**			**Goya**			**Pantanal**
Year			Discharge	Level	Perrnan.	Discharge	Level	Perman.	Area of inundation
Low	Actual/Future	Without	9.4.8			9.4.9	9.4.20		9.4.14
Low	Actual/Future	With							
Low	Actual	Without/With			9.4.31	9.4.24		9.4.32	9.4.33
Low	Future	Without/With	9.4.40	9.4.46	9.4.52	9.4.41	9.4.47	9.4.53	9.4.54
Typical	Actual/Future	Without							9.4.17
Typical	Actual/Future	With							
Typical	Actual	Without/With							9.4.34
Typical	Future	Without/With							9.4.55
High	Actual/Future	Without							9.4.21
High	Actual/Future	With							
High	Actual	Without/With							9.4.35
High	Future	Without/With							9.4.56

*Numbers refer to figures in the EIA (TGCC, 1997

Consistency of Results

As mentioned previously, the data base used in the hydrological assessment is insufficient, and the model does not produce realistic results. Nevertheless, it seems worthwhile to check whether the simulations of the hydrological changes produce consistent results.

The environmental risk of the Project causing most concern is probably the potential for changes in the flooding of the Pantanal. The question is whether the simulated data for the discharge, water level, and Pantanal flooding are reasonable.

As stated above, there is a problem in the discharge graph of Ladário, which affects mainly the rising part of the curve. Otherwise, the curve seems to make sense and relates reasonably well to the water level curve (compare Figs. 9.4.11 and 9.4.37 of the EIA).

The error in the water level curve is more serious, as it affects the scale of the level. The entire curve is too high and cannot be used to calculate the flooding of the Pantanal. However, the water level can be estimated using the empirical discharge/level formula $Q = 20(h^2) + 210h + 600$.

A further problem is that there is no explicit information in the EIA about the simulated total area flooded in the Pantanal. Only values for the changes in flooded area are given; but since these are presented as area (square kilometers) and as percentage, a rough calculation is possible:

a) The maximum discharge at Ladário in a low water year with actual land use is 1,240 cubic meters per second (EIA-Figure 9.4.23). The two-month mean discharge of the peak flood, required for the Hamilton formula, is about 1,210 cubic meters per second.

b) This corresponds to a water level of 2.37 meters [1.210 $20(2.37)^2 + 210(2.37) + 600$].

c) The maximum area flooded would then be 26,580 square kilometers [approximately (2.37 × 18,520)-17,309].

d) The EIA estimation of the reduction of the flooded area is 510 square kilometers, or one percent (TGCC, pp. 9-45). The total flooded area would then be 51,000 square kilometers, or almost double of the area calculated above. Obviously the numbers are incompatible. The numbers for the area flooded are for "without Hydrovia Project" and "without land use change." The differences cannot be an impact of the Project; they are indeed an error of the simulation.

e) The minimum discharge for the same situation (low water year, actual land use) is 840 cubic meters per second (TGCC, Fig. 9.4.23). The two-month mean is about the same.

f) The corresponding water level is 1.04 meters. As the Hamilton formula is only valid for water levels over 1.3 meters, the minimum area flooded found by Hamilton et al. (1996) must be assumed here to be less than 6,770 square kilometers.

g) The EIA estimates the decrease of the flooded area for low water as 610 square kilometers, or four percent. The total area flooded would then be 15,250 square kilometers. Again, the numbers for discharge and area flooded are incompatible. Now it could be speculated that the reduction of 610 square kilometers in the flooded area was actually a nine percent decrease, but the errors involved in the hydrological modelling would preclude accurate conclusions.

3.7.3 INTERPRETATION AND EVALUATION OF RESULTS

The Preliminary EIA

In a preliminary version of the EIA (TGCC, 1996), the results were very different from the results presented in the final version, but no explanation for this difference was given (see Table 3.6). It is obvious that the results of the final EIA are much more optimistic concerning impacts of the Project.

Apparently some input parameters were changed to minimize the differences between the simulations "with" and "without" the Project. Unfortunately the input parameters are mostly not documented, especially those regarding dredging. As can be seen from the analyses above, the hydrological assessment process leaves room for uncertainties.

Evaluation of the impacts remains practically unchanged, except that the following sentence is missing in the final EIA: *"Sin embargo, la simplificada naturaleza dei análisis de inundación [dei Pantanal] y sus suposiciones inherentes limitan ia exactitud de este valor* [However, the simplified nature of the Pantanal flooding analysis and its inherent assumptions limit the precision of this value]" (HLBE, pp. 5-9).

Table 3.6 Comparison of Results of the Preliminary and the Final EIA

	Discharge (m^3/sec)				**Water Level (cm)**			
	Maximum		**Minimum**		**Maximum**		**Minimum**	
Low Water Year	Prelim. EIA	Final EIA	Prelim. EIA	Final EIA	Prelim. EIA	Final EIA	Prelim. EIA	Final EIA
Descalvados	–15	–3	–4	2	–2	–1	–15	–11
Corumbá	11	–1	15	1	1	–1	–1	–1
Porto Murtinho	10	3	10	3	0	–1	–<1	–1
Asunción	0	0	0	0	0	–1	0	–1
Corrientes	0	0	0	0	0	–1	0	–1
Goya	0	0	0	0	0	–1	0	–1
Typical Year								
Descalvados	–4	–1	10	1	–2	–1	–14	–9
Corumbá	–30	3	–5	1	–7	–1	?	–2
Porto Murtinho	–10	–10	5	5	–3	–3	–3	–3
Asunción	0	0	0	0	–5	–1	–1	–1
Corrientes	0	0	0	0	0	–1	0	–2
Goya	0	0	0	0	–<1?	–<1	–<1?	–<1
High Water Year								
Descalvados	–8	–3	9	3	0	0	–7	–5
Corumbá	–12	–3		–3	–5	–0.5	?	–1
Porto Murtinho	0	0	0	0	0	–0.4	–3	–0.2
Asunción	0	0	0	0	0	–0.5	0	–0.2
Corrientes	0	0	0	0	0	0	0	0
Goya	0	0	0	0	0	0	0	**0**

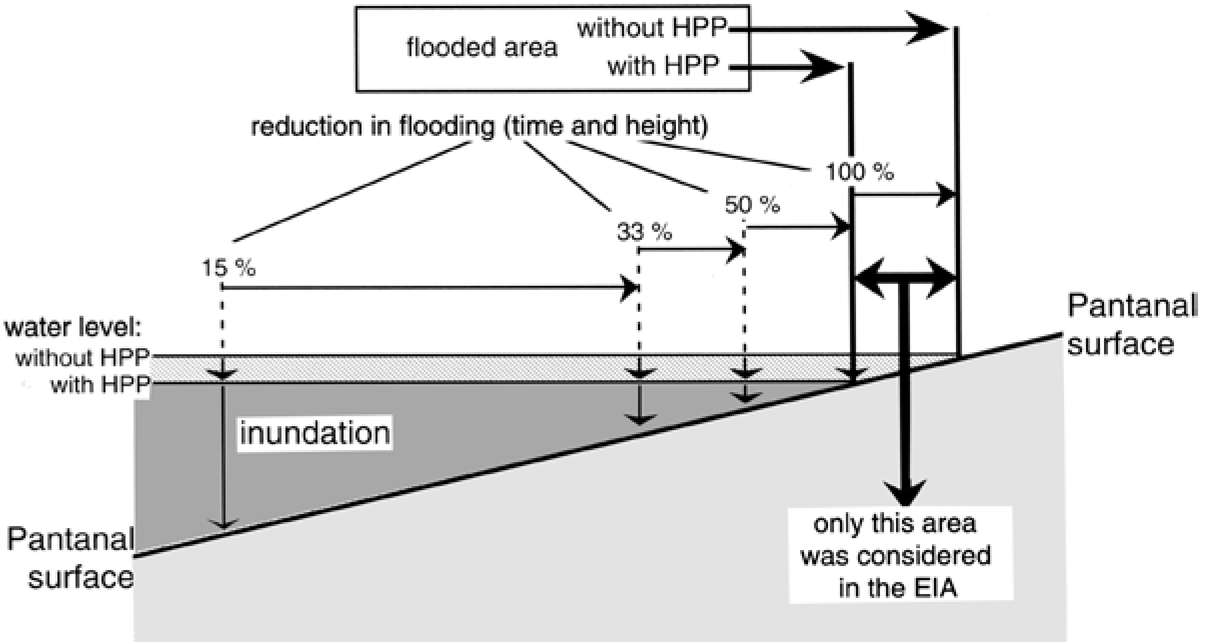
	Area Flooded in the Pantanal (km^2)			
	Max. Inundation		Min. Inundation	
	Prelim. EIA	Final EIA	Prelim. EIA	Final EIA
Low Water Year	–1780	–510	–960	–610
Typical Year	–770	–220	–1220	–430
High Water Year	–440	–170	–760	–450

Interpretation Flooding of the Pantanal

One of the potential impacts of the Project is the reduction of the area flooded in the Pantanal. The EIA has estimated the possible reduction and found it insignificant when compared with the total area flooded. It was assumed that areas where flooding was reduced by 100 percent would have an impact, but even a 50 percent reduction could also change the vegetation and/or the suitability of habitat for wildlife.

In the EIA, an impact greater than 15 percent on the natural variation is regarded as an "impact of great magnitude" (TGCC, pp. 10-12). Consequently, areas affected by a reduction of flooding of more than 15 percent should also be considered in the impact assessment. This would mean a more than six-fold increase in the flooded area of the Pantanal that should be considered in the EIA (see Figure 3.2).

Figure 3.2 Floodplain Area Affected by Reduction of the Water Level



Interpretation Natural Variability and Anthropogenic Changes

Comparing the simulated hydrological changes with the natural variability of the hydrology, the EIA concludes that changes caused by the Project are smaller than natural variation and are therefore insignificant. Hydrological changes were consequently disregarded and no attempt was even made to describe the potential impacts of the simulated changes.

The following are misconceptions in the EIA on how to recognize an impact:

a) For a proper assessment, it would have been necessary to analyze how the simulated hydrological changes influence the biotic and human environment, and then to determine the magnitude and significance of these potential impacts. In the EIA, however, the hydrological changes were declared insignificant before any impact assessment was instigated. This declaration of insignificance was accepted uncritically.

b) The hydrological changes do not occur instead of, but in addition to the natural variability. For example, a reduction of flooding combined with naturally occurring stress, such as drought, could have greater critical impacts on the environment than the flooding reduction alone.

c) Due to the shortcomings in the hydrological models, a more critical analysis of the hydrological assessment's reliability is needed. The optimistic evaluation must raise doubts about the reliability of the EIA.

Key Questions

An interpretation of the hydrological assessment for the EIA is given in the form of answers to 10 "key questions" (TGCC, pp. 10-9ff). Those questions are repetitive, overlapping, have no systematic order, do not address all relevant questions, and do not all relate to hydrology (e.g., key question 10). The impact on the Pantanal is successfully addressed in key questions one, two, three, and seven; and indirectly in key questions four, five, six, and nine. The answers are just affirmations of what has been stated before on pages 9-54 to 9-57 of the EIA (and needlessly repeated on pages 10-1 to 10-4).

Three key questions were not addressed in the hydrological assessment: (1) impacts of fixed hydraulic control structures, e.g., groynes; (2) impact on groundwater levels; and (3) impact on river pollution. The hydrological impacts of fixed hydraulic control structures have been studied for one situation that is not a representative sample (Ita Piru; TGCC, pp. 10-5 to 10-8). No plans exist yet for the location of sites and number of fixed hydraulic control structures, nor has an in-depth study on the impact of groundwater and pollution been done. Nevertheless, the EIA declares that all potential impacts are minimal.

CHAPTER 4 IMPACTS OF THE HYDROVIA PROJECT ON LANDSCAPE FEATURES, VEGETATION, AND FLORA

by Mário Dantas and Erika Schneider

The following sections provide a brief description of the impacts of the Hydrovia Project on landscape features, vegetation and flora. Relevant chapter and page references to the EIA report are provided in the appendix.

Photo 12. Fecho dos Morros, near Porto Murtinho and the confluence of the Apa River and Paraguay River, Brazil.
This landscape acts as a natural dike, holding the flood water in the Pantanal.
Photo: André Leite/WWF Canada

4.1 Conclusions

Proper environmental assessment should evaluate potential impacts of the Project on the flora, vegetation, and landscape features of the region. The only valuable information, however, is a rather imprecise, general statistical analysis of habitat types potentially affected by the dredging. The EIA does not consider all sources of potential impacts, and regards only parts of the environment affected. This, combined with significant errors, makes the EIA critically incomplete and faulty.

There is no assessment of the impacts on the flora of the region. There is only a superficial analysis of the number of species in different parts of the region, which is based on inaccurate numbers, and is not regarded in the impact assessment. Flora is addressed in a key question regarding the risk of introducing exotic species, but the answer is based on incorrect assumptions. This was not analyzed in the EIA.

The EIA does however, make a great effort to develop and apply sophisticated models to predict the impacts of the Project on vegetation and landscape features. Unfortunately, the attempts to assess the impacts failed, for several reasons:

a) the data base was incomplete and inaccurate;

b) the models were inappropriate for the problem;

c) not all potential sources of impacts were considered.

The EIA uses two concepts to evaluate the potential impacts of the Project on the flora, vegetation, and landscape features:

a) The flood-pulse function FITRAS was meant to describe the interactions of the flood pulse and landscape features of the region of the Project. It should thus predict changes in the landscape features that could result from hypothetical hydrological changes. However, the EIA accepted the interpretation that the impacts predicted by the hydrological model were ecologically insignificant. The FITRAS model was consequently not used.

b) The Ecological Land Classification attempts to give differentiated values to spatial units of complex landscapes. Evaluation of the habitats is rather arbitrary, though the statistical calculation of a highly abstract value appears objective. There are also errors of calculation in the process, so that the result is not meaningful.

However, as the assessment was essentially based on the underestimation of the potential impacts, the evaluation would probably give no more realistic results if the data base of vegetation and landscape features was sound. Also, the answers to the key questions are incorrect in important aspects and do not address all relevant problems, making the evaluation superficial.

4.2 Recommendations

a) The assessment is inadequate to use as a basis for decisions concerning implementation of the Project. Decisions should be postponed until a more competent and focused study of the impacts on the landscape, vegetation, and flora is completed.

b) This assessment should be based on a more comprehensive analysis of the actual situation, and on more realistic assumptions about the sources of impacts such as hydrology, accidents, disposal of dredged material, wave action, and land use change.

4.3 Assessment of Impacts on Landscape Features, Vegetation, and Flora

4.3.1 ORGANIZATION OF THE CHAPTERS ON LANDSCAPE FEATURES, VEGETATION, AND FLORA

The nature of the assessment of impacts on vegetation and landscape features is not appropriate. Theoretical concepts such as FITRAS are too sophisticated to be of practical use, considering the vast extension of the region, the low quality and resolution of available data, and the limited understanding of ecological interactions. Consequently, the chapters on landscape features, vegetation, and flora contain more theoretical reasoning than concrete facts about the region.

The complex hierarchy of subchapters and paragraphs within each chapter (e.g., paragraph nº l0a in chap. 4.1.b.5.1) results in a labyrinth of information fragments, connected by retrospectives on earlier subchapters, outlooks on coming ones, and cross-references to others. This leads to the presentation of identical facts and ideas in many different places.

In contrast to this structural complexity, the information used in the assessment is very poorly documented. For instance, there is very little information about the satellite images used, e.g., whether they were taken during high or low water and in which year. Some information—for example, the spatial resolution of images (30 by 30 meters; TGCC, Table 11. 1.6.2), scale (1:100,000; TGCC, pp. 11-31), and the area covered—can be found elsewhere in the subchapters. However, since no information is given about the area actually covered by them, and the water stage at the time, it remains mysterious how they were used at all.

4.3.2 FIELD STUDIES

A total of 83 transects along the Project were studied, starting from the river channel to the limit of the floodplain. Along these transects, several typical sample areas were studied. A map of the locations of the transects is given in the chapter on fauna, together with the information that the sample plots (*parcelas*) were 10 by 10 meters in size (TGCC, pp. 4-27). Information on location of the transects, geographical coordinates, and number of plots is spread over 15 pages (TGCC, Table 11.2.3). This sample effort is insufficient to make a significant contribution to the knowledge of the flora and vegetation types of the region.

The following parameters were recorded for different vegetation strata: dominant species, global cover of each strata, and height and diameter of trunks or grass tussocks. Additionally, indicators of disturbances such as fire, flooding and grazing were recorded, and the sensitivity of the vegetation to frequent disturbance was evaluated. Parameters of water quality, which could influence the distribution and abundance of plants, were determined in the studies of water quality (TGCC, Tables 4.1 .b. 1 to 4.1 .b.4).

Table 4.1 .b.4 of the EIA also contains information about the level of resources of each habitat for fauna. The abbreviations “A, R, M, S, I-P” remain unclear. Only one explanatory remark states the information does not have the “specificity and definition” as does the chapter on fauna (TGCC, pp. 4-22). The information appears much more specific than the information in appendixes 7C to 7E, as it even distinguishes between breeding and feeding habitats.

Information on the ecology of a number of species (TGCC, appendix lIA) illustrates 54 graphs of the distribution of plants in relation to the water level. This information would be very interesting and relevant if it was more complete and accurate concerning the water level and the stage at which the data were collected. For instance, the willow *Salix humboldtiana* was recorded in two-meter deep water, which indicates a flood phase.

Of course, the distribution of plant species in a floodplain is not only determined by flooding. Often groundwater dynamics, which correspond in complex ways to the river water, are the decisive factors. It seems the interactions between vegetation and groundwater are generally insufficiently studied.

The problem of groundwater dynamics in drier tropical zones is related to the salinization of soils. Natural inundations efficiently prevent accumulation of salt in the upper soil layers. Salinization in floodplains due to human interventions are known from the Lower Danube and Volga Rivers in Europe (Finlayson, 1992; ICPDD et al., 1997).

43.3 FLORA

Flora refers to the total number and distribution of plant species in a certain region. An impact on the flora would mean a change in the specific composition, through the disappearance or invasion of one or more species. One would expect there to be an analysis of species of special concern, such as endemic and endangered species, or those critically exposed to the potential impacts of the Project. This would be followed by an analysis of the potential sources of impacts, and then assessment of their magnitude and significance.

The chapter on flora in the EIA contains none of this. It does not analyze the possibility of invasion of exotic species, even though river corridors offer ideal “pioneer” habitats on sandbars and riverbanks.

No serious attempt was made to assess the impacts of the Project on the flora of the region. The potential problem of invasion of exotic species was addressed in the key questions, but it was not analyzed.

A more thorough assessment of the impacts on the flora would have been possible. For instance, the water lily *Victoria cruziana* is found in the backwaters of the Paraguay River in the Pantanal, but is not normally exposed to currents or intensive waves. Increased traffic could have a greater impact on this plant species than on other aquatic plants. Relationships like this should have been identified, perhaps for indicator species, and the distribution and sensitivity of the respective species studied.

The floristic part of the EIA produced a measure of species richness in different parts of the region, including areas that are not part of the Hydrovia Project (e.g., the Uruguay River). The EIA did not attempt to comprise a catalogue of plant species, a task which was regarded as impossible given the limited availability of time and human and economic resources. So the EIA produced a "compilation" instead of a catalogue, which was meant to be contained in an appendix but which is apparently missing (TGCC, p. 4-4). The compilation was based on 1,620 species selected from 8,000 examples found in herbaria, literature, and during the field investigation (TGCC, pp. 4-3). The EIA did not try to verify the species names found in the data sources, so species could be listed several times under different names (TGCC, p. 4-4).

With this compilation, the EIA pursued an ambitious plan to "relate the spatial and temporal complexity of the flora ... to the principal factors which could cause the presence of plant species ... in the area of the Project" (TGCC, pp. 4-1). The only other data recorded for the ecoregion in which the plant occurred was the hydrological situation (e.g., "high water/inundated soil" or "low water/soil not water covered") (TGCC, p. 4-4). It remains unclear whether this is related to the water stage or the topographical situation of the sampling site.

The differences in species numbers are discussed and some "speculation" is given (TGCC, pp. 4-Sff), but this is not reliable, and did not contribute to the impact assessment process.

Obviously, these considerations are based on incorrect numbers of plant species, at least for the Pantanal. There are more than 1,755 terrestrial plant species in the Pantanal alone, and a further 220 aquatic plant species (Abson, Pott, & Silva 1997, Pott & Pott, in press). On the other hand, it would be interesting to know which species are to be found in the "river course" habitat category in the delta. In the ecological land classification this habitat (Al) is described as "grassland, dominated by one species" (TGCC, Table 7.7), yet elsewhere it was found to have the highest species number of any habitat type in any ecoregion (TGCC, Fig. 4.1.a.2).

4.3.4 ECOLOGICAL LAND CLASSIFICATION

Description

The assessment of impacts on the landscape features and vegetation is based on Ecological Land Classification (ELC). ELC is a method for arranging a complex landscape mosaic into a hierarchical order with a limited number of habitat types, called "ecosections", as the base units. "Ecodistricts" and "ecoregions" are geographical units of higher order. In the case of the Hydrovia Project, only ecoregions and ecosections are meaningful.

The basic tool for the ELC is a map of the ecosections in the region concerned, which can also be used for statistics of the area covered by each ecosection. Naturally, not all ecosections have the same ecological importance. This importance can be evaluated using different criteria, such as the number of endangered species found in the ecosection.

An impact will affect a certain area that contains one or several ecosections. The ELC can then be used to calculate whether the impact affects a significant portion of the area of those ecosections and whether those ecosections have higher or lower importance. The calculation will produce an abstract number of the relative value of the affected area to the total area considered.

Problems in the Hydrovia Project Region

The ELC encounters two problems:

a) The landscape mosaic of floodplains has natural variability. Besides the seasonal changes, accounted for in the ELC, the landscape mosaic can change according to the severity of the annual flood peak, and as a consequence of natural shifting of the riverbed.

b) ELC is based on the assumption that the ecosections are ecologically independent of one another. This is certainly not true in the floodplains of the Project region. Hydrological changes could influence greater areas, but with different impacts in different ecosections. A reduction of the flooding time and area could turn pools in the Pantanal into salt pans or grassland, but it could also turn grassland into forest. It is not clear how ELC could help to assess impacts of hydrological changes on the vegetation.

Basic Geographical Information

The basic information of the ELC is a satellite map covering a strip reaching 10 kilometers away from both banks of the river. This is less than the “area of influence on the biotic environment” (TGCC, Fig. 1.6.2), which correctly covers all of the Pantanal. But even this narrow map appears questionable if compared to the “area of influence on the physical environment” (TGCC, Fig. 1.6.1); certainly impacts on the physical environment, such as hydrology or climate, would also affect the biotic environment. Nevertheless, since the EIA considers only the direct impact of dredging on the environment, and no indirect impacts, the limited area of the satellite images seems acceptable. The spatial resolution of the satellite images is 30 by 30 meters (TGCC, Table 11.1.6.2).

Stepwise Development of the ELC

Step one: The ecosections of the region are defined based on their vegetation. Extensive and repetitious descriptions of the ecosections and ecoregions are given in pages 7-11 to 7-37 of the EIA.

Step two: The ecosections are evaluated using different criteria, such as:

a) extent of the ecosection;

b) number of patches;

c) degree of influence of the river on physical and biological processes;

d) diversity and function of flora and fauna;

e) potential for rare species of flora and fauna;

f) sensitivity for disturbance; and

g) potential for land-use changes.

Results are presented for every ecoregion (TGCC, Tables 7.16 to 7.19). Each criterion was estimated as high, medium, or low (corresponding to one, three, and five); the sum of these values is the global number for general sensitivity of the ecosection. The criteria are called "indicators" (TGCC, pp. 7.9. 1 ff), which can lead to confusion with indicator species used in the faunistic assessment. The criteria are described and explained several times (TGCC, pp. 7-39, 7-39 to 7-48, Table 4.1.b.3), but the definition of the criteria varies. There is also inconsistency in the criteria in so far as most are applicable generally to the ecosection, while the degree of disturbance can only be determined for specific sites.

This process is not, in contrast to what was stated in the EIA, consistent with the "issue scoping" of a normal process of EIA. Scoping is ". . . intended to focus the EIA on the most important issues, . eliminating irrelevant impacts" (Wood, 1995). Nonetheless, in the ELC the general sensitivity of habitats is evaluated, which is a value independent from the Project.

Errors within the evaluation include:

a) The "a" and "b" are switched in Tables 7.16ff, in the category "distribution." (See TGCC, pp. 742.)

b) It is not clear whether a highly fragmented habitat should score high "a" or low "b." The explanation is not unambiguous (TGCC, pp. 7-42 to 7-43), but as the contiguous rivers are given a “low,” probably more highly fragmented habitats are considered more sensitive. Why this should be so is not explained.

c) The data on the diversity of the flora are based on insufficient information, while determination of the diversity of the fauna is inaccurate (see next chapter). The same applies to the “potential of rare species.”

d) It is not clear why the sensitivity for disturbances should be so variable in different ecoregions.

e) No explanation is given for “potential for changes of the use” for habitats like Open Water (Al), Forest Plantations (J3), or Agricultural Areas (J2).

In summary, determination of the general sensitivity of the ecosections contains significant errors, and the results must therefore be considered invalid.

Step three: All significant consequences of potential impacts of the Project on the landscape features, vegetation, ecological functions, and potential uses by humans are identified (TGCC, pp. 11-2 to 11-20, Fig. l1.1.4.a,b).

Though these ecological interactions can be identified, quantification of the described impacts is mostly hypothetical. Information available about the cycling of nitrogen in the region of the Project is far from sufficient to make predictions on future conditions, with or without the Project. Here, a high degree of precision in the study is pretended, which is neither required nor realistic for the assessment.

There is a comparison of the species composition (probably plants) of some of the ecosections, but as the plant list is obviously inaccurate, the results cannot be very reliable. Furthermore, it is not explained what the comparison contributes to the EIA.

Information about the disposal of dredged material is in contradiction to its recommended treatment, as it is clearly expected to take place on riverbanks or islands (TGCC, pp. 11-13). This is probably a realistic assumption, as opposed to using narrow parts of the channel, as is the case in the northern parts of the Project. Description of the impact of this disposal, however, is insufficient. The impression left is that the quantity of dredged material is underestimated. Most likely, the disposal will take place close to the river in low-lying areas, to diminish the costs. Gallery forest and oxbow lakes connected to the river will probably be most affected, and the hydrological connection between river and floodplain will be disturbed.

Step four: For every ecosection, the area within each ecoregion and ecodistrict is determined using satellite and videographic images for zones of 10 kilometers on both sides of the main rivers (TGCC, Tables 11. 1.6.1, 11.1.6.2).

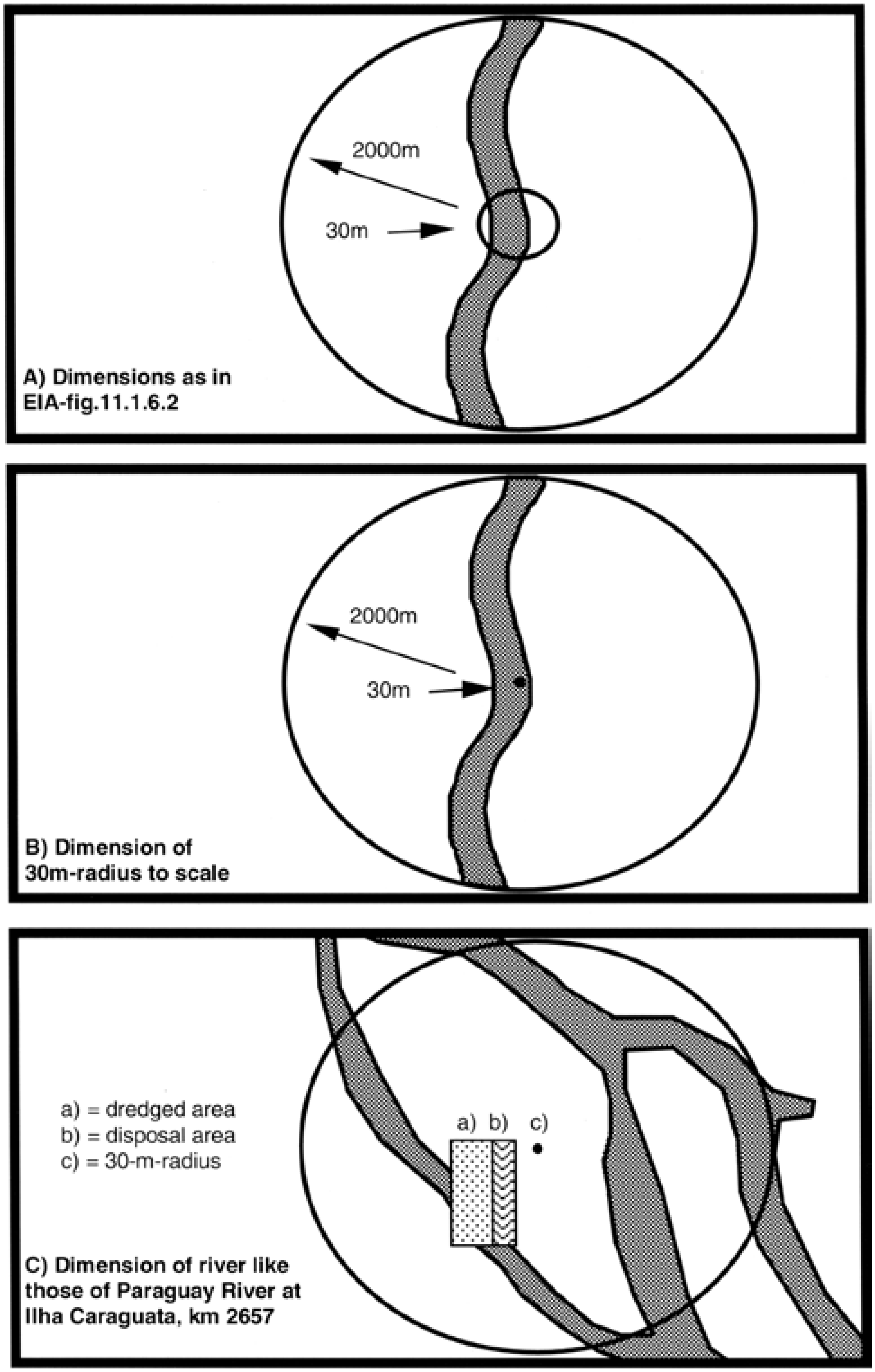
As hypothetical zones of impacts, circles were defined around the critical passes, which have either a two-kilometer or 30-meter radius. Figure 4.1 shows the size relationships of the circles with a two-kilometer (TGCC, Table 11.1 .6.4) and a 30-meter radius (TGCC, Table 11.1 .6.3), as it is illustrated in the EIA, and shows how they would be with correct dimensions. The 30-meter radius is too small to cover the dredging area. It appears there is a misconception about the magnitude of the interventions planned for the Project.

The two-kilometer radius seems adequate to cover the area most intensely affected by the dredging operations. The impact in this two-kilometer zone, however, is direct and intensive, not indirect and extensive, as stated in the EIA.

Step five Interpretation of the assessment is given in the form of answers to eight “hypotheses of possible impacts” (TGCC, pp. 11-21 to 11-22), reformulated as eight “key questions” (TGCC, pp. 11-22 to 11-50).

Figure 4.1 Comparison of Zones of "Indirect Impact" With a 30-m and 2-km Radius

a) Dimensions as illustrated in Figure 11. 1.6.2 in the EIA
b) Dimension of 30-m Radius to scale of 2-km radius
c) Dimension of River to Scale of 2-km Radius, example (simplified) from the Paraguay River at Ilha Caraguata 2,657 km



4.3.5 KEY QUESTIONS

The key questions are general enough to cover all significant impacts. However, the key questions are somewhat iterative and sometimes self-evident; e.g., *"Pregunta 1: Podra producir la remoción … de la vegetación... la pérdida… de la vegetación… ?* [Question 1: Can the removal… of vegetation… produce a loss of vegetation… ?].*"*

Answers to questions are limited to the Corumbá and Cáceres reach (TGCC, pp. 11-23). Formulations of the key questions are modified below, in an attempt to give them a more systematic structure.

Key Question One: How great will the effects of dredging and disposal of dredged material be on the vegetation and landscape features? (TGCC, pp. 11-22 to 11-36)

The following parameters were calculated:

> a) Areas of indirect influence: As described above, the areas of circles of two-kilometer and 30-meter radius around the sites of dredging were calculated. The total area of those zones of indirect influence is only nine percent and 0.0007 percent, respectively, of the total area. (The EIA calculates the area to be dredged as 52 hectares, while the area of the 30-meter radius circle is 14 hectares.) This is regarded by the EIA as insignificant, though the EIA does not even calculate the percentage of the total area contained in the two-kilometer-radius circles. For certain critical habitats, the proportion in the two-kilometer-radius circles would be high (e.g., the species-rich gallery forest, at 23 percent). It must be emphasized here that the two-kilometer-radius circles are not remote from and little affected by the dredging: a disturbance of 23 percent of the gallery forest in the Pantanal by dredging alone, without the disturbance from navigation, should be an unacceptable impact.
>
> b) Fragmentation of habitats: This was calculated using the quotient of area and perimeter of habitat patches. The EIA did not show conclusively that this parameter is really meaningful for the landscape along the Project. It is an important aspect in other regions, where natural and semi-natural habitats have been significantly fragmented by humans. But in the region of the Project, especially the Pantanal, this is not the case.
>
> c) Sensitivity of habitats: This was estimated earlier (TGCC, Table 7.16ff, repeated as Tables 11.1.6.7ff; for critique, see above). The EIA compares only the relative portion of more or less valuable habitats in the circles of indirect influence, but not their relation to the total area of valuable habitats. Such comparisons are misleading and unrealistic.

The answers to this key question serve to hide the magnitude of the potential impacts, rather than to give an objective evaluation. Considering the two-kilometer-radius circles, which are congruent with a zone of high to moderate influence of the dredging operation, the impact on the most valuable habitat type is critically high, with 23 percent of the area affected.

Key Question Two: Could changes in hydrology have impact on vegetation and landscape features? (TGCC, pp. 11-36 to 11-38)

The analysis of this question depends exclusively on the predictions of the hydrological models. The simulations of those models predicted rather small, insignificant changes in water level, mainly for low water stages (see chapter 1). However, as EIA-appendix 11A shows, many plant species are distributed in a very limited zone in relation to water level, often not more than a few decimeters, despite the natural fluctuations of the river level.

The ecological significance of the simulated hydrological changes was established by the hydrologists. Instead of testing this statement, it was accepted by the ecologists without further consideration.

Key Question Three: If vegetation was changed due to the Project, would this influence the flooding pattern in the floodplain? (TGCC, pp. 11-38 to 11-40)

This is a secondary effect, relevant only if significant changes in vegetation or landscape features are expected (key questions one, two, four and eight). It was concluded for key questions one and two (and anticipated for the others) that there will be no perceptible impact, making this key question purely academic.

Certainly, the influence of changes in the vegetation cover could have important impacts on the hydrology and climatology of the region. Considering the high rate of evapotranspiration in the Paraguay River basin, it seems probable the climate of neighboring regions could be affected. Potential impacts on albedo were discussed by Ponce (1995).

Probably the existing information, even if it had been used, would be insufficient to answer this key question.

Key Question Four: Will the Hydrovia Project increase the risk of invasions of exotic species? (TGCC, pp. 11-40 to 11-43)

The answer to this question considers mostly physico-chemical changes of the water and sediments as possible factors facilitating the expansion of exotic species. It is expected that such changes can appear only temporarily and locally, and therefore will not favor exotic species. *"No hay especies exóticas en la cuenca que puedan resistir la variabilidad de los ambientes fluviales* [There are no exotic species in the basin that could resist the variability of the riparian environments]."

This is an incomprehensible statement, as there *already are* exotic species in the floodplains of the Paraguay and Paraná Rivers. All over the world, exotic species are spreading preferentially along rivers, using fresh sedimentary and disturbed areas, where they encounter less competition by indigenous species. The dredging, even more the "shaving," of riverbanks, and above all the disposal of dredged material, could create hundreds of hectares of land devoid of vegetation, and thus give exotic species considerably more habitat to establish.

The increased traffic from the Project will also directly favor the spread of exotic species. An important mechanism for the spread of neophytes and neozoons will be the release of ballast water. Certainly, the transport (of soya) along the Project will be mainly downriver, so the region of the Upper Paraguay would be mostly affected by passive transport of plants.

There are good reasons to believe that the Project would facilitate the invasion of exotic species. Though this may seem to be of little importance to the natural environment, it could have been studied in the EIA by comparisons with the mechanisms of distribution of exotic species that have already reached the Project region (e.g., *Spergula arvensis).*

Key Question Five: Could land use change influence the vegetation and landscape features? (TGCC, pp. 11-43 to 11-45)

Land use changes such as the expansion of agriculture over formerly pristine land can affect the floodplains of the rivers. This impact is regarded as small to moderate over the long term. The EIA concludes, however, that the Project will not cause major land use changes, even though it also states the impacts from land use changes are cumulative. Further, it is not explained how these cumulative impacts will interact with other impacts. Even at present, there are indications that the mere prospect of the implementation of the Project has already led to land use changes in the region.

Also, the list of possible impacts of land use changes is incomplete. For example, increased sediment load of the Taquari River will have more consequences than just “increased turbidity.”

Not analyzed in the EIA (but addressed in the measures of mitigation) is the possible increase in the exploitation of timber resources, which could increase the destruction of gallery and other forests in the region of the Project.

Key Question Six: Could increased navigation cause erosion and thereby affect vegetation and landscape features? (TGCC, pp. 11-45 to 11-47)

Wave action from increased navigation could influence the riparian vegetation (TGCC, Table 9.2.2). However, this vegetation is believed to be well adapted to waves due to wind action, so that the additional impact of the navigation would be imperceptible. Nevertheless, during the soy season, moderate but local and brief disturbances, followed by rapid recuperation, are expected.

As parts of the river channel are not really stable, it would have been worthwhile to determine the natural morphological dynamics of the rivers, to be able to judge competently the accumulative effect of wave action by navigation.

Vegetation, like gallery forests, helps to stabilize the riverbanks. Where vegetation is removed, erosion starts. Navigation could, therefore, have a cumulative effect on riverbanks already destabilized by dredging for the Project.

Waves caused by wind and navigation have different characteristics. Wind affects mainly the surfaces of water bodies causing compensatory sub-superficial water movements, while barges push aside large volumes of water. Vegetation in areas such as oxbow lakes are often adapted to fluctuating water levels rather than to currents or wave action. Species such as the water lily Victoria cruziana and the bladderworts Utricularia spp. could fall victim to fluctuating water levels.

Assessment of the potential impacts of wave action caused by increased navigation is superficial and deserves a more comprehensive analysis.

Key Question Seven: Could increased risk of accidents due to increased traffic have impacts on vegetation? (TGCC, pp. 11-47 to 11-50)

Risk of accidents will decrease rather than increase as a consequence of the Project, since traffic is not expected to increase between Corumbá and Nueva Palmira, and the security will be improved by signalization. The EIA assumes that accidental pollution during low water should have rather localized impacts; isolated incidents should have impacts only on seeds and young plants; and only repeated incidents should lead to changes in the landscape.

This answer is based on incorrect assumptions, as the risk of accident will almost certainly increase (see chapter 3). The different opinion in the EIA is based on a misinterpretation of accident statistics on the Mississippi River.

The EIA believes that during low water, pollution cannot reach the floodplain; and even during floods, pollution is unlikely to cover the entire floodplain. But, as the SANDOZ accident on the Rhine River in Central Europe has illustrated (Kinzelbach, 1987), pollution can affect hundreds of kilometers of the river's reach, even at low water.

Key Question Eight: Could the Project produce changes in the vegetation and in the complexity of the landscape units (categories in the ELC) at the level of communities or populations? (TGCC, pp. 1 1-50)

This question does not address any aspect unique to the other key questions.

4.4 Mitigation, Control, and Monitoring

Nine measures of mitigation have been proposed by the EIA (TGCC, pp. 11-50 to 11-51):

a) At least one of the crew of every dredger should be native to the region.

b) The crew should know what to do in the case of accidents and pollution.

c) In case of accidents the authorities should be informed.

d) Extractive activities should be controlled.

e) Smuggling of legally protected natural resources should be controlled.

f) The velocity of barges should be reduced in narrow and meandering parts of the Project.

g) Dredged material should be disposed of in the riverbed or, if necessary, on the riverbanks, but not in contiguous areas, which could isolate the river and its floodplain.

h) Regulation and control over the land use in the river basin should be optimized, forbidding technologies that favor soil erosion and contamination.

i) The amount and quality of the sediments in the tributaries of the Project should be maintained in a control program.

Though all of these measures are entitled “Methods of Mitigation of Impacts,” none of them concern mitigation of impacts. Three refer to the training of personnel for the operation of dredges and ships. Another suggests agreements among the countries to effectively protect the vegetation and landscape against extractive activities. (This measure, together with the review of enforced transport regulations for products from natural environment, such as timber, fruits, and seeds, is very important and makes sense due to the facilities offered by the Project.) While all of these measures may be useful, they do not mitigate the direct impacts of the Project.

The last measures are very important to implement regulation and control over land use to prevent erosion and contamination, and to establish a program to monitor the tributaries of the Project that drain agricultural and industrial zones, measuring the concentration and quality of sediments and liquid wastes. This is important because the implementation of the Project may result in population increases in cities located along the main river or around the Pantanal. There are also expectations of an increase in industrial activities as a consequence of other large projects, such as the gas pipeline from Bolivia to Brazil.

There are general proposals for monitoring vegetation after the implementation of the Project (TGCC, chap. 14.2.l.2.l, found on pp. 14-160. It is stated that five percent of every ecoregion, and 20 percent of the Pantanal, shall be covered twice every year by field studies of the structure and function of the vegetation. Cost and other practicalities would make it nearly impossible to accomplish this in the Pantanal, even if the area is restricted to a 10-kilometer zone along the Paraguay River itself.

The cost of a thorough monitoring program of vegetation and water quality can be estimated. Considering that investment for equipment will be made only in the first year, about U.S. $ 600,000 would be necessary for monitoring vegetation and water quality every year.

Technical Services $210,000

Field and laboratory activities, data analyses and interpretation, preparation of reports on vegetation and water quality (limnology and hydrology) including seven researchers for three months during the dry and humid season.

Other Services $61,000

Boat for six people for 30 days	$36,000
Small plane for five people, 50-hr flight	$15,000
Communication, film development, etc.	$10,000

Laboratorial Analyses $217,440

72 analyses of stable isotopes	$11,520
72 analyses of phytoplankton	$ 7,200
72 analyses of zooplankton	$ 7,200
72 analyses of heavy metal from sediment	$36,000
72 analyses of PAH in water	$36,000
144 analyses of hedrocarbon (PCB and pesticide in water and sediment)	$72,000
72 analyses of herbicides in sediment	$36,000
72 analyses of oil and grease in sediment	$ 7,200
72 analyses of water	$ 2,160
72 analyses of sediment	$ 2,160

Material $20,000

Including millipore filter, lamps, fuel, plankton net, etc.

Equipment $78,300

2 water quality meters HORIBA G 99590-10	$ 6,600
2 flow meters	$14,000
2 horizontal freezers 4301	$ 2,000
2 vacuum pumps Nalgene-Mityvac	$ 200
1 spectrofotometer Micronal B380	$ 7,500
1 COD TOC 5000 /shimadzu analyser	$35,000
1 GPS Magellan-Nay 5000 Protm	$ 3,000
Small (termical plate, sampler, boat engine, small boat, cabinet)	$10,000

Satellite Images $16,000

16 for dry season	$8,000
16 for humid season	$8,000

4.5 Special Considerations About the Pantanal

The Pantanal is a complex set of different ecosystems that present specific characteristics due to the water action and the variation in water regimes among seasons and years. Every year in the Pantanal is unique, depending on remote precipitation (the basis of flooding) and local rainfall. In this process it is necessary to consider the water source: 1) precipitation which occurs in higher areas *(planalto)* surrounding the floodplain, such as the headwaters of the main river, the Paraguay, and its tributaries, and the basin of the Upper Paraguay, which is spread over 361,000 square kilometers; as well as, 2) local precipitation in the floodplain, that promotes water accumulation depending on the soil structure, and thus supplies the water table.

Both sources contribute to the flooding of the Pantanal. The slope of the terrain also characterizes this behavior. Runoff is slow and the river channel does not support the water discharge causing overflow into contiguous areas covered by grassland or savannahs.

There are four zones of water accumulation in the Pantanal, which consist of extensive shallow reservoirs that regulate flood propagation along the Paraguay River (PCBAP, 1997). The main zone is located in the northern part of the basin and its control point is below the confluence of the Paraguay and Riozinho Rivers. This reservoir receives water from the Paraguay, Cuiabá, Itiquira/Piquiri, and São Lourenço Rivers, and from smaller ones that drain the alluvial fans. The second zone has its control point at Porto da Manga. This reservoir has tributaries, the Paraguay and Taquari Rivers. The third zone is formed by the floodplain of the Aquidauna and Miranda Rivers and its control point is situated at Porto Esperança. It receives the water of the Paraguay, Miranda, Aquidauana, and Negro Rivers. The fourth zone is located in the lowest part of the basin corresponding to the Nabileque depression until the control point at Porto Murtinho. At this location, the crystalline basement is closer to the surface of the depression, only 37 meters deep according to PETROBRAS surveys.

The Pantanal is known for its species richness. Within the Upper Paraguay basin, Pott and Pott (in press) note the existence of 3,350 species of higher plants, of which 1,755 occur within the Brazilian Pantanal. They also describe 220 species of aquatic species from Pantanal region. This information has not been used in the EIA.

Vegetation in the Pantanal is strongly correlated with water level. The presence of water can vary from permanent ponds *(baias)* or rivers to ridges that never flood *(cordilheiras)*. Vegetation ranges from aquatic to pure grassland or herbaceous savannah *(campo limpo),* grassland with sparse shrubs or small trees *(campo sujo),* shrubs and trees *(campo cerrado),* high trees *(cerrado)* and dense and high trees *(cerradão)* or semi-deciduous forest (Coutinho, 1990; Goodland, 1971). The successional stage of vegetation is clearly correlated with the groundwater table or the water level.

Severe and irreversible impacts on the Pantanal can be expected from the implementation of the Project:

> [The] ecology of the region is determined by the flooding pulse that depends on the hydraulic geometry of the system. Hydraulic geometry includes total quantity and periodicity of discharges of rivers and their flow through floodplain, the shape of riverbeds and the sedimentary load. Any

> modification of the hydraulic geometry of the system will result in modifications of the ecosystems. Considering the low relief of the floodplain, a few meter pulse modification will deeply affect large areas of Pantanal, modifying its structure and functions (Junk & da Silva, 1997).

Cooper et al. (1973) state:

> The results of these man-induced changes are usually either a reduction or sharp increase in the supply of silt and nutrients to downstream environments or a change in river dynamics. Both effects have profound impacts on biological activity in rivers, marshes, deltas, valleys . . . wetlands and ox-bow lakes, where highly productive ecosystems are located land] are normally subject to an annual flood period. The amplitude and regularity of flooding is of the utmost importance in these fluctuating water level ecosystems (Odum, 1969), where communities are adjusted to the pulse of seasonal variations in water levels. Decreased water flow can also cause several pollutants, such as excess heat, particulate matter, industrial and domestic wastes, etc., to reach undesirable levels. Although we understand these specific effects, the rearrangement of hydrological patterns, such as the proposed creation of a series of man-made lakes that would interconnect the Orinoco, Amazon, and Rio de la Plata Basins in South America (Panero, 1967), will result in such large-scale changes that the ecological consequences cannot be predicted from current information.

There is a great need for research in the Pantanal (Wade, 1997). Major projects, such as the Hydrovia Project, that involve the Pantanal cannot be properly evaluated without sufficient understanding of the hydrology of the area and the response of plant and animal communities to hydrological alteration.

Pantanal vegetation that reflects the landscape was pointed out by Prance and Schaller (1982) follows:

> A striking aspect of the Pantanal is its curious combination of mesic and xeric vegetation growing side by side. The reasons for this mixture are the topography and the seasonal climate. Hence, patches of *terra firma* experience severe drought during the six month dry season. These areas of higher ground are often interspersed with flooded areas of swamp or aquatic vegetation type.

The little information that is known about the dynamic relationship between vegetation and water was ignored in the EIA. During exceptionally dry periods woody vegetation such as *Vochysia divergens* increases in dominance at the expense of shrubs and herbs (Pott & Pott, 1994a,b). During high flood periods, the opposite happens, and those tree species die. The results of these changes can be observed in some lagoons and older parts of the main rivers:

> Natural or anthropic changes in hydrological level cause changes in vegetation occurring in Pantanal . . . Higher flooding causes a decrease in tree occurrence and conversely drier periods or lower flooding causes an increase in tree occurrence. During the dry years of 1960-1974, trees appeared even in the river beds, e.g., Abobral and Negro Rivers, and in the bottoms of lagoons. Those trees eventually die with the new flood cycle. In the Taquari River, sedimented and overflowed, riparian

> forest has become impoverished and died. Where there is a road, one can clearly observe this tendency in vegetation succession because bushes and trees appear in dikes, while aquatic plants appear along road sides excavated to remove material for the road. If the Hydrovia Project causes drought of areas in the Pantanal by lowering the water table level, certainly woody vegetation will increase, i.e. floodable fields will be replaced by pioneer stages of vegetation dominated by thornscrub *(espinheiral)* and *Vochysia divergens (cambarazal)* towards Cerrado and forest. RADAMBRASIL (1982) says that in Pantanal the vegetation tends to evolve to woody formations. Along Pantanal rivers, nature frequently plays the succession game, felling down trees of old riparian forest along the banks which are being excavated and beginning again the colonization process by shrubs *(saran, pateiro* and others) followed by trees *(Vochysia divergens, Tabebuia,* etc.) in the river banks where sediments are being deposited. (PCBAP, 1997).

There are many aquatic plants that germinate under water (e.g., *Typha domingensis, Eichhornia azurea, E. crassipes, Pistia stratiotes, Lemnaceae, Nymphaea spp., Victoria amazonica, Oryza spp., Discolobium puichellum)* and others that depend on water to break down seed dormancy or seed tegument to initiate the germination process or simply disperse them *(e.g., Licania parvifolia, Pterocarpus michelii, Aeschynomene fluminensis, A. sensitiva, Vitex cymosa, Sesbania virgata, Ipomoea carnea spp. fistulosa) (Pott & Pott, 1994a,b, in press).* This contradicts the EIA, which states categorically that all species recorded in the region of the Project demand soil *not* covered by water for their germination (TGCC, pp. 6-3).

The implementation of the Project will cost about U.S. $ 100 million. To restore the Everglades wetlands in Florida, U.S., will cost an estimated U.S. $ 2 billion (Wade, 1997). How much will it cost to recover the Paraguay-Paraná system? Should the rivers be modified to suit the ships or should the ships be suited to the rivers? The waterway has been used for centuries and this must continue, but one condition needs to be respected: The hydrology of the system must not be changed by the proposed modifications. Cutting through of meanders, and straightening and widening the river channel are operations that significantly alter the hydrological regime.

CHAPTER 5 IMPACTS OF THE HYDROVIA PROJECT ON TERRESTRIAL FAUNA

by Juan Schnack and Peter Petermann

Terrestrial fauna in the EIA refers to the vertebrate classes of amphibians, reptiles, birds and mammals. Terrestrial invertebrates are ignored in the EIA due to lack of information. This part of the EIA is centered on birds, as they are more numerous and better known than the other vertebrate classes.

The following sections provide a brief description of the hydrological aspects of the Hydrovia Project. Relevant chapter and page references to the EIA report are provided in the appendix.

Photo 13. Greater Rhea *(Rhea americana)* from the Brazilian Pantanal.
Photo: André Leite/WWF Canada

5.1 Conclusions

The assessment of impacts on the terrestrial fauna is unsatisfactory, as it does not cover all sources of impacts, the magnitude of potential impacts is greatly underestimated, and monitoring is incomplete.

a) Incomplete data and analysis: Impacts in Module A (Santa Fe-Corumbá) were not assessed, and the impact of hydrological changes, especially in the Pantanal, was not analyzed. Ecological interrelations are not adequately analyzed and considered.

b) Errors in the data: The EIA contains incorrect information about distribution and habitat requirements. The field studies were insufficient to improve the available information.

c) Inaccurate results: As the assessment of the loss of habitats for indicator species was based on biased assumptions of habitat requirements, the potential impacts are not accurate. Impact on critical habitat (e.g., breeding sites) in the Pantanal would potentially be very serious.

Based on the available information, it is believed that important habitats and wildlife refuges could be endangered by the Project. Evaluation of the impacts indicates impacts of great magnitude if more realistic assumptions are applied.

5.2 Recommendations

a) The existing EIA does not supply representative information concerning terrestrial fauna on a very fundamental level, and should, therefore, not be used as a basis for decisions on the Project.

b) Planning of the Project should not continue before the consequences for the terrestrial fauna are properly analyzed. This is especially true for any action with irreversible consequences for the river morphology.

c) Plans for Module B1 should be abandoned due to the probable impacts on important species that could otherwise become critically endangered.

d) Information about the distribution and population sizes of species, the terrestrial invertebrates, and ecological interactions must be used in a new assessment of the impacts of the Project on the terrestrial fauna.

5.3 Assessment of the Impacts on Terrestrial Fauna

The assessment was based on published information and data from field studies (TGCC, pp. 8-14). Species richness and number of endangered/protected species per habitat (ecosection) were used, among other ecological parameters, to calculate the relative value of habitats in the ELC. The relative importance of impacts on the terrestrial fauna was evaluated by calculating the percentage reduction of available habitat area due to the Project for a number of carefully selected indicator species.

5.3.1 FIELD STUDIES

In the course of the EIA, vertebrate collection was undertaken on 130 transects divided into 453 plots of 10 square meters each (TGCC, pp. 4-27). Vertebrates were counted, and habitat, stratum of vegetation, time of observation, and behavior of the animal were also recorded (TGCC, pp. 4-27 & 11-62).

Illustration of the transect locations show that the sites were located in areas of easy access, such as close to major roads or cities in areas rather disturbed by people (TGCC, Fig. 4.2.1). The transects are therefore not representative and there is no clear, scientific description of the method of the field studies. Sample plots of 100 square meters are not enough for censuses of birds or mammals.

The number of indicator species (see 5.3.2) recorded during the field campaign is given in Table 5.1.

Table 5.1 Frequency of Indicator Species Encountered During the EIA Field Study

		Pantanal		Lower Paraguay		Lower Paraná		Delta
	Season:	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Scientific Name	**English Name**							
Jacana jacana	Wattled Jacana	46	30	28	3	73	25	12
Jabiru mycteria	Jabiru Stork	16		1				
Casmerodius albus	Common Egret	49		397	1		7	9
Rynchops nigra	Black Skimmer	270		13	9			
Phalacrocorax olivaceus	Neotropical Cormorant	360	18	778	26	46		15
Galbula ruficauda	Rufous-tailed Jacamar	7	3					
Icterus cayanensis	Epaulet Oriole	5		36	1			
Anodorhynchus yacinthinus	Hyacinthine Macaw	17						
Aiouatta caraya	Black Howler Monkey	57	11	21			4	
Lutra longicaudalis	Neotropical River Otter	3		5				4
Panthera onca	Jaguar	7	1					
Blastocerus dichotomus	Marsh Deer	12						
Hydrochaeris hydrochaeris	Capybara	124	19	21	3	1		134
Caiman crocodilus	Spectacled Caiman	55						
Caiman latirostris	Caiman							
Eunectes notaeus	Anaconda							1
Boa constrictor	Boa Constrictor							
Tupinambis teguixin	Tegu Lizard							

Note: The numbers of animals recorded in the surveys are small, except for the jaguar *(Panthera onca);* but these records were tabulated from feces and remains of prey (TGCC, pp. 11-73). Higher numbers represent colonial animals (e.g., *Casmerodius albus, Rynchops nigra, Phalacrocorax olivaceus, Anodorhynchus hyacinthinus, Hydrochaeris hydrochaeris).*

Source: TGCC (1997), Tables 11.2.3.9 to 11.2.3.12 and André Leite, WWF Canada

As some of these species are usually very numerous along the rivers (personal observation and available literature), the low numbers recorded can only be explained by insufficient sampling effort.

For each species, it was noted in which ecosection it was encountered in relatively greater number than if it was equally abundant in all habitats. Given the small sample numbers for most indicator species, this method can hardly produce useful results (TGCC, Tables 11.2.3.9 to 11.2.3.12).

5.3.2 INDICATOR SPECIES

From the total number of species in the three animal groups (reptiles, amphibians, birds, mammals), a small number of indicators was selected. These indicators were then used to estimate the impact through potential loss of habitat for every species. No additional information has been gleaned by the use of indicators. It appears their use was based on a misinterpretation of the indicator concept (see chapterl).

For the selection of indicator species, nine criteria were employed (TGCC, pp. 4-30; repeated on pp. 8-15 and 11-60); values are given in brackets:

a) Ecological relevance: Small or rare species score low (scale one to three).

b) Socio-economic status: Species of high consumptive value score high (scale one to three).

c) Conservation status: Endangered species score two points, others one (scale one to two).

d) Representative of an ecological category: Species which share their life-history strategies with others score higher (scale one to three).

e) Aptitude for monitoring: (scale one to three).

f) Availability of information: (scale one to three).

g) Distribution: present in one ecoregion, one point; in two to three, two points; in all four, three points. (Compare this with the next criterion.)

h) Ecoregional exclusivity: Present in one ecoregion, three points; in two to three, two points; in all four, one point.

i) Potential sensitivity for the project: Species that will suffer negative impacts score high (scale one to three).

Species with a high value for ecoregional exclusivity are automatically preselected as potential indicator species; while those with low availability of information or aptitude for monitoring are excluded.

Problems with the Criteria:

a) Why should small species be excluded? They can have greater ecological importance than larger ones.

b) The criteria distribution and ecoregional exclusivity are contradictory: Species that score high in one criterion automatically score low in the other. This doesn't make sense. It may be speculated that ecoregional exclusivity was originally meant to be the category for endemicity, e.g., species that are exclusive for the Project region. It is difficult to comprehend, however, why species that occur in only one part of the Project region should be more suitable as indicator species than species that occur throughout the Project region. These exclusive species will mostly be species on the limit of their natural distribution, which are more at home in neighboring biomes.

c) In the assessment process, sensitivity of indicator species for impacts of the Project should be examined. It is a circular argument to have sensitivity as a criterion for the selection of indicator species, that are to be used to test for sensitivity. Further confusion arises for habitat categories (TGCC, pp. 4-28, 8-14), which are repeatedly explained but have almost no influence on the selection of indicator species: Migratory species are totally left out of consideration; indicator species are mostly, but not exclusively wetland species; species of gallery forests were often omitted. Also, the categories are different for the different vertebrate classes, leading to more confusion.

The Pantanal bird list contains more than 40 species that do not occur in the region. This is over 20 percent of the total 187 species. This mistake is apparently due to the use of the list of "Birds of the region of the Pantanal" by Brown (1986; used also by Dubs, 1992), where those species that are only known from the neighboring Amazonia or Cerrado, but not from the Pantanal, are correctly identified as such, but are not in the EIA.

This process resulted in the selection of 18 indicator species: eight birds, five mammals, and five reptiles (TGCC, appendix 4A, Tables 14 to 17; Table 11.2.3.1). The species finally selected however are not the top-ranked species from the process, but those found in first, fourth, 10th 14th 15th, 76th, 80th and 115th rank. The common tern, *Sterna hirundo,* a rare Nearctic migrant, scores higher than the great egret, *Casmerodius albus,* one of the most common species. Similarly, the horned screamer, *Anhima comuta,* an Amazonian species that does not occur in the Pantanal, holds the fifth rank. The selected bird indicator species are apparently chosen because they are large, easy to observe and identify, and well known. Indicators are generally not hunted or endangered (except *Anodorhynchus hyacinthinus),* have unique ecological niches (except *Casmerodius albus* and *Icterus cayanensis),* and are widely distributed in and outside the Project region. Finally, there must be serious doubt about whether the number of 18 indicator species is sufficient to account for environments with very high biodiversity.

Each indicator species was given an IAH value (index of habitat suitability) for every habitat, according to each habitat's presumed importance for the species. These values (0, 0.33, 0.67, and 1.00) were based on the field studies, literature, and opinion of local experts (TGCC, Table 11.2.3.17).

The IAHs do not distinguish among critical habitats, such as those used for reproduction, and habitats that are used only as resting sites. While the assignment of species to habitats is acceptable, the numeric values do not weigh the relative importance of different habitats in a realistic way.

However, it is repeatedly emphasized that the models used here are preliminary, although the results of the assessment are treated as definitive and reliable in the EIA.

The IAH values were used to estimate the direct impact of dredging on the indicator species. The formula *IAHs × areas of the respective habitats lost* results in an abstract value for the magnitude of the impact, which can be compared to the total area of available habitat *(IAHs × total area of habitat available for the species).* The quotient is the weighted loss of habitat.

This calculation depends of course on the area of habitats thought to be affected by the dredging, which, in turn, depends on 1) the alternative of the Hydrovia assumed for the assessment and 2) the area around the sites of dredging (buffer zone) expected to be affected.

To calculate the relative loss of habitat in relation to total habitat available for every indicator species, it was assumed that all habitat was lost in a radius of 30 meters around the site of dredging and two kilometers around the site of dredging (TGCC, pp. 11-23).

The 30-meter radius seems to be based on a profound misconception about the magnitude of the interventions planned (see section 4.3.4). In contrast, the two-kilometer-radius does make sense. It can be expected that colonially breeding wading birds or skimmers will abandon colonies in the vicinity of dredging sites, especially if the disturbance is repeated annually in the breeding season. Jaguar and other large mammals will almost certainly avoid these areas.

According to TGCC, the comparison of habitat available and habitat impacted for the indicator species seems to indicate that only between 0.06 percent and 0.31 percent of the available habitat for any species would be lost. The results of the evaluation of two-kilometer circles are presented between Corumbá and Cáceres only for direct impacts by dredging and channelization, and not for maintenance of the channel, navigation, or potential hydrological and other indirect impacts (TGCC, Tables 11. 2.5.4 to 11.2.5.6).

Reproductive habitats are critical for most species. For example, while the skimmer needs open water or flooded areas for feeding, it is much more sensitive to disturbances of its breeding sites (both have an IAH value of 1.00). How much of the area of potential breeding sites is affected? Table 5.2 shows the result of an analysis using only breeding habitats, re-calculated from TGCC's numbers based on a directly affected area of two kilometers radius.

Table 5.2 Re-calculated Percentage of Breeding Habitat of Several Wetland Species in Close Vicinity (2 km) to Dredging Sites in the Pantanal

	Breeding Habitat	Habitat Available	Habitat Affected	%
Jabiru Stork,Great Egret, Neotropical Cormorant	Fl, F2, F3	135.239 ha	31.121 ha	23
Skimmer	D, E	980 ha	138 ha	14

Note: The jabiru stork is not a typical bird of the gallery forest, as was assumed in the ETA (TGCC, pp. 11-67); (e.g., Sick, 1984).

The potential loss of 14 to 23 percent of breeding habitat seems realistic and is unacceptably high. The impact on breeding populations, especially of colonial waterbirds, can obviously be much greater than the data presented in the EIA suggests.

The assessment of impacts on the terrestrial fauna is thus based on inadequate evaluation of the relative importance of habitats, and consequently comes to unrealistic and optimistic interpretations of the magnitude of impacts. Using a more realistic approach, it can be shown that species that are colonial breeders in gallery forests, sandbars, or beaches can expect an enormous loss of critical habitat (especially breeding sites). This does not include loss of habitat caused by the operation and maintenance of the Project.

5.3.3 ECOLOGICAL LAND CLASSIFICATION

This ELC, described earlier (see section 4.3.4), considers the fauna as one component determining the sensitivity of ecosections. This sensitivity of habitats was calculated using several criteria, of which only two apply to the terrestrial fauna: (a) species richness of the habitat, and (b) number of endangered species per habitat.

Both the species richness and number of endangered species were estimated in a three-point scale, but considering only or mainly wetland species (TGCC, pp. 7-45). Habitats that have at least 67 percent of the number of all species, or that host endangered species, are considered to have high sensitivity; those with less than 33 percent have low sensitivity. For all species, the habitats are listed in appendix 7E of the EIA.

These procedures were carried through separately for the herpetofauna, birds and mammals, and for the lists provided by the International Union for the Conservation of Nature and Natural Resources (IUCN, 1994) and the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES, 1995). The resulting values for the three animal groups were finally lumped into one habitat specific value. For each habitat, two numbers of endangered/protected species based on IUCN and CITES were obtained. The higher one was used in the ELC (TGCC, Tables 7.16 to 7.19).

It is questionable whether the list of endangered species (IUCN, 1994) can be applied to the Project. It is conspicuous that so few endangered species are found in a region so rich in wildlife. The reason for this is obviously that great parts of the region are still ecologically intact. Those species that have the center of their distribution in this area are not generally endangered *("Jandaia-de-cabeça-preta," Nandayus nenday,* and *Theristicus caeruleus),* except for species which are directly persecuted by humans (e.g., jaguar, *Panthera onca,* or hyacinth macaw, *A. hyacintinus).* A more meaningful statistic would be the number of species that actually have the bulk of their population in this region, such as endemic species or species already extinct elsewhere.

CITES (1995) is not a list of endangered species, per se, but a list of species threatened by unsustainable trade. For several families of birds, all species are included, whether they are endangered or not. It is not an alternative to the IUCN (1994) list, as the objective of the CITES list is quite different.

The data base for this procedure is the information on habitat for wetland species (TGCC, appendix 7E). There are several errors within the list. The list does not distinguish among breeding habitat, feeding, or roosting; it gives rare species the same weight as common species; and the information about habitat requirements are inaccurate. In the case of the Pantanal, some of the mistakes probably derive from the misinterpretation of the bird list of the "region of the Pantanal" in Brown (1986). This list contains many species that occur in the surrounding highlands but have never or only rarely been recorded in the Pantanal itself. Great grebe *(Podiceps major),* little blue heron *(Egretta caerulea),* agami heron *(Agami agami),* zigzag heron *(Zebrilus undulatus),* horned screamer *(Anhima comuta),* Brazilian merganser (Mergus octosetaceus), sharp-tailed streamcreeper *(Lochmias nematura)* and several others are not birds of the Pantanal, but have only been recorded as rare sightings.

On the other hand, some characteristic species are missing, namely, the black-hooded parakeet *(Nandayus nenday),* a small species that feeds on grass seeds in flooded savannahs; other members of the parrot family (Psittacidae), which live in gallery forests; and the lesser kiskadee *(Philohydor [Pitangus] lictor).*

Finally, the habitat information for many species is inaccurate. For example, all species of herons and egrets are assigned the same habitat requirements despite the considerable ecological differences among them. Terrestrial flycatchers (Family Tyrannidae) should not be listed as species of open water, especially when none of the duck species are found on this list.

Clearly, available information was not used adequately, as there is sufficient published information available to prepare a complete and accurate list of habitats. The information compiled in the EIA (TGCC, appendix 7E) is insufficient and renders the list worthless for the habitat sensitivity evaluation (diversity of fauna, endangered species). Even if the data base was adequate, the method employs too gross a classification to be a useful tool for the impact assessment.

5.4 Key Questions

The evaluation of impacts on the terrestrial fauna is finally addressed in 10 "key questions" (TGCC, chap. 11.2.5). The answers are partially based on the analyses and considerations already explained, but to a greater part only on "professional experience," which must be questioned in light of the many errors described above. The classification of impacts (magnitude, duration, area of influence, importance, reliability of data, and methods) are subjective and often questionable.

The key questions are again partially reformulated (see previous chapter).

Key Question One: Will dredging and activities related to dredging cause animal mortality? (TGCC, pp. 11-79 to 11-81)

Factors causing animal death include (a) contact with dredges, (b) contact with ship screws, (c) burial by dredged material, (d) poisoning by polluted sediments, (e) explosions used to remove rocks, and (f) destruction of nests or young animals. It is assumed that only a very limited number of animals will fall victim to these problems. It is believed they could easily move away from the danger, yet not all animals that occasionally swim across a river are agile enough to avoid contact with the dredging equipment. This question should have been investigated, as there are already experiences on the Paraná and Paraguay Rivers, where dredging has repeatedly taken place.

Dredged material partially deposited along the riverbanks is not considered an impact. Yet freshly deposited, water-logged, and unstable sediment areas can be dangerous for all kinds of terrestrial animals. Naturally deposited sediments usually are sorted and structured, which increases their stability. The death of mammals and birds on deposited sediments has been reported frequently to ruin fields. It is a realistic possibility that areas of sediment disposal might turn into death traps for larger animals. The other problems are probably not nearly so important as the dredge deposits.

Key Question Two: Will dredging lead to a loss of area and/or quality of habitat? (TGCC, pp. 11-81 to 11-85)

Habitat or habitat quality can be lost through (a) contamination by pollutants, (b) increased turbidity of the water, and (c) direct removal of habitat by dredging and disposal of material.

As the levels of pollution are assumed in the EIA to be almost undetectable, the impact can only likewise be assumed to be negligible.

Increased turbidity will probably have more impact on the trophic base for many species of terrestrial fauna, such as water birds and giant river otters, *Pteronura brasiliensis,* than on the animals themselves.

The direct physical removal of habitat by dredging was estimated using the 30-meter and two-kilometer-radius zones around the sites of dredging. It has already been shown that this approach is inappropriate, and leads to optimistic assumptions about the magnitude of impacts (see Ecological Land Classification: chap. 5.3.3).

Probably neither pollution nor turbidity will have important impacts on the terrestrial fauna, but this is more a guess than a well-founded analysis.

Key Question Three: Will dredging lead to disturbances of the habitat by sensory impacts (e.g., noise)? (TGCC, pp. 11-85 to 11-87)

Based on the estimation of habitat areas in a two-kilometer-radius around the sites of dredging, the impact is assumed in the EIA to be low or negligible.

Interpretation of the habitat data in the EIA is misleading (see 5.3.3). For several species, it can be shown that the disturbance of critical habitat (breeding sites) affects more than 10-20 percent of the available habitat, so this is doubtless a serious negative impact.

Key Question Four: Will hydrological changes reduce the extent and quality of habitats for terrestrial fauna? (TGCC, pp. 11-87 to 11-89)

The hydrological changes were estimated using models (see chapter 3). The EIA's model simulations showed rather small hydrological changes, so the EIA concluded that an assessment of the impacts on landscape features or vegetation was not warranted (see chapter 5.3.3).

Regarding the terrestrial fauna, however, the EIA emphasized that (a) reduction of the area flooded by 390 square kilometers is not negligible, (b) estimation of the area affected in the Pantanal is unreliable, and (c) different habitats will be affected differently.

Overall, the potential impact of hydrological changes on habitat extent and quality was classified by the EIA as *"entre bajo y alto"* – between low and high.

Although the EIA frequently refers to impacts on fauna as being indirect, such impacts are not indirect just because the possible impacts could happen more than 10 kilometers distant from the river. Direct and indirect relate to position in causal chains, not to geographical distances. Neither should impacts be regarded as regional just because the impact of hydrological changes was simulated only for the Pantanal. In fact, most of the Project below the Pantanal is bordered by floodplains that might be similarly affected. These areas were almost completely disregarded in the EIA.

Key Question Five: Will land use changes caused by the Hydrovia reduce the extent and quality of habitats for the terrestrial fauna? (TGCC, pp. 11-89 to 11-90)

The EIA did not expect any land use changes due to the Project, so these non-impacts cannot have consequences for terrestrial fauna. The impacts are nevertheless classified as *"bajo a despreciables"* – *low* to negligible (TGCC, pp. 11-90). For a non-existent impact, this is a relatively high classification.

It is certainly difficult to question predictions about land use changes related to the Project, as economic forecasts of time spans over 20 years are always speculative. It would nevertheless be useful to regard the ongoing expansion of agriculture into formerly pristine areas of the region as a cumulative impact, as was done in the assessment of impacts on landscape features. They certainly will have indirect impacts on the terrestrial fauna of the Project region, due to direct loss of habitat, pollution, erosion, sedimentation, and so on.

Key Question Six: Will increased traffic on the Hydrovia Project kill animals? (TGCC, pp. 11-90 to 11-92)

The EIA structured the answer to this key question by considering that increased traffic could kill animals in three ways: collisions with the ships, accidental pollution, and increased poaching.

Regarding collisions, it must be questioned whether caimans, anacondas, turtles, or other large water animals are really able to avoid collisions, as stated in the EIA. This assumption looks unrealistic, as it is not founded on any study or experience.

Instead of classifying the impact of accidental pollution as high or low it would have been more appropriate to make a concrete risk assessment. The probability of an accident with massive oil spill or pollution with pesticides might be extremely small and still unacceptable due to the magnitude of its potential impacts. Certainly, a more realistic analysis of statistics of accidents from other waterways, combined with an analysis of dangerous cargo transported on the Paraguay and Paraná Rivers, could have given a more realistic impression.

Poaching and other forms of unsustainable exploitation of natural resources might increase as a result of the Project, but realistic predictions are impossible. Control of illegal hunting and smuggling of endangered species has proved difficult in the past, and the Project will not improve this situation.

Key Question Seven: Will increased traffic on the Hydrovia Project change the quantity or quality of habitats of the terrestrial fauna? (TGCC, pp. 11-92 to 11-93)

The habitat could be affected by erosion due to wave action or by reduced food availability due to deterioration of the aquatic environment.

Key Question Eight: Will increased traffic lead to disturbances of the habitat by sensory impacts (e.g., noise)? (TGCC, pp. 11-93 to 11-94)

This problem is almost identical to the one analyzed under key question three, but affecting the total course of the Project. In the Pantanal, where the river channel is rather narrow and the greatest increase in traffic is expected, the impact is classified as indirect, of long duration, and of great magnitude. This evaluation seems realistic, except for the classification as indirect: Noise from increased traffic is a direct impact of the Project on the environment.

Key Question Nine: Will maintenance dredging have impacts on the terrestrial fauna? (TGCC, pp. 11-95)

The EIA concludes that impacts will be similar to those during the initial dredging, except that additional impacts on hydrology are not expected, and recovery of disturbed areas might be delayed. The impacts are classified as direct, of long duration, and of low magnitude, as the areas affected are already disturbed.

It is easier to determine the interventions necessary for the initial dredging than those for later maintenance dredgings, as the reaction of the river to the changed morphological and hydrological situation is not reliably predictable. The experience with European rivers has shown that channelization can trigger riverbed degradation, making additional and sometimes increasing interventions necessary. The Danube and Rhine Rivers are excellent examples of this. It may be too optimistic to assume that maintenance dredging does not have a cumulative impact on the hydrology.

Certainly, disposal of dredged material is a cumulative impact, unless it is assumed that the dredged material disappears without impact on the river. The impacts of maintenance dredging are generally more difficult to predict than those of the initial dredging.

Key Question Ten: Will the cumulative impacts of construction and operation of the Hydrovia Project cause a change in the biodiversity of the terrestrial fauna? (TGCC, pp. 11-95 to 11-97)

Biodiversity is analyzed in the EIA based on the relative species richness of the ecosections. Using the 30-meter-radius zones and two-kilometer-radius zones to establish the relative area of every habitat affected, it was estimated whether the habitats affected have higher or lower diversity and potential for endangered or protected species.

The classification of impacts is vague and speculative. With the information available (or used) in the EIA, biodiversity can only be established at the highest level of generalization, the landscape level. Analysis of the landscape changes has already been addressed.

The calculated diversity of the terrestrial fauna in the habitats, as well as the assumed number of endangered or protected species per habitat, is based on inaccurate information (see section 5.3.2). As already stated, the use of 30-meter or two-kilometer-radius zones for the estimation of the magnitude of impacts has many weaknesses. The combination of an inaccurate data base with an inadequate method will certainly not produce reliable results. This key question, perhaps the most vital, cannot be addressed seriously with the available data and tools.

5.5 Monitoring

Appendix 1 1D of the EIA explains the IAH model for the Project, with special regard for future monitoring of the impacts. A detailed analysis of the complicated model is unwarranted, as the monitoring actions proposed are extremely simple. Of the 18 indicator species, only three were chosen for monitoring: great egret *(Casmerodius albus),* howler monkey *(Alouattafusca),* and caiman spp.

This is certainly not a serious or adequate program for monitoring large-scale impacts from a project as enormous as the Hydrovia Project. Neither the number of species nor the species selected are sufficient to obtain information about changes in the environment. The great egret is a cosmopolitan species with high ecological flexibility, occurring even in city parks with artificial ponds. It has no specific value as an indicator species, and certainly cannot be considered as representative for the total of several hundreds of bird species in the region.

The minimum habitat area of a species *("hábitat contiguo que una especies requiere para sobrevivir y reproducirse")* was estimated for the great egret to be 0.4 hectares. (TGCC, appendix 11D, p. 9). This statement is unrealistic for such a large and mobile water bird.

The model for the monitoring is based on an extremely complicated and totally unrealistic theoretical approach. Yet, the three species to be monitored seem to have been selected for their ease of monitoring only, not because they are representative or indicative of impacts.

CHAPTER 6 IMPACTS OF THE HYDROVIA PROJECT ON AQUATIC INVERTEBRATE FAUNA

by Jean-Gabriel Wasson (with contributions by Petr Obrdlik)

The following sections provide a brief description of the impacts of the Hydrovia Project on the aquatic invertebrate fauna. Relevant chapter and page references to the EIA report are provided in the appendix.

Photo 14. Water Hyacinth *(Eichhornia crassipes)* going down the Paraguay River, near Concepción, Paraguay.
Photo: André Leite/WWF Canada

6.1 Conclusions

The EIA contains an incomplete and inadequate diagnosis of the aquatic invertebrate fauna of the region of the Project; therefore, potential impacts of the Project are not assessed at all in the EIA. This is a serious shortcoming of the EIA, as the aquatic invertebrate fauna is, due to its ecological position and direct exposure to the impacts of the Project, a critically affected resource.

The diagnosis is incomplete in the following aspects:

a) Zooplankton, a key group due to its critical position in the aquatic foodwebs, was omitted.

b) Only the main river channel was considered, though the region of potential impacts on the biotic environment also includes the floodplains.

c) The published information considered in the EIA is poorly used.

d) Habitat of the aquatic fauna is insufficiently described, as regards the river morphology and physical characteristics.

e) No description of the ecological relationships of the aquatic fauna of the region is given.

f) There is very little information on the Upper Paraguay River.

The field studies are inadequate, as can be seen from the following facts:

a) The number of sample sites and the number of samples taken at each site are insufficient and do not include floodplain habitats.

b) The habitat conditions at the sampling sites are not described adequately.

c) The sampling protocol is poorly documented, if at all.

d) Sampling was not repeated at different water stages.

e) Data on control factors of the aquatic fauna were insufficiently collected.

f) The number of species found in the field studies are only a small fraction of the species known to occur in the river.

The impact assessment itself (e.g., the analysis of the potential impacts of the Project on the aquatic invertebrate fauna) is completely missing in the EIA. Though in the evaluation of impacts the aquatic fauna is addressed, this is misleading as it refers only to fish. Given the great ecological importance of aquatic invertebrates, their complete absence in the assessment of impacts is a serious flaw of the EIA.

It must be expected that aquatic invertebrate fauna will be seriously affected by the Project, through:

a) removal, disposal and transport of sediments due to dredging;

b) the increased turbidity due to dredging and increased navigation;

c) the expected hydrological changes caused by the implementation of the Project;

d) the increased risk of accidental release of pollutants;

e) the greater possibility of introduction of exotic species;

f) the disruption of the faunal interchange between river and floodplain, caused by hydrological changes and/or disposal of dredged sediments on riverbanks or in lateral branches.

The impacts will be higher in the Upper Paraguay River, where they could be of great magnitude and duration. Due to the greatly increased navigation, even the collapse of the existing aquatic invertebrate community cannot be dismissed.

6.2 Recommendations

a) No decisions on the Project should be taken before the potential impacts of the project on the aquatic invertebrate fauna are thoroughly analyzed.

b) No irreversible interventions in the riverbed, such as removal of geomorphological control points, may take place before their potential consequences for the ecosystems of the rivers are known.

c) The plans for the Corumbá-Cáceres reach should be abandoned, as the existing information is sufficient to expect a very serious disturbance of this critical habitat of outstanding importance, principally due to the expected increase in shipping traffic.

6.3 Introduction

This part of the independent review deals principally with the aquatic invertebrate fauna associated with riverbed sediments and floating vegetation, which will be referred to as “benthic invertebrates” and “periphyton,” respectively, to simplify the text.

These components of the aquatic ecosystem have been poorly investigated in the diagnostic section and are completely omitted in the section on impact evaluation. This leads to the fundamental question: Can the impacts of the implementation of the Hydrovia Paraguay-Paraná Project be adequately assessed without considering the aquatic fauna?

The answer to this is not as simple as it seems, as shown by two preliminary observations:

a) Benthic fauna is poorly represented in the mobile sandy sediments that occupy large parts of the riverbed in the Paraguay-Paraná system.

b) Prof. J.J. Neiff, coordinator of the “Area Biotica” in the EIA, together with Dr. Alicia Poi de Neiff, member of the EIA team, have investigated the benthic and periphytic fauna of the Paraná (mainly in the lower section of the system) and are probably the best specialists of this topic for this region.

The executive summary (TGCC, *“Resumen Ejecutivo,”* and Table 3.1) concludes that changes in the aquatic fauna due to dredging and navigation (direct mortality and habitat modifications) are expected to be low in magnitude (negative effect) and local in extent (short to medium in duration), with a medium to high confidence in data and results for the whole extent of the Project. This is based exclusively on the impact assessment on fish (see chap.10 of the EIA), as the following statement from EIA clearly shows: “The individuals [of aquatic fauna] can easily move out of the influence of the plume [of turbidity caused by dredging]” (pp. 38-39). This might be true for most fish, but certainly not for benthos and periphyton.

The following critical review of the assessment of impacts of the Project on the aquatic fauna is divided into four main sections. Section 6.4 is an analysis of whether the existing information on the aquatic fauna is sufficient for the assessment of the Project, whether it was used adequately in the EIA, and whether it was adequately supplemented by field studies. Section 6.5 reviews the consideration given to the ecological importance of aquatic fauna in the ecosystems potentially affected by the Project. Section 6.6 analyzes whether the sources of impacts are comprehensively identified and assessed. Section 6.7 reviews the proposed measures of mitigation.

6.4 Adequacy and Reliability of the Database

6.4.1 USE OF PUBLISHED INFORMATION IN THE EIA

Generally, the invertebrate fauna of large South American rivers has been poorly investigated. Concerning the Project region, the existing knowledge seems to be inversely related to the distance to the main centers of limnological investigation, located in Buenos Aires and in the southern part of the Paraná River system.

Concerning the periphytic fauna, Dr. A. Poi de Neiff (member of the EIA team) has participated in almost all studies referred to in the bibliography. We can assume that this review is exhaustive. Most studies deal with benthic fauna associated with macrophytes colonizing lagunas in the Paraná River floodplain in Argentina. No work is registered for the Paraguay River upstream of Asunción (probably even upstream of Corrientes).

The benthic fauna was investigated by several authors (among them, mainly Bonnetto, Ezcurra de Drago, and Marchese), but there are few published papers. These papers deal with the main channel of the upper and lower Paraná River, and again the Paraguay River seems almost unknown.

The lack of studies from the Upper Paraguay River seems surprising; however, some additional publications concerning the aquatic fauna (plankton, benthos, periphyton) of the Pantanal are cited by Por (1995). It thus remains questionable whether such existing publications have been adequately considered in the EIA.

Zooplankton is not mentioned in the EIA, even though it is an important link in the food chain of alluvial rivers. Though the majority of fishes in the Paraguay-Paraná River system are detritivorous, zooplankton is the main source of food for fry and young stages of many fish species. This omission seems even more peculiar considering the studies of Paggi and Paggi (1990) from the Middle Paraná River.

Assessment considers the mainstem of the rivers, excluding water bodies in the extensive floodplain, which could be affected by the Project in several ways:

a) changes in the hydrology of the rivers, and possible changes in groundwater levels;

b) interruption of the exchange of fauna between floodplain and river, due to dredging and disposal of dredged material;

c) changed patterns of erosion and sedimentation.

6.4.2 ADEQUACY OF EXISTING INFORMATION FOR THE IMPACT ASSESSMENT

As stated above, information concerning the aquatic fauna of the Paraguay River is almost absent.

For the Paraná River, the published information dealing with aquatic fauna seems of good value, as most of the cited papers give ecological information about factors that control the invertebrate community structure. The trophic role of periphytic invertebrates in recycling the macrophytic biomass is duly emphasized. However, this information is only addressed in a qualitative way, and neither quantitative relationships between the fauna and its control factors nor simplified models such as the FHAU utilized for the fishes are presented. Such simplified habitat models exist also for invertebrates, at the level of the global community or for functional feeding groups. The very simple structure of the benthic community in the main channel would probably allow derivation of quantitative relationships, e.g., between invertebrate densities and current velocities or substrate composition.

Thus, for the Paraná River, the existing information is probably good but poorly used in the EIA.

Another very important problem involves describing the aquatic environment in a way that permits an interpretation in terms of habitat suitability for the aquatic fauna. The existing data about this are poor, and the information presented in the EIA is inadequate.

The benthic fauna is expected to react to its physical habitat (current velocity, depth, substrate composition, stability), hydro-chemical characteristics (temperature, oxygen, pH, suspended sediment, ionic composition), and trophic resources (benthic and periphytic micro-algae, living macrophytes, organic detritus coming from the decomposition of macrophytes or from riparian vegetation). Although some of these parameters may vary at a local scale, they can be described in a synthetic or statistical manner at the scale of a whole river section, to define the conditions of life for aquatic organisms. This can be achieved by a preliminary description of river morphology, beginning with a division of the river into sectors (sectorization) on the basis of macroscale control factors, followed by a quantification of aquatic habitat characteristics in one or two representative reaches for each section.

However, in the EIA, the description of the river morphology and riverine habitat is poor, contrasting with the comprehensive description of the floodplain. Thus, the sectorization of the major rivers reflects more the engineering problems than the ecosystem structure. No relationship is presented between the description of ecoregions and ecodistricts, nor between the morphological and physico-chemical characteristics of the rivers.

This relationship does exist, and the ecodistricts seem to be the proper level of precision for sectorizing the mainstem. There is a relatively good correspondence between the limits of ecodistricts, and the morphological and physico-chemical characteristics of the mainstem, as described in various parts of the report. This correspondence has been overlooked in the EIA; it seems that the specialists of the floodplain and those of the aquatic fauna have worked in completely separate ways, as if on different systems.

More problematic is the absence of a comprehensive description of the morphological characteristics of the rivers. The little information provided in chapter 3.2.3 of the EIA is hardly usable: There is no sectorization on a geomorphological basis, the parameters are poorly and incompletely quantified, and the absence of a map and synthetic table makes the use of the data particularly difficult. Due to the fact that most of the planned interventions for the Project concern the main channel, a description of the river morphology was expected at the same level of precision as the floodplain description.

The physical aquatic habitat is only described in general terms, and the information about parameters that should permit an interpretation of aquatic fauna structure are dispersed in the text and barely quantified. For example, it is impossible to get from the EIA even a rough idea of the percentage of sediment that can be considered as mobile (shifting sand) on a cross-section of the river, despite the fact that this is recognized as the most important factor in determining benthic invertebrate densities in this type of river.

Existing information about physico-chemical characteristics seems to be properly addressed, but here again a synthetic table is lacking. The role of the Pantanal as a sediment trap is shown, as well as the downstream influence of the Bermejo River as the major source of suspended sediment. However, in the section *"diagnostico ambiental,"* a major problem concerning the origin of suspended sediments entering the Pantanal has been overlooked.

Suspended sediment and turbidity are two of the major factors ruling aquatic ecosystem functioning. But while high sediment input from rivers coming from the arid Andean basins, such as the Bermejo River and less so the Pilcomayo River, is a natural phenomenon, the sediment input in the Pantanal was recently increased by human activities, mainly intensive agriculture (soya, sugar cane) and mining (gold, diamonds) in the Upper Paraguay River basin (Junk & da Silva, 1995). In its natural state, the Upper Paraguay River would be a clearwater river with a much lower sediment load than the whitewater rivers coming from Andean basins (Junk & da Silva, 1995; see TGCC, Table 13.3.6.lb). For comparison, the Itenez River flowing northward in Bolivia, through the same ecoregions, is a clearwater river, especially during low flow *(sensu* Dinerstein et al. , 1995). That means that the aquatic fauna of the Upper Paraguay River and its tributaries is under anthropic stress, and the Pantanal actually functions as a buffer reducing this stress, especially during a high water stage. This is shown clearly through Secchi disk measurements (TGCC, Fig. 3.6.6). This essential buffer function of the Pantanal has not been adequately addressed in the EIA. The optimistic statement from EIA that the aquatic fauna of the rivers is very well adapted to high turbidity is therefore unfounded (pp. 13-16, repeated pp. 13-27).

As a consequence, the main channels of the major rivers cannot be considered as homogeneous in terms of aquatic habitat (physical and physico-chemical). Under natural conditions, there would be a clear difference between the river upstream and downstream of the Bermejo River. Upstream, the Paraguay River would be a clearwater river, presently affected by sediment input from agricultural land use, and partially restored by the Pantanal sediment trap. Downstream, the Bermejo River is a whitewater river with high turbidity and sediment transport. Thus, the possible impact of sediment due to implementation of the Project cannot be evaluated the same way for these two sections.

We can conclude from these observations that, upstream of the Bermejo River, existing data/information dealing with aquatic fauna and its control factors is *not* adequate to make sufficiently safe predictions about potential impacts of the implementation of the Project on the aquatic fauna.

6.4.3 FIELD STUDIES

Ideally, the purpose of field studies in an EIA would be to fill gaps in the information needed for the assessment process and to verify existing data. It is not clear what the purpose was of the field studies on aquatic invertebrates in the EIA, for they do not contribute any additional information that could help to evaluate the impacts of the Project.

Periphyton and benthos were studied in the field (TGCC, chap. 4, 4.3.2.2.3, pp. 4-1310. Here, the faunistic data and the control factors will be addressed separately.

Sampling Design

All samples are from the main river, none from the floodplain. Benthos were sampled at 20 sites in July 1995, 10 each in the Paraguay and Paraná Rivers. Periphyton was sampled at 10 sites, seven in the Paraguay River and three close to the confluence of the Paraguay and Paraná Rivers (TGCC, Table 4.3.35, appendix 4B). Apparently, 18 different plants of three species were investigated: *Eichhornia crassipes* (seven plants), *E.azurea* (nine plants), *Salvinia herzogii* (two plants). However, there is a contradiction between Table 4.3.34 and appendix 4B of the EIA: Was *Eichhornia crassipes* or *Salvinia herzogii* sampled in the Paraguay River?

In relation to the ecodistricts (TGCC, chap. 7.6, Fig. 7.10), the sample sites are distributed as follows:

a) Delta and pre-delta	(two [2] sample sites for benthos / none [0] for periphyton)
b) Lower Paraná River:	
• Santa Fe-Goya	(3 / 0)
• Goya-Corrientes	(5 / 1)
a) Lower Paraguay River:	
• Corrientes-Bermejo	(0 / 2)
• Bermejo-Pilcomayo	(3 / 0)
• Pilcomayo-Apa	(1 / 2)
a) Pantanal:	
• Nabileque	(1 / 1)
• Paraguay	(4 / 4)
• Cuiabá (Descalvados-Cáceres)	(1 / 0)

A proper description of the fluvial morphology of these ecodistricts would perhaps allow a simplification of this scheme. For invertebrate fauna, an adequate sampling scheme would consider two stations in each ecodistrict.

Unfortunately, it is very difficult to locate the sampling sites because neither the coordinates, nor the kilometer markers, nor the site names are indicated on any map. Moreover, sampling sites are not the same for benthic and periphytic fauna.

Another problem lies in the number of samples and location of the benthic fauna sampling points, situated sometimes at the margin, sometimes in the center of the channel, and still other times in unknown locations because precise locations are not revealed. Three samples were taken in each sampling site (TGCC, chap. 4.3.2.3). Such a low number of samples per site is likely to describe the fauna only if the physical habitat conditions are homogeneous. However, in such large rivers there is obviously a transverse gradient of habitat conditions, even considering only depth and velocities. Thus, the only sampling scheme adequate to describe the heterogeneity of habitat conditions would have required sampling along a transect of the river; a minimum of 10 samples per transect, preferably replicated. Such a sample design would have required collecting about 200 benthic samples for one hydrological stage (10 ecodistricts × two stations × 10 samples), about three times the sampling effort of the EIA.

The hydrological stage is another factor controlling the abundance and structure of aquatic invertebrates in most tropical rivers. Apparently, the sampling was conducted in one period (June to September 1995; TGCC, Table 4.3.34), corresponding to a high-flow stage for the Paraguay River, and low-flow stage for the Paraná River (TGCC, chap. 4.3.7.1). This fact alone makes a comparison of the fauna of the two rivers difficult. A minimum of two sampling campaigns, separated by a six-month interval, seems necessary to adequately sample the aquatic fauna during both high and low flow in the two rivers. This would correspond to a sampling effort about six times higher than recorded in the EIA. Considering that the fauna of the Paraná River is better known, this sampling scheme could perhaps be less intensive in the lower course of the river, but the minimum sampling effort necessary to get an adequate knowledge of the aquatic fauna would be four to five times higher than what was made in the EIA.

Faunistic Results

The processing of the samples and the identification of the aquatic fauna are adequate, except for the surprising lack of identification of caddisflies (Family Trichoptera) in the benthic samples (TGCC, Table 4.3.36).

However, the presentation of the data is rather succinct: tables indicating the presence or absence of taxa in the Paraguay and Paraná Rivers (TGCC, Tables 4.3.34 and 4.3.36), a global indication of benthos densities for each station (TGCC, Table 4.3.35), and the percentage of the most abundant groups of benthic and periphytic samples (TGCC, appendix 4B). Moreover, the natural dominance of oligochetes in such environments hides the representation of others groups, and it is notable that the group "Others" frequently represents an important proportion of the fauna in the periphytic samples. Such a dispersed presentation is inadequate to give a good impression of the faunistic differences between stations.

The number of benthic taxa found is very small: of the more than 200 species in La Plata basin (TGCC, pp. 4-144), only 27 taxa were sampled, of which only 13 could be determined specifically (TGCC, Table 4.3.36). Some 74 taxa of periphyton were found (no comparative numbers available).

Control Factors

As stated above, the control factors of aquatic fauna refer to physical habitat, physico-chemical parameters, and trophic resources.

Concerning the physical habitat, although the compiled information was poor, and there was evidence that implementation of the Project may significantly alter those parameters, no supplementary data concerning hydraulics (depth and velocity transects) were collected in the course of the EIA. The sediment granulometry is properly quantified (TGCC, chap. 3.6.4.3; and Table 3.6.5), but the potential mobility of the fine sediments remains unknown.

Data on trophic resources are much more difficult to collect. The macrophyte production is addressed in chap. 4.1 .b.6 of the EIA; some values are indicated for the Lower Paraná River but no estimation is made for the Paraguay River. The phytoplankton was quantified by way of chlorophyll values, together with physico-chemical parameters, and will be discussed later. The organic matter content of the sediments, an important parameter that is simple to estimate, was not investigated.

A proper sampling scheme would have included measurements of both hydraulics such as depth and velocities and sediment characteristics such as granulometry and organic matter content at the sampling points along the transects. These measurements are relatively simple and represent little additional effort compared to faunistic analysis.

Physico-chemical characteristics were measured along the mainstem during two campaigns, in June/July 1995 and December/January 1996. The sampling scheme seems reasonable except between Corumbá and Apa River, where no samples were collected. Standard methods of analysis were used. The results are somewhat difficult to read because, once more, there is no clear correspondence between the map of sampling points (TGCC, Fig. 3.6.1) and the kilometric scale used to present the data (Figs. 3.6.2 to 3.6.12). More problematic is the statistical analysis of the results (Table 3.6.1), because here also the sections (whose limits are not shown on the map) are arbitrarily defined and do not refer to the natural structure of the river system. As an example, Section 2, apparently extending from the lower Pantanal to the Paraguay-Paraná confluence, is very heterogeneous, as it includes the confluences of the Andean Rivers: Pilcomayo and Bermejo. Computing statistics under such conditions is somewhat nonsensical.

Thus, the studies conducted in the course of the EIA are not sufficient to fill the gaps in the database, due to an insufficient sampling effort of aquatic fauna, especially in the Paraguay River (inadequate sampling scheme), and the lack of data on physical habitat (hydraulic conditions).

6.5 Ecological Importance of Aquatic Fauna

6.5.1 IMPORTANCE OF AQUATIC FAUNA IN THE PARANÁ AND PARAGUAY RIVERS

In the section "diagnostico de situación actual" of the "resumen ejecutivo," only fish are considered in the aquatic fauna (TGCC, p. 9). Omission of the invertebrate fauna could indicate either that the authors of the EIA consider it to be negligible in the ecosystem functioning, or that the invertebrate database was inadequate to derive valuable conclusions. In both cases, this omission constitutes a serious shortcoming of the EIA.

This is surprising, as the corresponding sections of the EIA provide valuable information about the key role of invertebrates in recycling decaying macrophytes (TGCC, chaps. 4.3.2.1 and 4.3.2.2). The nursery role of aquatic vegetation is well known, and it can be expected that periphytic invertebrates provide food to the young stages of various fish species and to aquatic birds.

The ecological role of benthic fauna is less well documented, probably due to the lack of information. However, two important phenomena seem to have been overlooked. First, the benthic fauna, although little diversified, is not as scarce as postulated in the EIA (e.g., TGCC, pp. 4-186); results of the Table 4.3.35 of the EIA indicate densities of over 2,000 per square meter for the Paraná River. Moreover, all studies cited indicate a high transversal heterogeneity in the faunistic density, depending on sediment stability and characteristics. Thus, there are probably many places in the river where the benthic fauna is quite abundant. A description of the physical habitat that could make a possible rough estimation of habitat suitability for benthic invertebrates is missing. Second, dominant invertebrates in the benthic community, mainly oligochetes and chironomids, are polyvoltin species with high reproductive rates, and thus potentially high productive capacity. Their contribution to the diet of numerous benthic fish species feeding on sediment cannot be inferred as negligible.

Conceptually, in the absence of quantitative data, there is no definitive reason to believe that aquatic invertebrates are negligible in the Paraguay-Paraná ecosystem functioning. Thus, the ecological importance of the aquatic fauna has not been adequately considered in the diagnosis of the EIA.

6.5.2 IMPORTANCE OF CONTROL FACTORS FOR AQUATIC FAUNA

As indicated in section 6.4, some valuable data exist for the control factors, except for hydraulic conditions. We will now examine if these data have been adequately considered for the interpretation of the distribution of the aquatic fauna.

As emphasized, the lack of hydraulic data precludes the interpretation of benthic fauna abundance and structure in relation to substrate stability. As substrate granulometry can be roughly considered homogeneous along the channels of the major rivers, it would have been relatively simple to determine a potential instability due to hydraulic conditions. An accompanying evaluation of organic matter contents of the sediments would have allowed an adequate interpretation of benthic invertebrate abundance in relation to these two essential factors.

Another important parameter, contents of suspended sediment and the related water turbidity, was not used in the interpretation of the distribution of aquatic fauna. The real question to be addressed here was: "Is there a significant difference in faunistic composition and abundance between clear and turbid water?" This is valid for the periphytic as well as for the benthic fauna. For instance, the benthic fauna sampled in the Pantanal is more heterogeneous than in the rest of the Paraguay River: An important group of insects (Trichoptera, not identified) represents 80 percent and 16 percent, respectively, at the sampling points kilometer-2,049 and kilometer-1,688 (TGCC, appendix 4B, Figs. 20 and 22). Can these differences be attributed to the lower turbidity? These observations are simply mentioned in the EIA without any interpretation.

Generally, the interpretation of the faunistic results (TGCC, chap. 4.3.7) is purely descriptive and factual, and does not produce any quantified ecological relation between the observed fauna and its potential control factors. Thus, even when data exist, the control factors of the aquatic fauna are not adequately considered in the diagnosis.

6.6 Assessment of the Impacts of the Hydrovia Project

As already stated in the evaluation of the impacts on the "aquatic fauna", only fishes were considered, while invertebrate fauna is completely missing. It cannot be assumed that the impacts on the fish fauna and the invertebrates are identical.

The following analysis of control factors is focused on the main sources of impacts. Others, such as the expected hydrological changes, accidental release of pollutants, or introduction of exotic species due to increasing traffic on the waterway, will not be discussed in detail here.

It must be emphasized that due to the important gaps in the data base and the lack of quantitative relationships between aquatic fauna and environmental parameters in the EIA, the analysis presented below is derived both from data presented in the EIA and personal experience on European and Bolivian rivers (Wasson, Larinier, & Allardi, 1982; Wasson, Mann, et al., in press).

The question of potential negative impacts due to implementation of the Project on the aquatic fauna cannot be answered uniformly for the whole region, due to the differences in ecosystem characteristics and planned interventions.

In the EIA, the potential impacts are distinguished only between Module A, from Nueva Palmira to Corumbá, and Module B1, from Corumbá to C áceres. However, Module A cannot be considered as uniform in terms of ecosystem structure due to the major changes in water turbidity and sediment transport caused by the input of the Andean rivers Pilcomayo and "principally" Bermejo. This is fundamental in anticipating negative impacts, as the main sources of potential perturbation are (1) removal and transport of sediments due to dredging and (2) increase in water turbidity due to dredging and navigation.

Module A (Santa Fe to Corumbá/Tamengo Channel

For Module A, different impacts are anticipated for the three river sections:

a) Delta-Bermejo, extending from the delta to the Bermejo River confluence;

b) Bermejo-Pilcomayo, between the confluences of these two rivers;

c) Pilcomayo-Corumbá, upstream the confluence of the Pilcomayo River.

The practicality of this sectorization is shown by the measurements of transparency (Secchi disk, TGCC, Fig. 3.6.6) and by the small amount of data on river morphology; channel stability was not investigated in the EIA.

In the lower section, Delta-Bermejo, transparency is generally low all year round, and the channel, braided to anastomosed, is generally unstable. However, in the upper section of this reach, extending approximately until kilometer-800, there is a high transversal heterogeneity of these parameters due to the slow mixing of the waters coming from the Paraguay River (turbid, right side) and the Paraná River (clearer, left side). Potential impacts on aquatic fauna in this reach can be anticipated to be of low magnitude and restricted to the winter period, probably not significant in the lower section or right side of the upper section, but potentially significant in the left side of the upper section.

In the upper reach, Pilcomayo-Corumbá, transparency is much higher (greater than one meter) during winter high stage, but the higher turbidity in low flow is probably a human impact. The river morphology is characterized by a single channel, with medium (1.5) and relatively constant sinuosity. Such morphological features are generally considered as indicative of good stability of the riverbed.

Potential impact on aquatic fauna in this reach is expected to be significant, but its magnitude and duration will depend on the intensity and duration of dredging operations. The magnitude of impact may be expected to be low to medium.

In the middle reach, Bermejo-Pilcomayo, environmental characteristics (turbidity and channel stability) are also intermediate between those of the upper and lower reaches. Thus, the potential impact on aquatic fauna is also expected to be intermediate, but probably significant.

Concerning the sources of negative impact, three facts must be emphasized.

First, in the EIA, no significant increase of the number of convoys resulting from to implementation of the Project is expected in the Module A. However, the size of convoys is not considered. A greater convoy size could lead to an increase of the turbidity caused by each convoy. Thus, an increase in the impact of navigation in Module A cannot be dismissed, especially in the upper reach Pilcomayo-Corumbá, contrary to what was assumed in the EIA.

Second, the impact of dredging operations is considered in the EIA as a short-duration impact, occurring during the implementation phase of the Project. This assumption disregards maintenance dredging. In reality, a continuous impact, although of lesser intensity, is much more likely.

Third, in the EIA, the physical impact of dredging is assumed to be "not cumulative," due to the sandy nature of the bed sediment. However, it is obvious (although granulometric curves are missing) that these sediments also contain finer particles, which are responsible for the turbidity "plume." The problem lies in the fact that the finest particles settle very slowly, or not at all when current velocity is sufficient. For instance, in the Beni and Mamoré Rivers in Bolivia, there is no significant reduction in the diameter of transported particles (from seven to 13 micrometers) over an 800-kilometer reach in the Llanos, despite a gradient as low as that of the Paraguay-Paraná system (Guyot et al. , in press). Thus, the non-cumulative effect of increasing turbidity due to dredging operation is not guaranteed.

Module B1 Preliminary Short-term Engineering work between Corumbá-Cáceres (also referred as scenario B2) and Preliminary Long-Term Engineering work between Nueva Palmira-Corumbá/Tamengo Channel-Cáceres

In the Corumbá-Cáceres reach, river characteristics are very different from those of the Nueva Palmira-Corumbá reach. The river channel is narrower and shallower, requiring much more intensive interventions for the Project, even for convoys of reduced size and draft.

Water transparency gradually decreases upstream from Corumbá to Cáceres, due to the inputs from various tributaries draining agricultural areas. These sediment inputs could lead to localized channel instability. As in the Nueva Palmira-Corumbá reach, potential negative impacts will come from dredging operations and navigation.

The high spatial frequency and the relative importance (as compared to the river width) of projected dredging areas will lead to a much higher negative impact on sediment stability and water turbidity, as compared to the Nueva Palmira-Corumbá reach. The shallowness of the channel and continuous sediment inputs will also induce the necessity of regular maintenance dredging.

Even more important would be the impact of navigation. The frequency of convoys expected in 2020 could be more than one per hour (scenario without Ferronorte). With such a frequency, and taking into account that the turbidity caused by each convoy will be important due to the high ratio draft/channel depth, there is a very high probability that the river will remain permanently turbid. This will also cause sedimentation of fine material in the shallower places of the river margins, reducing the possibility of development of submerged macrophytes and algae.

Regarding the experience of European rivers supporting navigation with a traffic intensity similar to what is anticipated in the EIA, one has to expect, with a high level of probability, a very significant impact on the invertebrate fauna as a whole. This negative impact will be of high magnitude, permanent, and is likely to be generalized to the entire reach. In the worst case, depending on the intensity of maintenance dredging and the frequency and characteristics of the convoys, the eventuality of a general collapse of the pristine aquatic community cannot be dismissed.

As stated in the EIA, there is no probability of any positive impact on aquatic fauna.

6.7 Measures of Mitigation

Some measures of mitigation for dredging and navigation impacts are described in the EIA. Their reliability is rather an engineering problem. However, these measures are hardly credible in the Project context, such as the efficiency of permanent control of turbidity caused by every dredging operation. Only two "physical" measures of mitigation could present some efficiency:

a) Limitation of the number of dredges operated simultaneously during the Project implementation and maintenance, after a proper evaluation under field conditions of the impact of the turbidity caused by each dredging plant to limit the total length of the reaches affected;

b) Limitation of the draft of the convoys in relation to the shallowest reaches of the Hydrovia Project, to effectively limit the turbidity caused by navigation.

CHAPTER 7 IMPACTS OF THE HYDROVIA PROJECT ON WATER AND SEDIMENT QUALITY

by Petr Obrdlik and Peter Petermann

The following sections provide, a brief description of the impacts of the Hydrovia Project on water and sediment quality. Relevant chapter and page references to the EIA report are provided in the appendix.

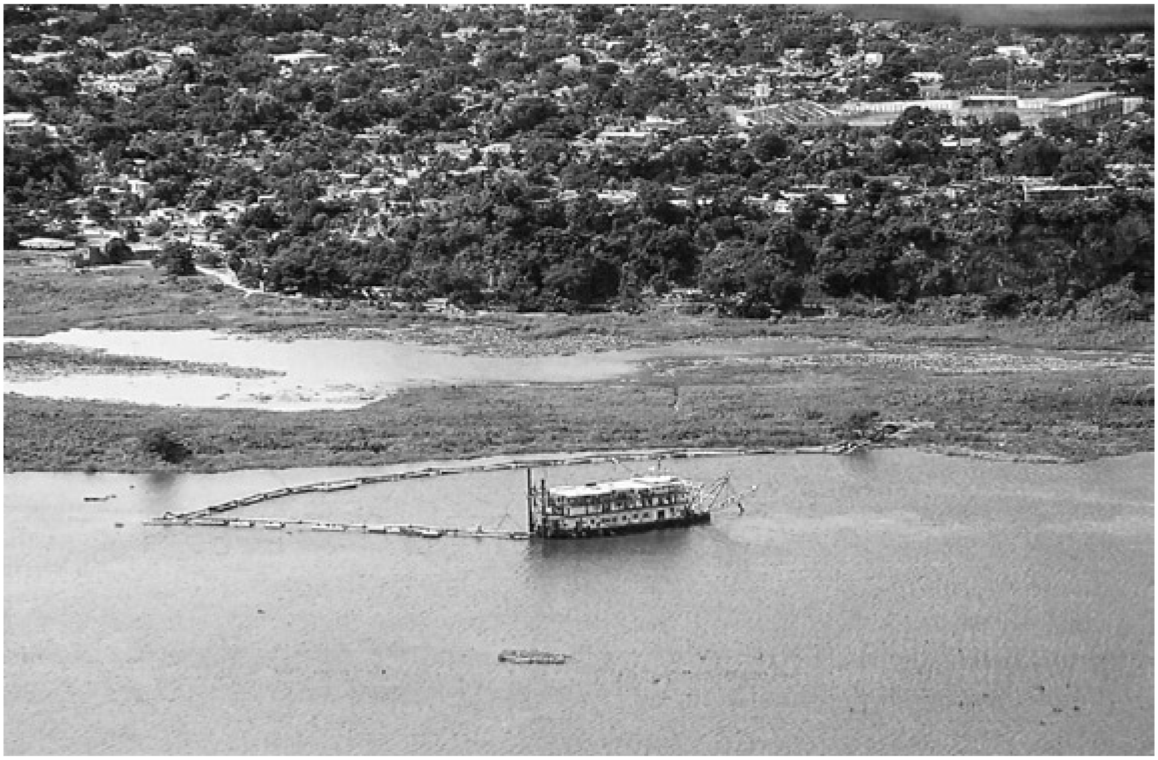


Photo 15. Dredge operating in the Tamengo Channel close to the water intake of Corumbá, Brazil.
Photo: André Leite/WWF Canada

7.1 Conclusions

The assessment of the impact of the Project on water and sediment quality in the EIA is based on a comprehensive review of published information and an extensive field study, adding valuable information. The otherwise insufficient information was effectively supplemented. However, some questions remain insufficiently answered, such as the pollution situation in the Tamengo Channel. The use of bio-indicators, especially fish, to monitor the levels of pollution in the aquatic biocenosis could have given a more complete picture of the actual situation.

Generally, the levels of pollution of the aquatic environment seem to be low, despite the fact that large amounts of pollutants, such as agrochemicals and mercury used in gold mining, are being released to the environment in the Paraguay-Paraná basin. The fate of those pollutants seems to be poorly understood, and the possibility that they will reach the main rivers in the future cannot be excluded.

The potential sources of impacts were comprehensively identified and explained in the EIA, but the existing information does not permit a quantification of the impacts. The measures of mitigation recommended in the EIA do not appear realistic (e.g., the widening of the navigation channel to reduce the mobilization of sediments by passing convoys).

In a strange contrast to the comprehensive and thorough identification of potential impacts, the classification of those impacts is characterized by superficial and euphemistic statements. Despite the fact that a quantification of impacts is hardly possible in any case, almost all impacts are considered to be of "low" magnitude.

7.2 Recommendations

a) The assessment should be supplemented by additional studies of the sediment quality at critical sites, especially the Tamengo Channel.

b) The fate of pollutants, e.g., agrochemicals and mercury, released in the river basins should be monitored carefully to ensure that the levels of pollution remain as low as they appear to be now.

c) The levels of contamination, e.g., heavy metals and pesticides, in bio-indicators, especially fish, should be studied, and monitoring programs developed and implemented.

7.3 Introduction

Quality of the river water and sediments is of invaluable importance for the entire region, as the rivers provide a great part of the local population with drinking water, fish for food, transportation, and recreation.

The Project will directly influence water quality in many different ways during the implementation and operation phases, and in more subtle indirect ways later. For example, it might change the physico-chemical characteristics of the rivers, such as turbidity, or the levels of dissolved oxygen or nutrients; it might weaken the self-purification capacity of the river, remobilize pollutants from river sediments, or be an additional source of pollution as a result of accidental spills of fuel, lubricants, or dangerous cargo; or it might encourage hazardous land use changes.

Generally, the levels of environmental pollution in the main rivers appear to be low, and the buffering capacity of the rivers high, so the outlook appears to be good. On the other hand, release of potentially harmful substances in the vicinity of river basins has increased in recent decades, especially agrochemicals, mercury from gold mining, and domestic and industrial sewage. The fate of those substances in the environment has not been studied locally. This is a classic challenge for the assessment of environmental impacts that are not readily recognizable in the planning phase of the Project.

It should be emphasized here that the EIA chapters regarding water and sediment quality are of considerably higher quality than most of the chapters in the EIA. The field studies seem to be well designed and produce valuable information that apparently cannot be obtained from published information alone.

However, the EIA is focused on the physico-chemical characteristics of the rivers and on the manifest levels of pollution, disregarding the sources of contamination. Though most sources of pollution are certainly independent of the Project, the impact of pollution on the water quality can be magnified by the Project, e.g., if it reduces the buffering capacity of the river or remobilizes pollutants from river-bottom sediments. Any prognosis on the impact of the Project on water quality that does not consider the tendencies of environmental pollution seems futile.

Realistically, the EIA claims it does not attempt to quantify the impacts. However, in the classification of the identified potential impacts, they are in fact quantified as “low,” “medium,” and “high” magnitude, though these can be no more than rough estimates.

The independent review cannot attempt to fill the gaps left by the EIA. In the narrow frame of the assessment produced by the EIA, the study seems valid with few exceptions.

7.4 Data Base/Field Studies

The EIA found that the published information about water and sediment quality was insufficient (TGCC, pp. 3-112). An extensive field study of water quality during high and low water stages, and of sediments, was therefore conducted. More than 200 sites were sampled in the main rivers, but also in tributaries and lakes (TGCC, “Resumen,” p. 16). Besides the physico-chemical parameters of the water, the eventual pollution by chemical pollutants and heavy metals was investigated.

Water quality was studied on the main rivers in two campaigns, in June/July 1995 and December/January 1996, using standard methods of analysis. The sampling scheme seems reasonable. The presentation of the results is rather awkward because in the map of sampling sites (Fig. 3.6.1), neither the Hydrovia-kilometers nor the limits of the four river sections are indicated. The graphical presentation of results (TGCC, Figs. 3.6.2 to 3.6.12) shows only Hydrovia-kilometers and river sections, making comparisons and interpretation difficult.

Sediment quality was studied only during one campaign, at fewer sites (TGCC, Fig. 3.6.13). It is not reported how many individual samples were taken, but results are given for 85 (TGCC, Table 3.6.5).

For the statistical treatment of the data, the Paraguay-Paraná system was divided into four sections (TGCC, pp. 3-105). This division, adapted from Bucher et al. (1993), is based on the hydrological characteristics of the river sections but not on physico-chemical parameters. For example, section two, extending from the lower Pantanal to the Paraguay-Paraná confluence, is very heterogeneous as it includes the confluences of the Andean rivers Pilcomayo and Bermejo. It doesn't make sense to characterize this section by mean values of chemical parameters (e.g., suspended solids), as in Table 3.6.1 of the EIA. This has already been emphasized by Bonetto (1986).

The EIA did not study the level of contamination in the aquatic biota, which could have revealed effects of biomagnification, or localized sources of pollution. Ferreira et al. (1994) have documented biomagnification of mercury in the Paraguay River near Corumbá.

7.5 Assessment of Impacts on Water and Sediment Quality

Impacts are addressed in the EIA in the form of two "key questions," which relate to the implementation and operation phases of the Project (TGCC, pp. 10-20 to 10-31). The key questions are so general that they include all possible impacts. Indeed most relevant impacts seem to be mentioned in the EIA; however, the information in the EIA about water and sediment quality and sources of pollution does not permit a quantification of the impacts (pp. 10-20).

The EIA distinguishes direct and indirect impacts: Impacts related to the implementation phase of the Project are regarded as direct; those related to the operation phase, including the maintenance dredging, are regarded as indirect impact. This is not logical, but is related to the fact that "indirect" impacts are mostly disregarded in the EIA.

The following distinction of impact types seems more adequate:

a) impacts on the physico-chemical parameters of the rivers (e.g., contents of suspended solids, dissolved oxygen, nutrient levels);

b) impacts on the level of pollution in the aquatic environment (e.g., heavy metais, agrochemicals, hydrocarbon):
    - remobilization of pollutants already existing in the environment (e.g., in sediment "sinks");
    - addition of pollution by sources connected to the Project.

7.5.1 IMPACTS ON THE PHYSICO-CHEMICAL PARAMETERS OF THE RIVERS

The Project will influence the physico-chemical characteristics of the river water through:

a) an increase of suspended solids and turbidity;

b) a reduction of dissolved oxygen levels;

c) hydrological changes, reducing the self-purification capacity of the rivers.

Except for the changes in the hydrology, these potential impacts are addressed in the EIA.

Floodplains and their natural vegetation, riparian forests, and inundated grasslands play an important role in the self-purification of the river water by supplying it with dissolved oxygen. If the changes in hydrology lead to a disconnection of the floodplain and main river, this capacity could decrease. Also, shortening of the river (e.g., by cutting through meanders and widening curves) and reduction of the water retention time reduces the capacity for self-purification. Since larger cities on the Paraguay River, such as Asunción, do not have sewage treatment plants, the water quality of the river might deteriorate due to the impact of the Project. This cumulative effect is also felt through an increasing population.

7.5.2 IMPACTS OF POLLUTION ON THE AQUATIC ENVIRONMENT

The main sources of pollution for the aquatic environment are apparently:

a) agriculture, releasing agrochemicals and fertilizers, and increasing the sediment load;

b) mining activities, mainly gold mining, releasing mercury;

c) sewage from cities and industry;

d) navigation.

The Project could influence the levels and impacts of pollution through:

a) mobilization of pollutants from sediments in the dredging operations (including maintenance dredging);

b) mobilization of pollutants from sediments due to increased navigation;

c) pollution due to dredging operations (e.g., leakage of lubricants or fuel);

d) pollution due to navigation (e.g., leakage of oil, release of contaminated ballast water);

e) increased risk of accidental pollution, due to increased navigation;

f) operation of harbors;

g) increased mining activities.

Two kinds of impacts should be distinguished:

a) remobilization of pollutants already existing in the rivers: dredging and navigation, as well as changed patterns of erosion due to changed hydrological characteristics, can lead to a release of pollutants contained in the sediments of the river. This is one of the main reasons for concern, especially for the Tamengo Channel near Corumbá.

The actual levels of contamination of the water and sediments seem to give no cause for concern, though the situation is less clear in the Tamengo Channel, where in a few samples, raised values for different pollutants have been found (TGCC, Table 3.6.5). As this site is critical, due to the water supply for Corumbá, the problem must be studied more comprehensively.

In the basin of the Paraguay-Paraná river system, increasing amounts of pollutants are released into the environment. These include mercury from gold mining, increasing amounts of agrochemicals from the expansion of agriculture, and sewage water from the increasing population. It must be expected that the situation of water quality will deteriorate even without the Project. The impact of the maintenance dredging and navigation might then become more important.

b) additional input of pollutants: due to increased navigation, the release of fuel, lubricants, and other chemicals into the river will be more probable. In the past, they have been limited to small amounts, thus restricting their impacts. The greatest problem is the increasing risk of accident, especially with accidental spills of fuel. The greatest risk is in the Corumbá-Cáceres reach, due to the expected high levels of traffic.

This problem has been insufficiently analyzed in the EIA.

7.5.3 CLASSIFICATION OF IMPACTS

The potential impacts are apparently thoroughly identified in the EIA, but a quantification is impossible for most impacts. It is noteworthy that in this part of the EIA the limits of the assessment are expressively stated (e.g., TGCC, pp. 10-34).

Realistic predictions are possible for the increase in suspended solids and turbidity. Certainly, the greatest impact must be expected for the Upper Paraguay due to the anticipated increase in ship traffic. During the time of the soya transport, up to 16 ships are expected to go up or down the river per day. According to the study by Bhowmik (1993; TGCC, pp. 10-24), the increase in the concentration of suspended sediments can last up to 90 minutes after the passage of a convoy. Thus, an almost permanently raised level of suspended solids seems probable. An important impact on the levels of dissolved oxygen is also likely.

The EIA nevertheless classifies the impact as "low to moderate" (TGCC, pp. 10-35). This classification seems incomprehensible, given the very low level of suspended solids in these parts of the river (TGCC, Fig. 3.6.7). To excuse an unwelcome "high" classification, the EIA adds that the implementation of this part of the Project is not likely due to economic reasons.

The classification of impacts (TGCC, chap. 10.3.5) does not so much appear "subjective" (TGCC, pp. 1034) as euphemistic. For instance, the EIA warns that a single, prolonged release of contaminants could seriously affect "localized areas." Why "localized"? Experience shows that pollution due to accidents can have impacts hundreds of kilometers downriver. Nevertheless, this risk is classified as *"bajo"* – low (TGCC, pp. 10-35).

7.5.4 MITIGATION

Of course, accidental or unintentional release of pollutants can be avoided by, among other things, training, increasing public awareness, implementing sewage treatment plants. All these measures, addressed in the EIA (TGCC, pp. 10-31 to 33), will require money and infrastructure in order to be effective. So the effect of the measures of mitigation will depend on whether the resources needed for their implementation will be made available.

Others, such as the increased turbidity due to navigation, cannot be mitigated realistically. The EIA proposes enlarging the river channel, as this would reduce the impact (TGCC, pp. 10-33). This is not realistic, as it would incur not only additional costs, but also other environmental impacts, e.g., those of the maintenance dredging.

CHAPTER 8 IMPACTS OF THE HYDROVIA PROJECT ON FISH AND FISHERIES

by Emiko Kawakami Resende and Petr Obrdlik

The following sections provide a brief description of the impacts of the Hydrovia Project on fish and fisheries. Relevant chapter and page references to the EIA report are provided in the appendix.

Photo 16. Woman selling a Pacu *(Mylossomaparaguavensis)* in Corumbá, Brazil.
Photo: André Leite/WWF Canada

8.1 Conclusions

Extensive compilations were made of the fish and fisheries along the Project region.

Though the EIA contains a complex attempt to select a number of indicator species from the list of fish species of several segments of the Paraguay and Paraná Rivers, they are not used to qualify and quantify the expected impacts of the planned actions of the Project.

Surely, the methodology used to assess the impacts of the Project on fish and fisheries was not the best for this kind of development proposal.

Although the EIA performed an extensive review of available information about fish and fisheries in the Project area, many factors made reliability of the predictions uncertain. Factors such as the dimension of the area, insufficient knowledge about the biology and ecology of fishes, an incipient knowledge about the functioning of tropical floodplain and/or wetlands, and the uncertainties related to the hydrologic modelling to foresee the changes in the flood parameters (time, duration, level) all contributed to this unreliability.

8.2 Recommendations

a) The data base alone is not enough to adequately evaluate the possible impacts of the planned actions of the Project. The basic question is related to the uncertainties within the hydrologic modelling concerning the reduction of floodable area in extension and duration time of inundation.

b) Since fishing is a very important source of food and income for the traditional local population (more than 3,500 fishers, in the Pantanal region alone) and for local people that find jobs in the increasing sportfishing activities (60,000 sportfishers a year in the Pantanal), this question must be carefully assessed before any kind of decision is taken.

c) From the ecological point of view, the impacts on fish need to be evaluated carefully because they are the base of the food web for numerous animal species. These include birds, caimans, and a number of endangered species like the jabiru stork, giant otter, and neotropical river otter, whose populations, so far, are not endangered in the Pantanal.

8.3 Assessment of Impacts on Fish in the EIA

The assessment of the impacts on fish and fisheries starts with a comprehensive compilation of the available information, including the results of experimental fish captures, published information, inquiries among fishermen, and field studies of fish. This compilation gives basic information about the fish fauna, their migrations, ecological relationships with the floodplains, importance of fisheries, and description of natural and anthropogenic fish mortality that have occurred in the river basin. Gaps in the knowledge are duly indicated (e.g., TGCC, pp. 4-195).

There are great differences in the magnitude of hydrological changes between the preliminary (TGCC, 1996) and the final version of the EIA (TGCC, 1997). Nevertheless, the expected impacts on the fish fauna remain the same.

The study area was divided into four segments (TGCC, pp. 4-129): (1) the Paraná delta, (2) the Lower Paraná River, (3) the Lower Paraguay River, and (4) the Pantanal.

(The use of the term "segment" can lead to confusion with the three river segments defined in the Pantanal; TGCC, pp. 1-16). This division of the river does not reflect ecologically homogeneous reaches of the river. This has already been explained in chapter 6.4.3.

There is some valuable criticism of the use of the ELC in dynamic ecosystems, like floodplains (TGCC, pp. 11-108, 11-114, etc.). This critique is valid not only for the application of ELCs to the fish fauna, but also for vegetation and terrestrial fauna. It was not duly considered there, and despite the criticisms in the chapter pertaining to impacts on fish, they apparently result in no consequences for the assessment process on fish.

8.3.1 FIELD STUDIES

Two study sites were chosen in each of the four river segments (only one in the delta) for experimental fishing in the main river, side branch, and floodplain (TGCC, pp. 4-129). Additionally, parameters of water quality were recorded (TGCC, pp. 4-131). Captures by local fishermen were recorded in different harbors.

Results of the experimental captures, containing information about the species composition, absolute and relative number, weight, diet, number, and importance of fisheries in the different segments are found in chapter 4.3.6 of the EIA (TGCC, pp. 4-147 to 4-184). This provides information on the distribution, relative abundance, and trophic ecology of fish, as well as on community composition. The economic importance of fisheries can also be evaluated.

Experimental captures were few and of such a small duration that no reliable data can be extracted from them. The fish communities in the region are dynamic throughout a hydrological period of one year and are extremely different if you take into consideration the topology of the area, the degree of connection if a river is involved, how long the area is flooded, if at all, and the type of vegetation in the area. Chapter 4.3.6 of the EIA only exists because a compilation of existing literature about distribution, relative abundance, trophic ecology, and community composition that was added to the chapter.

8.3.2 THE MODEL FHAU (FISH HABITATS AND ANTHROPIC USE)

For the assessment of impacts on the fish fauna and fisheries, the model FHAU (Fish Habitats and Anthropic Use) was developed. The first part of the relevant chapter contains several attempts to describe the model, which differs more or less from the model finally applied to the data (TGCC, pp. 11-109 to 11-112). The impression is that this part of the chapter was written before the model was fully developed.

Step one: The relative importance of habitats for the fish fauna is evaluated. For 377 species known to occur in the Project region, the habitats used by every species for migration, reproduction, and feeding were determined (TGCC, Table 11.3.4.1). For migration and reproduction, only the most important habitats were considered; while for feeding, one main and two secondary habitats were considered. For each habitat in every ecoregion, the number of times it was recorded for the biological functions in the table was summed up. These sums were then used to calculate a unique value of "Importance of Landscape Units" (i.e., habitats, ecosections), giving the biological functions different weight: reproduction, migration and main feeding, 100 percent; secondary feeding 50 percent (TGCC, pp. 11-115).

For example, habitat "Al-Open Water" was recorded for 130 species as main habitat used for migration (130 × 1 = 130); for 88 species as main habitat for reproduction (88 × 3 = 264); for 59 species as main habitat for feeding (59 × 1 = 59); and for 66 and 63 species as secondary habitat for feeding ([66 + 63] × 0.5 = 64.5). The importance of habitat Al for the fish fauna is 130 + 264 + 59 + 64.5 = 517.5 (TGCC, Table 11.3.4.1).

Step two: Indicator species are selected (TGCC, pp. 11-116). Nine criteria were used to evaluate the aptitude of the 377 species as indicators for impacts of the project (pp. 11-116; EIA-Table 11.3.4.3): (1) presence, (2) abundance, (3) commercial value, (4) value for subsistence fisheries, (5) value for recreational fisheries, (6) importance in trophic food chains of the ecosystem, (7) potential of recovery from impacts, (8) sensitivity, and (9) conservation status.

Every species was given a value of one to three for each category, except for "presence," which was assigned either zero or five. The points were summed up for every species, multiplied with the value for "information available" from Table 11.3.4.1, resulting in the "Ecological value versus Information." (The "presence" category is quite superfluous, as absent species were not assigned values for the other categories.)

Those species that reached at least 41 points of "Ecological value versus Information" in at least three of the four ecoregions were selected as indicators (TGCC, Table 11.3.4.5): 42 species for the Pantanal, 41 species for the Lower Paraguay, 51 species for the Lower Paraná, and 29 species for the delta. There are 14 pages with mostly uninformative tables illustrating this selection process (TGCC, Table 11.3.4.4). Table 11.3.4.5 of the EIA, now covering five pages, would easily fit into a one page table (see Tables 8.1 and 8.2).

Step three: Impacts are analyzed addressed in the form of "key questions." The potential impacts were considered in 10 hypotheses, reformulated as nine key questions (TGCC, pp. 11-118 to 11-141). Of interest to the indicator species, only five of them were casually mentioned in the analysis of key questions: *Prochilodus "linneatus" (lineatus), Colossoma mitrei (Piaractus mesopotamicus* in the tables), *"Oplosternon" spp., "Oplias"* spp., *"Opleritrinus" spp.* (TGCC, pp. 11-131; *Hoplosternum, Hoplias, Hoplerythrinus)*. The other species discussed are not South American: *Coregonus clupeaformis, Prosopium williamsi, Cyprinus ("Ciprinus") carpio, Clupea harengus, Polypoden spatula* (TGCC, pp. 11-119, 11-120, 11-130, 11-132, 11-133). There remains the question, what the function of the FHAU should be.

8.3.3 KEY QUESTIONS

As in the previous chapters of the independent review, the key questions were slightly modified:

Key Question One: What are the direct impacts of dredging on fish habitats? (TGCC, pp. 11-119 to 11-124)

In the EIA, three kinds of direct impacts were considered: (a) increased turbidity, (b) effects of use of explosives, and (c) deposition of dredged material.

There is a detailed compilation of known impacts of turbidity on fish. However, for the following reasons the conclusion is that impacts will be low, localized, and of short duration (TGCC, pp. 11-121):

a) Dredging will take place only in the river channel where currents are higher.

b) The Paraguay and Paraná Rivers have relatively low suspended solids and could transport more.

c) The fish species are well adapted to turbid waters, as the fish fauna of the very turbid Bermejo River is no different from that of the other rivers of the basin;

d) There are no polluted sediments in the river, which might cause impacts.

At least some of the dredged material will be deposited along the river margins or in side branches of the river. So the first argument is unfounded. The naturally low sediment load of the rivers cannot be used as proof that an artificially increased turbidity will not cause negative impacts. The possibility that some or many species do not tolerate high turbidity is not ruled out. How many species have actually been studied in this respect? As the majority of young fish eat plankton, selection of food in increasingly turbid water may become difficult. Similarly, the catch success of predatory fish may diminish. There is no doubt that increasing amounts of pollutants from agriculture and gold mining are entering the river basin, but the question is whether the pollution of the river is really sufficiently known (see previous chapter).

At one or more sites, explosives will be used for the opening of the river channel (TGCC, pp. 11-122). The effects are expected to be localized and, consequently, of low impact.

Great amounts of dredged material must be deposited in or along the river. The EIA proposes that these disposals should be studied in detail, making periodic controls to assure the process of natural succession, and presents a plan for dealing with problems that arise *("en caso que se presenten problemas").* Again, the problem of disposal of the dredged material is greatly underestimated. The EIA fails to assess this problem.

Key Question Two: Are the changes in fish habitat quality due to altered river channel geometry? (TGCC,pp. 11-124 to 11-125)

Despite the deepening, widening, and straightening of the river channel, as well as the cutting through of one meander, the EIA concludes that no impacts are to be expected. Figure 11.3.3.1.b of the EIA was meant to illustrate this key question, but emphasizes exclusively the hydrological changes, which are in fact addressed in the following key question, but not in key question two.

It is more than questionable that the existing information on the habitat preferences of fish in the river channel is sufficient to competently assess this question. Two other concerns are:

a) Geometry of the river channel is affected not only by dredging, but also by disposal of dredged material. This aspect was not taken in consideration.

b) Migratory fish often move along the shore to take advantage of structures that inhibit strong currents and thus reduce energy. Such structures are removed by "shaving" the shorelines.

Table 8.1 Evaluation of Indicator Species (In the EIA, this data is spread over 14 pages.)

Species that Scored More than 30	Pantanal	Lower Paraguay	Lower Paraná	Delta
Potamotrygon brachyurus		1	3	
P. falkneri		1	1	3
P. hystrix		1	1	3
P. motoro		1	3	3
Aphyocharax anisitsi	1	1	1	
A. ratbuni	1	1	1	
A. rubropinnis			1	
Cheirodon interruptus		1	1	1
Ch. Piaba			I	
Holoshestes pequira	1	1	1	
Odontostilbe microcephala		1	1	1
0. paraguayensis	1	1	1	
Pnonobrama paraguay.	1	1	1	
Astyanax abramis	1	1	1	1
A. alleni	1	1	1	
A. bimaculatus	1	1	1	1
Astyanax b. paraguayensis		1	1	
A. fasciatus		1	1	1
A. lineatus	1	1	1	
A. eigenmanniorum	1	1	1	1
Bryconamericus exodon	1	1	3	1
Bryconamericus iheringi		1		
Hemigramus caudimaculat.			1	1
Markiana nigripennis	1	1	1	1
Moenkhausia dichoura	3	1	1	
M. intermedia	1	1	1	
M. sanctae-filomenae	1	1	1	
Gymnocorymbus ternetzi	1	1	1	
Psellogrammus kennedyi	1	1	1	
Hyphessobrycon anisitsi	1	1	1	1
H. callistus	1	1	1	

Species that Scored More than 30	**Pantanal**	**Lower Paraguay**	**Lower Paraná**	**Delta**
Tetragonopterus argenteus	1	1	1	1
Poptella paraguayensis	1	1	1	1
Brycon orbignyanus		1		1
Asiphonichthys stenopter.		1		1
Cynopotamus argenteus	1	1		1
Galeocharax humeralis	1	1	1	1
Cyrtocharax squamosus		1		1
Charax gibbosus	1	1	3	
Roeboides bonariensis	1	1	3	1
R.progratus	1	1	1	
Salminus maxillosus	3	6	6	3
Triportheus paranensis	1	1	1	1
Pseudocorynopoma doriai		1	1	1
Pyrrhulina australis	1	1	1	
Toracocharax stellatus	1	1	1	1
Raphiodon vulpinus	1	3	3	3
Acestrorhynchus altus	1	1	1	1
Oligosarcus hepsetus			3	1
O.jenynsi			3	1
Apareiodon affinis	1	1	3	1
Characidium fasciatum		1	1	
Ch. Rachowi			1	
Curimatopsis saladensis			1	
Curimatorbis platanus		3	1	1
Gasterostomus latior		1	1	1
Pseudocurimata bimaculata		1	1	
P. giberti		1	1	1
P. nitens		1	1	
Prochilodus lineatus	3	6	6	6
Schizodon fasciatum		6	3	
Abramites solarii	3	3	6	
Leporinus friderici	6	6	6	6
L. maculatus		6	6	
L. lacustris	3			
L. nigripinnis			6	
L. obtusidens	6	6	6	6
Hoplerythrinus unitaeniatus	1	3	1	
Hoplias malabaricus	1	3	1	1
Serrasalmus marginatus	1	1	1	1
S. nattereri		1	1	1
S. spilopleura	1	1	1	1
Metynnis maculatus	3	1	1	
Myloplus asterias	3	1	1	
Piaractus mesopotamicus	6	6	6	
Mylossoma orbignyanum		1	1	1
M. paraguayensis	3	1	1	1
Gymnotus carapo	3	3	3	3
Eigenmannia virescens	3	3	3	3
Hypopomus artedi	3			

Species that Scored More than 30	**Pantanal**	**Lower Paraguay**	**Lower Paraná**	**Delta**
Rhamphichthys rostratus	3	3	3	3
Apteronotus albifrons	1	1	3	3
Ageneiosus brevifilis	3	6	6	6
A. valenciennesi	3	6	6	6
Auchenipterus nigripinnis	3	3	1	1
A. nuchalis	3	6	1	1
Hypophthalmus edentatus	1			
Trachycorystes ceratoph.		1		
T. galeatis				
T. striatulus		1	1	1
Trichomycterusjohnsoni	1	1		
Anadoras wedelli	1	1	1	
Doras eigenmanni	1	1		
Oxydoras kneri	3	6	6	1
Pterodoras granulosus	3	6	6	6
Rhinodoras d'orbignyi	3	3	1	1
Trachydoras paraguayensis	1	1	1	
Heptapterus mustelinus		1	1	1
Iheringichthys westermanni	3	6	6	
Microglanis cottoides	3	1	1	
Parapimelodus valencienn.		3	3	6
Pimelodella cristata		3	3	
P. gracilis	3	3	3	6
P. laticeps		3	3	
Pimelodus albicans		3	6	3
P. argenteus	3	3	6	3
P. brevis			6	3
P. darias maculatus	3	3	6	3
Rhamdia hilari	3			
R. sapo		6	3	3
Pseudopimelodus zungaro	3	6	3	
Perugia argentina			3	1
Hemisorubim platyrhynchos	6	3	6	
Sorubin lima	6	3	3	3
Brachyplatystoma filament			3	
Paulicea lüetkeni	3	3	3	3
Pseudoplatystoma corusc.	6	6	6	3
P. fasciatum	6	6	3	
Luciopimelodus pati		3	6	3
Pimrumpus pirinampu	3	1	1	
Bunocephalus doriai		1	1	
B. iheringi		1	1	
Callichthys callichthys	1	1	1	1
Corydoras aeneus	1	1	1	
C. microps				
C. paleatus				
C. aurofrenatus	1			
Hoplosternum littorale	1	1	1	1
H. thoracatum		1	1 -	-

Species that Scored More than 30	**Pantanal**	**Lower Paraguay**	**Lower Paraná**	**Delta**
Otocinclus arnoldi				
O. vittatus	1	1	1	
Loricaria macrops			1	
L. vetula		1	1	1
L. anus		1	1	1
L. maculata		1	1	1
L.typus		1	1	1
L. lima				1
Rineloricaria parva	1	1	1	
Peckoltia vittata		1	1	
Plecostomus commersoni		1	1	1
P. laplatae			1	1
P. plecostomus			1	1
Rivulus strigatus		1	1	
Pterigoplichthys anisitsi		1	1	
Strongylura microps			1	
Rinelepis strigosa	1			
Liposarcus anisitsi	1			
Pterolebias longipinnis	3	1	1	1
Cynolebias belloti			1	1
Cnesterodon decenmacul.		1	1	1
Jenynsia lineata			1	
Basilichthys bonariensis			6	6
B. perugae			6	6
Trigonectes balzanii	3			1
Plagioscion temetzi	6	6	3	6
Pachyurus bonariensis	6	6	3	6
Apistogramma borelli	1	1	1	
A. commbrae	1	1		1
Gymnogeophagus balzanii	1	1	1	
Geophagus australis		1	1	
G. brachyurus		1	1	
G. brasiliensis		1	1	3
Crenicichla lepidota		1	1	1
C. vittata	1	1	1	
Aequidens centralis			1	
A. paraguayensis		1	1	
A. portalegrensis		1	1	
Ciclaurus bimaculatus	3	1	1	
C. facetus	3		1	1
Synbranchus marmoratus	1	1	1	
Achirus lineatus		1	3	3
Lepidosiren paradoxa		1	1	
H. brevirostris	3	3	3	
Microlepidogaster maculip			1	1
H. lüetkenii	1	1	1	

Source: TGCC (1997), Table 11.3.4.4

Table 8.2 Selection of Bio-Indicators from the Fish Species within the Hydrovia Project Region: Species that Score More than 40 Points in the EIA

(The original data was spread over five pages.)

Species that Scored More than 40	**Pantanal**	**Species that Scored More than 40**	**Lower Paraguay**
Moenkhausia dichoura	3	Salminus maxillosus	6
Salminus maxillosus	3	Raphiodon vulpinus	3
Prochilodus lineatus	3	Curimatorbis platanus	3
Abramites solarii	3	Prochilodus lineatus	6
Leporinus friderici	6	Schizodon fasciatum	6
L. lacustris	3	Abramites solarii	3
L. obtusidens	6	Leporinus friderici	6
Metynnis maculatus	3	L. maculatus	6
Myloplus asterias	3	L. obtusidens	6
Piaractus mesopotamicus	6	Hoplerythrinus unitaeniatus	3
M. paraguayensis	3	Hoplias malabaricus	3
Gymnotus carapo	3	Piaractus mesopotamicus	6
Eigenmannia virescens	3	Gymnotus carapo	3
Hypopomus artedi	3	Eigenmannia virescens	3
H. brevirostris	3	H. brevirostris	3
Rhamphichthys rostratus	3	Rhamphichthys rostratus	3
Ageneiosus brevifilis	3	Ageneiosus brevifilis	6
A. valenciennesi	3	A. valenciennesi	6
Auchenipterus nigripinnis	3	Auchenipterus nigripinnis	3
A. nuchalis	3	A. nuchalis	6
Oxydoras kneri	3	Oxydoras kneri	6
Pterodoras granulosus	3	Pterodoras granulosus	6
Rhinodoras d’orbignyi	3	Rhinodoras d’orbignyi	3
Iheringichthys westermanni	3	Iheringichthys westermanni	6
Microglanis cottoides	3	Parapimelodus valencienn.	3
P. gracilis	3	Pimelodella cristata	3
P. argenteus	3	P. gracilis	3
P. darias maculatus	3	P. laticeps	3
Rhamdia hilari	3	Pimelodus albicans	3
Pseudopimelodus zungaro	3	P. argenteus	3
Hemisorubim platyrhynchos	6	P. darias maculatus	3
Sorubin lima	6	R. sapo	6
Paulicea lüetkeni	3	Pseudopimelodus zungaro	6
Pseudoplatystoma corusc.	6	Hemisorubim platyrhynchos	3
P. fasciatum	6	Sorubin lima	3
Pimrumpus pirinampu	3	Paulicea lüetkeni	3
Pterolebias longipinnis	3	Pseudoplatystoma corusc.	6
Trigonectes balzanii	3	Luciopimelodus pati	3
Plagioscion temetzi	6	Plagioscion temetzi	6
Pachyurus bonariensis	6	Pachyurus bonariensis	6
Ciclaurus bimaculatus	3	P. falkneri	3
C. facetus	3	P. hystrix	3
P. fasciatum	6	P. motoro	3
Potamotrygon brachyurus	3	Bryconamericus exodon	3

Species that Scored More than 40	Pantanal	Species that Scored More than 40	Lower Paraguay
P. motoro	3	Charax gibbosus	3
Roeboides bonariensis	3	Salminus maxillosus	3
Salminus maxillosus	6	Raphiodon vulpinus	3
Raphiodon vulpinus	3	Prochilodus lineatus	6
Oligosarcus hepsetus	3	Leporinus friderici	6
O. jenynsi	3	L. obtusidens	6
Apareiodon affinis	3	Gymnotus carapo	3
Prochilodus lineatus	6	Eigenmannia virescens	3
Schizodon fasciatum	3	Rhamphichthys rostratus	3
Abramites solarii	6	Apteronotus albifrons	3
Leporinus friderici	6	Ageneiosus brevifihis	6
L. maculatus	6	A. valenciennesi	6
L. nigripinnis	6	Pterodoras granulosus	6
L. obtusidens	6	Parapimelodus valencienn.	6
Piaractus mesopotamidus	6	P. gracilis	6
Gymnotus carapo	3	Pimelodus albicans	3
Eigenmannia virescens	3	P. argenteus	3
H. brevirostris	3	P. brevis	3
Rhamphichthys rostratus	3	P. darias maculatus	3
Apteronotus albifrons	3	R. sapo	3
Ageneiosus brevifilis	6	Sorubin lima	3
A. valenciennesi	6	Paulicea Iüetkeni	3
Oxydoras kneri	6	Pseudoplatystoma corusc.	3
Pterodoras granulosus	6	Luciopimelodus pati	3
Iheringichthys westermanni	6	Basilichthys bonariensis	6
Parapimelodus valencienn.	3	B. perugae	6
Pimelodella cristata	3	Plagioscion temetzi	6
P. gracilis	3	Pachyurus bonariensis	6
P. laticeps	3	Achirus lineatus	3
Pimelodus albicans	6		
P. argenteus	6		
P. brevis	6		
P. darias maculatus	6		
R. sapo	3		
Pseudopimelodus zungaro	3		
Perugia argentina	3		
Hemisorubim platyrhynchos	6		
Sorubin lima	3		
Brachyplatystoma filament.	3		
Paulicea lüetkeni	3		
Pseudoplatystoma corusc.	6		
P. fasciatum	3		
Luciopimelodus pati	6		
Basilichthys bonariensis	6		
B. perugae	6		
Plagioscion temetzi	3		
Pachyurus bonariensis	3		
Achirus lineatus	3		
G. brasiliensis	3		

Source: TGCC (1997), Table 11.3.4.5.

Key Question Three: Are the negative impacts on fish habitat due to changes of the hydrological regime? (TGCC, pp. 11-125 to 11-127)

Key Question Four: Will the hydrological changes affect the movements of fish between river and floodplain? (TGCC, pp. 11-127 to 11-128)

These two questions are almost identical, or at least overlapping, so they can be analyzed together.

According to the EIA hydrological modelling, changes should be of low magnitude. Nevertheless, these changes could modify the distribution and extent of habitat used by fish, or cause qualitative changes in these habitats. However, the EIA follows the evaluation of the assessment of landscape features and vegetation, and expects no perceptible changes in the distribution and extent of fish habitat. Fish such as the *Prochilodus lineatus* (an important commercial fish), during the flood season use very shallow water, no more than 50 centimeters, for feeding on algae and organic debris deposited on the flooded vegetation. The proposed alterations will certainly modify the extension of this type of habitat.

As mentioned previously, neither the hydrological assessment, nor the assessment of the landscape features is reliable. However, based on the hydrological predictions only, it would have been worthwhile to analyze the impact of changes in the hydrology at low water levels on fish habitat in the floodplain. In this season, predation on fish by birds is very intensive, and small differences (10 centimeters) in the depth of shallow ponds can determine whether wading birds use it or not.

Furthermore, there could be other impacts, e.g., due to dredging and navigation, that could affect the movements of fish between river and floodplain.

Key Question Five: Will the Hydrovia Project lead to a reduction in the abundance of fish? (TGCC, pp. 11-128 to 11-129)

Key Question Six: Will the Hydrovia Project lead to a reduction in the quality of fish catches? (TGCC, pp. 11-129 to 11-130)

These key questions are not fundamentally different from the earlier ones, except that they are much more general, so the answers are also not different: No impacts are expected. For the same reasons as before, this evaluation seems inadequate. There seem to be no systematic order in the key questions; some problems are addressed repeatedly at different levels of detail, while others are not considered at all.

Key Question Seven: Will the Hydrovia Project favor the spread of exotic species? (TGCC, pp. 11-130 to 11-131)

The analysis of the EIA is focused on the carp *(Cyprinus carpio),* an Old World species introduced in the Paraná delta. It is admitted that other exotic species could expand their distribution, but this is not thought to be likely. Besides the carp, several exotic species (mainly Amazonian) are used in pisciculture in the Project region (Catella et al., 1995). The European experience with invasions of exotic species is that they are mostly unpredictable (or unpredicted), uncontrollable, and can have lasting effects on natural communities.

Besides the introduction of exotic fish species, the possible introduction of exotic fish diseases should have been addressed in the EIA.

Key Question Eight: Can the Hydrovia Project increase the risk of mass mortalities of fish? (TGCC, pp. 11-131 to 11-132)

An increase of mass mortalities of fish due to changes in hydrology is not expected, as the simulated changes in hydrology are small. Accidental pollution could cause fish mortality, but is believed to be a risk that can be "predicted and controlled." In fact, whether the problem of "accidental" pollution is easy to predict or control has been discussed elsewhere (section 4.3.4).

The increased content of suspended solids in the water due to dredging and/or navigation could result in a reduction of the level of oxygen in the water, which could cause mass mortalities of fish. Of course, this first requires an already critical situation.

Key Question Nine: What are the impacts of the increased traffic on the fish fauna and fisheries? (TGCC, pp. 11-132 to 11-141)

The EIA notices difficulties in answering this question due to lack of information about the possible impacts. Many published studies report impacts of high turbidity on fish eggs and larvae, and for values of suspended matter much inferior to those encountered in the Paraguay and Paraná Rivers (TGCC, pp. 11-133). Lesions due to collisions with ship screws have been described, but are rare in the Paraná River, according to the experience of the consultants.

Navigation could increase turbidity, and consequently affect phytoplankton. The impact is expected to be low. Similarly, benthos could suffer due to turbidity. This impact is remarkable only in the Pantanal, where it is nevertheless moderate.

A gross estimation of the possible duration and magnitude of disturbances of the river by passing barges shows that, in the Pantanal, the river channel might be affected one-third of the time, causing a most unfavorable effect on the fish (TGCC, 11-139). There are apparently no examples of how fish populations react to disturbances of this magnitude. A list of possible impacts is given.

For the assessment of impacts on the fisheries, only those impacts caused by changes of the abundance of fish are considered. The increased traffic, however, could directly affect the efficiency and security of the fishermen; but these aspects have not been addressed.

Tables 11.3.6.1.a and 11.3.6.1.b of the EIA are unnecessary and contain the same information already reported in the text.

The problem with this assessment is not only that possible impacts on fish are unknown, but that the estimation of the magnitude of the causes of impacts is missing, except for direct disturbance by ship traffic. Also, impacts analyzed in the chapters on hydrobiology should have been considered here, as they affect the food base of the fish.

The impact of the disturbance on the river due to passing barges should have been taken into consideration as well in the chapters on landscape features and vegetation, and on fauna.

Waves caused by increased traffic can disturb eggs and fry, and in some cases these can be killed by the propellers of the barges. There is no information about the consequences of this kind of impact on the eggs and fry. Nevertheless, this problem must be taken into consideration.

8.3.4 MITIGATION AND CONTROL

In the EIA, there is a list of proposals intended to minimize the expected impacts (pp. 11-141 to 11-144):

Dredging

a) Proposal 1: Only one dredge per 100 km of river shall be active simultaneously.

b) Proposal 4: Dredging shall only take place in seasons of low reproductive action. In the Pantanal, this would be between mid-April to August (high water).

c) Proposal 5: Use of explosives shall occur only at one site, by competent personnel.

d) Proposal 6: In every dredge crew, there shall be one local expert on fauna and flora.

e) Proposal 7: Dredged material shall be disposed of, if possible, close to the thalweg. At minimum, dredging should not impede the connection between river and floodplain.

f) Proposal 8: The slope of the dredged margins shall not be greater than 40 percent.

Studies of Impacts

a) Proposal 2: Experimental captures of fish shall be undertaken in the river above and below the site to be dredged, before and after the dredging.

b) Proposal 9: Water level shall be recorded daily.

c) Proposal 14 and 15: Fish movements in the river, and between river and floodplain, shall be studied.

d) Proposal 21: The behavior of fish during the passage of barges shall be studied.

e) Proposal 17: Limnological studies shall permit the detection of pollution and the situation of the food chain of fish.

Control of Fisheries

a) Proposal 3 and 10: Commercial and recreational fishing shall be forbidden in the river 100 kilometers above and below the dredge site, including the mouths of tributaries.

b) Proposal 12 and 16: The control of fisheries in harbors of the Project shall be enhanced; the dynamics of the commercial fisheries studied by regular sampling.

Public Information

a) Proposal 13 and 20: Increase the distribution of information on native species, fisheries, and related problems, and enhance the interchange of information between technicians, administrators, and operators in general.

Legal Improvements

a) Proposal 11: Legislation concerning the fisheries shall be harmonized in the countries concerned, and a manual of control put into function.

b) Proposal 18: The introduction of exotic species of animals and plants shall be limited in part by laws and policies.

c) Proposal 19: Cargoes transported shall be strictly controlled and unauthorized transport of organisms penalized.

The proposals mostly do not concern mitigation, but rather the study of the impacts. Proposals directed at impact mitigation (1, 4, 5, 7, 8) and are mostly irrelevant, as they are already contained in the technical studies, mostly for technical reasons such as time of dredging, disposal of dredged material, and use of explosives.

Proposal 2 cannot be implemented if the dredging takes place during the flood period, since few fish will be captured; therefore, the information cannot be relied upon. Proposals 14 and 15 cannot be implemented because the aquatic environment is of such magnitude that such kinds of study would be extremely difficult to take place. For proposal 21, there is no methodology available to implement this study. Proposals 3 and 10 have no existing studies or basis to adopt this kind of activity. For proposals 12 and 16, it is hard to figure out how this activity can be put into practice. The system to collect constant data for fisheries statistics involves a large number of people. The proposed resources will not be sufficient and the proposed system will not be efficient. For proposal 18, in the case of fish species, the introduction of exotic species should be forbidden.

Though grave impacts on fish and fisheries are believed possible in the Pantanal, the assessment does not recommend adopting the least environmentally destructive alternative for the implementation of the Project. All proposals for mitigation are based on the assumption that the maximal option for the configuration of convoys will be realized; though until the conclusion of the EIA, no decision had been made. As the central function of a serious EIA is to recommend mitigations that avoid potential negative environmental impacts, this document completely fails. There is a failure to identify and recommend the environmentally least adverse alternative, which in this case would be the zero-option not to build the Hydrovia Project.

CHAPTER 9 WWF'S RECOMMENDATIONS

by André Leite

It is essential to emphasize that WWF supports sustainable development and is not opposed to the rational use of the Paraná and Paraguay Rivers for navigation. WWF is also not opposed to the necessary improvements of the existing transport infrastructure in La Plata Basin (e.g., the Ferronorte railway and the improved signalization for safety of the existing waterway). However, as the results of the WWF analysis show, the planned massive interventions in the riverbed are neither necessary for the continued use of the waterway, nor economically feasible. Ecologically, they are threatening valuable natural resources of global outstanding importance, especially in the Pantanal. Therefore, WWF's scientific panel makes the following recommendations:

a) The existing plans and the EIA for the Hydrovia Paraguay-Paraná Project are completely inadequate to be used as a basis for decision-making on the improvement of the waterway. No decision should be taken before these shortcomings have been remedied. It is essential that no irreversible interventions be made in the riverbed before the impacts are assessed seriously and competently. Cumulative impacts caused by the Project, together with other development in the basin of the Paraguay and Paraná Rivers, should also be taken into consideration.

b) Plans for the Project through the Pantanal (especially in the Corumbá-Cáceres reach) should be abandoned immediately, as they are neither economically feasible nor ecologically sound. Irreversible damage to the biotic environment in the Pantanal, Paraguay and Paraná Rivers, and floodplain must be expected if Module B1 is implemented. To prevent further speculation, this decision should be made public and irrevocable as soon as possible. The situation of the Tamengo Channel near Corumbá needs further study.

c) Plans for the other parts of the Project should be thoroughly revised to minimize the environmental impacts. The decision on the size of the Project was based on an inaccurate economic feasibility analysis and ecological assessment and, therefore, must be revoked. This is of special importance for the river section between Asunción and Corumbá, where interventions in the river channel could seriously affect the Pantanal. There are no objections against improved signalization of the waterway, as it could reduce the risk of accidents.

d) Despite the complete failure of this EIA, the general importance of EIAs remains undeniable. EIAs can be a valuable tool to guide responsible decisions on programs and projects that could negatively affect the environment. They must not be misused as an instrument of propaganda for or against certain economic projects.

   The example of the EIA on the Hydrovia Project shows that the practice of environmental impact assessment is still insufficient. Future EIAs should include improving the terms of reference and quality control, giving EIA more weight in the political process of decision making, and should be given more weight in the elaboration of EIAs, and participation of the interested and affected public must be encouraged.

e) The scientific basis for sustainable, environmentally sound development planning can only be provided by or in co-operation with the regional institutions devoted to research and planning (e.g., in Brazil, EMBRAPA, IBAMA, and regional universities). Though the EIA obviously failed to use all information available, and despite the recent considerable increase in research in the region concerned, many aspects will need more intensive study. Therefore, secure funding for these institutions is also an issue.

f) Regional and international NGOs should be accepted as critical partners in the search for sustainable solutions for social and ecological problems affecting the basin.

CHAPTER 10 WWF'S CONCLUSIONS

by André Leite

10.1 Specific Technical Conclusions of the EIA

WWF's scientific panel for this independent review of the EIA for the Hydrovia Paraguay-Paraná Project has reached the following conclusions:

a) Both the technical plans and the EIA for the Project are faulty, incomplete, and inconclusive, and are therefore inadequate as the basis for political decisions concerning the Project. The main conclusions of the EIA, which are generally optimistic regarding the impacts of the Project, are either unfounded or inaccurate, due to a multitude of errors. Those errors are conceptual, methodological, calculatory, and factual, and are found in almost all parts of the EIA.

b) As the EIA consistently underestimates or ignores sources of impacts, it is likely the real impacts will be much more serious. The Project has the potential to seriously affect natural resources at a regional, national, hemispheric, and global level. The consequences could negatively affect the lives of the millions of people who depend on such things as flood control and healthy water from the rivers. It could also affect natural environments of global importance (e.g., the Pantanal), as acknowledged, for instance, in the Brazilian constitution.

c) The hydrological impacts of the Project deserve the most thorough analysis, as they are likely to have irreversible and serious consequences for humans and the natural environment. However, the modeling of the hydrological impacts in the EIA proved to be unreliable, as the simulated data of water discharge, water levels, and flooding of the Pantanal were unrealistic. In addition to these flaws, interpretation of the simulated impacts was inadequate and bound to underestimate the magnitude of impacts.

d) Evaluation of the impacts for the Project concerning the natural environment is based in large part on subjective and unsubstantiated opinions, not on a scientifically sound assessment and analysis. Quantification of impacts was only attempted for a few aspects, as a rough estimation of the proportion of landscape features and vertebrates (birds, reptiles, and mammals). This attempt contained errors on the distribution and ecology of species, and a fundamental underestimation of the magnitude of dredging, making the results and interpretation in the EIA worthless. The EIA fails to contain estimations on the distribution and population sizes of species and identification of key habitats.

e) The EIA is inadequate as a document for public distribution and consideration, as it is excessively voluminous (more than 3,300 pages), expensive (more than U.S. $1,000), and difficult to obtain. Its awkward structure, confusing and contradictory concepts, methods and definitions of terms, incomplete documentation of data, poor illustrations, and unnecessary and repetitive tables leaves this document far from appealing to read or suitable for analysis.

10.2 General Conclusions of the EIA and the Engineering-Economic Feasibility Analysis

EIAs are valuable tools to estimate and evaluate potential consequences of projects and thus to guide decision-making on their size and implementation. In order to be effective, EIAs must be clear, objective and conclusive. If not, they are unable to serve as reliable decision-making tools.

Certainly there are many reasons why the studies failed to produce the expected results: time was short, the region was too vast, and existing information was widely dispersed and often not readily accessible. All this might have been excusable if the studies did not maintain that the results and conclusions were generally reliable and valid.

WWF advises that the EIA should not be considered conclusive as the available data is limited and the existing data is unreliable. It is therefore not possible to rely on the its conclusions. The EIA does not provide a solid foundation as a decision-making tool, regardless of various political, economical, engineering or environmental alternatives. Any decisions based on the EIA's conclusions will be premature, possibly incorrect, with the potential for causing irreversible damage to the environment.

WWF advises that HLBE's Economic and Feasibility Analysis is seriously flawed and should not be used as a basis for evaluating the economic feasibility of the Hydrovia Project. WWF's analysis showed that correcting these errors, either singularly or in concert with one another, lead to an economic evaluation which does not support the Hydrovia Project as proposed by HLBE. That is, a corrected evaluation of the scenarios identified by HLBE showed negative net economic returns which will not contribute to improving the general welfare of the population of the region.

Therefore, based on all the evidences reached by WWF's scientific and economic panels, it is recommended that the Project be halted, only to be reinitiated after a meticulous critical analysis be conducted.

People living in the region of the Hydrovia Project will suffer the consequences of misguided decisions. They deserve, a more serious, competent, and comprehensive consideration of impacts concerning their future.

APPENDIX

The following sections list the locations of specific topics in the EIA report produced by HLBE (1996) and TGCC (1997). Unless otherwise noted, references are to pages in the specified documents.

1. Where to find information about the engineering aspects of the Project

a) Recent conditions of the Project
TGCC: 1-3 to 1-6

b) Alternatives and activities planned
HLBE: Pages 1-14 to 21 (alternative sizes of convoys, techniques and amounts of dredging); 7-3 to 7-8 (method of determination of the channel depth); 9-10 to 9-13 (technical details of dredging); appendix 9.3 (estimations of amounts of dredging for different alternatives for Module A)

c) Disposal of dredged material
HLBE: 9-8 to 9-10; 12-12;
TGCC: 1-19 to 1-20 (general plans for the treatment and disposal of dredged material); 10-49 to 10-50 (impact of disposal of dredged material on the river morphology); 10-57 (classification of the impacts of the disposal of dredged material); 11-13 to 11-14 (potential impacts of the disposal on terrestrial biota -differing from chap. 10.4.2); 13-9 to 13-10 (method of disposal); 14-34 to 14-43 (guide for the dredging and disposal of dredged material); appendix 14B (disposal of dredged material on land); appendix 14C (beneficial use of dredged material)

d) Navigation
HLBE: 9-19 to 9-23 (actual and future situation); 10-59 to 10-81 (impacts of the Project on transport systems)

2. Where to find information on legal and conceptual aspects of the Project

a) EIA
TGCC: 1-2 to 1-12 (legal base of the EIA); 2-15 to 2-22 (concept of the EIA); appendix lB (legislation)

b) Public participation
TGCC: 2-1 to 15 (meetings and documents)

3. Where to find information on hydrology aspects of the Project

a) Hydrological models used
TGCC: 3-88 to 3-104 (selection, description, validation of models); 8-44 to 8-48 (brief repetition of description); 9-35 to 9-65 (calibration and results of hydrological modelling)

b) Climate
TGCC: 3-1 to 3-5 (general description); 3-73 (source of precipitation data); 3-83 to 3-85 (selection and manipulation of data for modelling); 3-93 (data used for SWAT: meteorological stations, precipitation, temperatures); 8-45 (repetition of chapters 3.5.1.3 and 3.5.3); 10-84 to 10-86 (impact on climate); appendix 3E: Table 3 (meteorological stations)

c) Hydrology and hydraulics
TGCC: 3-70 to 3-71 (general sketch of data base), 3-74 to 3-80 (river net, gages used, hydrological regimes; HRUs); 8-44 to 8-45 (partial repetitions of chap. 3.5.1); 9-37 to 9-58 (results of hydrological models); 10-1 to 10-13 (evaluation of impacts); 11-2 to 11-11 (influence of hydrology on vegetation); Table 13.1 (classification of impacts); 13-5 to 13-24 (brief summary of evaluation); 14-6 to 14-9 (monitoring)

d) Groundwater
TGCC: 3-39 to 3-63 (general description of aquifers); 8-40 to 42 (much abbreviated version of chap. 3.3: 3-39 to 63); 10-10 (impact on groundwater); 10-13 to 10-18 (evaluation of impacts); appendix 3C (description of aquifers)

e) Soils
TGCC: 3-64 to 3-70 (general description, classification, characteristics); 3-81 (soil types of the HRUs); 8-43 (very general remarks about the soils of the countries of the Project); appendix 3D (comparison of different soil classification schemes, characteristics)

f) *Geology*
TGCC: 3-19 to 3-29 (general description); 8-34 (duplicates chap. 3.3.2: 3-29ff); appendix 3B

g) Topography/ geomorphology
TGCC: 3-29 to 3-39 (general description; geomorphological control points); 8-34 to 8-40 (almost exact repetition of 3-29 to 3-36, with minor modifications); 10-36 to 10-58 (evaluation of impacts on river morphology, erosion and sediments)

h) Land use
TGCC: 3-81 to 3-83 (transformation of land use data for SWAT); 6-6; 9-1 to 9-19 (calculation of land use changes); Table 9.4.1 (future land cover); appendix 1B: 1B-18 to 1B-19 (legislation)

4. Where to find information on vegetation and landscape feature aspects of the Project

a) Vegetation and landscape structures
TGCC: 4-1 to 4-22 (general description); 9-4 to 9-19 (land use change); 11-1 to 11-52 (evaluation and mitigation of impacts); 13-15 to 13-16; 13-26 (summary of earlier findings); 14-16 to 14-17 (monitoring); appendix 1B: 1B-32 to 1B-35 (forest legislation); appendix 11A; appendix 11B; appendix 11C (tables and figures)

b) Ecological land classification
TGCC: 7-1 to 7-52 (definition and description of ecosections); 8-1 to 8-14 (brief summary of chap. 7)

5. Where to find information on fauna

a) Fauna general
TGCC: 4-23 to 4-127 (selection of indicator species); 7-40, 7-44 to 7-47 (fauna and ELC); 8-14 to 8-22 (repetitions of chap. 4.2); 11-52 to 11-101 (evaluation and mitigation); 13-15 to 13-16, 13-26 to 13-27 (summary of assessment); 14-17 to 14-18 (monitoring); appendix 113: 1B-28 to 1B-32 (legislation); appendix 4A (tables); appendix 7C to 7E; appendix 11D (index of aptitude of habitat)

b) Amphibians
TGCC: 4-117 to 4-121 (general description); 8-15, 8-20 to 8-22 (selection of indicator species); appendix 4A (statistics), Table 17 (ranking of indicator species); appendix 7C to 7E

c) Reptiles
TGCC: 4.103 to 4-117 (general description); 8-14 to 8-15, 8-19 to 8-22 (selection of indicator species); appendix 4A (statistics), Table 16 (ranking of indicator species); appendix 7C to 7E

d) Birds
TGCC: 4-33 to 4-78 (general description); 8-14 to 8-18, 8-21 to 8-22 (selection of indicator species); appendix 4A (statistics), Table 14 (ranking of indicator species), Tables 18 to 22 (species observed); appendix 7C to 7E

e) Mammals
TGCC: 4-79 to 4-103 (general description); 8-14, 8-22 (selection of indicator species); appendix 4A (statistics), Table 15 (ranking of indicator species), Table 23 (species observed); appendix 7C to 7E

f) *Field studies*
TGCC: 4-121 to 4-125 (species observed); 11-61 to 11-78; appendix 4A (species observed)

6. Where to find information on aspects relating to the aquatic invertebrate fauna

a) Morphology of rivers
TGCC: 3-29 to3-35 (general description); 3-103 to 3-104 (quantity of sediment transport); 8-34 to 8-39 (repetition of chap. 3.2.3); 10-36 to 10-58 (results of assessment of impacts on river morphology)

b) Aquatic fauna
TGCC: 4-128 (sources of data); 8-28 to 8-30 (brief and confused summary of earlier chapters, e.g., 4142); 13-16 to 13-17 (summary of impacts, Module A); 13-27 to 13-29 (summary of impacts, Module B2)

c) Periphyton
TGCC: 4-131 (field studies: methods); 4-141 to 4-144 (bibliographic revision); 4-184 to 4-186 (field studies: results); appendix 4B (field studies: results, Figs. 1 to 18)

d) Benthos
TGCC: 4-132 (field studies: methods); 4-144 to 4-146 (bibliographic revision); 4-186 to 4-187 (field studies: results); 13-9; appendix 4B (field studies: results, Figs. 19 to 38)

7. Where to find information related to aspects of water and sediment quality

TGCC: 3-105 to 3-112 (bibliographic review), 3-112 to 3-122 (field studies); 8-48 to 8-52 (brief repetition of chap. 3.6); 9-57 to 9-65 (Tamengo Channel); 10-19 to 10-36 (brief repetition of chap. 8.3.6, results of impact assessment); 13-12 (summary of impacts, Module A); 13-23 (summary of impacts, Module B2); 14-9 to 14-15 (monitoring); 14-21 to 14-26 (monitoring); 14-26 to 14-34 (emergency program for accidental release of pollutants); 14-39 to 14-42 (control of turbidity); appendix 1B: 1B-45 to 1B-46 (international treaties); appendix 3F (Table of historical and recent data); appendix 14A (treatment of contaminated sediments)

8. Where to find information on fish and fisheries

a) Fish and fisheries general
TGCC: 4-128 to 4-141 (general description); 4-147 to 4-184 (field studies); 4-187 to 4-198 (special problems); 8-22 to 8-28 (brief summary of EIA-chap. 4.3); 11-102 to 11-145 (evaluation and mitigation); 13-16, 13-27 (repetition of EIA-chap. 11.3.8); 14-18 to 14-19 (proposals for monitoring)

b) Field studies
TGCC: 4-129 to 4-131; 4-147 to 4-184

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GLOSSARY

ADTP	Tietê-Paraná Development Agency
B.A.	Bachelor of Arts
BAP	Upper Paraguay Basin
BID	Inter-American Development Bank
B2w/F2E1	Scenario that would accommodate four-by-five barge trains on the Santa Fe-Asunción reach with a three-meter deep channel, four-by-four barge trains on the Asunción-Corumbá reach with 2.6-meter deep channel, and one-by-two barge trains on the Corumbá-Cáceres reach with a 1.8-meter deep channel
B/C	Benefit-Cost Ratio
CEBRAC	Fundação Centro Brasileiro de Referência e Apoio Cultural
CECOAL	Centro de Ecologia Aplicada del Litoral
CEMAVE	Brazilian Banding Agency
CES	Available knowledge on a specific species (fauna)
CIH	Intergovernmental Committee on Hydrovia
CITES	Convention on International Trade in Endangered Species of Wild Flora and Fauna (1975)
CMS	Convention on Migratory Species
CMO	Capability to be monitored (fauna)
COINTA	Taquari River Basin Sustainable Development Consortium
CONAMA	National Council on the Environment (Brazil)
CPAP	Agricultural Research Centre for the Pantanal
CPTCP	Comision Permanente de Transporte de la Cuenca del Plata
CPUE	Capturas por Unidad de Esfuerzo (Fisheries)
DAE	Distribution on the researched area (fauna)
DAP	Diameter taken at breast height
DIA	Environmental Impact Declaration (Paraguay)
DNOS	Departamento Nacional de Obras de Saneamento
DINAMA	National Department of the Environment
EAP	Endangered species (fauna)
EDF	Environmental Defense Fund
EDIBAP	Estudos de Desenvolvimento Intergrado da Bacia do Alto Paraguai
EE.UU.	United States of America (U.S.A.)
EIA	Environmental Impact Assessment; report produced by TGCC
ELC	Ecological Land Classification
EMBRAPA	Brazilian Agricultural Research Corporation
ETP	Evapotranspiration
EXE	Ecoregional exclusivity (fauna)

E2E1	Scenario that would accommodate four-by-four barge trains on the Santa Fe - Asunción reach of the Paraguay-Paraná Rivers with a three-meter deep channel, and four-by-four barge trains on the Asunción-Corumbá reach of the Paraguay River with a 2.6-meter deep channel
FAO	Food and Agricultural Organization
FHAU	Fish habitats and anthropic use
FONPLATA	Financing Fund for the Development of La Plata Basin
FITRAS	Pulse function (phase frequency, intensity, tension, regularity, amplitude, seasonality)
F2E1	Scenario which would accommodate four-by-five barge trains on the Santa Fe-Asunción reach with a three-meter deep channel, and four-by-four barge trains on the Asunción-Corumbá reach with a 2.6-meter deep channel
GIS	Geographical information system
HEP	Habitat evaluation procedures
HES	Habitat evaluation system
HLBE	Hidroservice, Louis Berger, and EIH; consortium of consulting firms responsible for the engineering-economic analysis of the Project
HPP	Hydrovia Paraguay-Paraná
HRU	Hydrologic response units
HIS	Habitat suitability index
HU	Habitat units
IAH	Index of aptitude of habitat or Index of habitat suitability
IBAMA	Brazilian Institute for the Environment and Natural Renewable Resources
IBGE	Brazilian Institute of Geography and Statistics
IDB	Inter-American Development Bank
INDEC	Instituto Nacional de Estadistica y Censos
IRR	Internal Rate of Return
IUCN	International Union for the Conservation of Nature and Natural Resources
ICV	Instituto Centro de Vida
LIDEMA	The Bolivian League for the Defense of the Environment
M.A.	Master of Arts
M.A.S.L	Meters above sea level
M.S.	Master of Science
MERCOSUR	Southern Cone Common Market
NAFTA	North America Free Trade Agreement
NGO	Non-Governmental organization (ONG)
NOAA	National Oceanic and Atmospheric Administration (US)
NPV	Net present value
ONU	United Nations Organization
OEA	Organization of American States (OAS)
OMM	World Meteorological Organization (WMO)
ONG	Non-Governmental organization (NGO)
PAH	Polycyclic Aromatic Hydrocarburates
PCBAP	Environmental Conservation Plan for the Higher Paraguay Basin
PCU	Project Co-ordination Unit

PDHBG	Primarily dependent on wetlands of gallery forests
PEH	Habitat evaluation procedures (HEP)
PETROBRAS	Petroleo Brasileiro South America
Ph.D.	Doctor of Philosophy (Doctoral Degree)
PNUD	United Nations Development Program
PNUMA	United Nations Environmental Program (UNEP)
PREVI	Pension Fund of Banco do Brasil
RCA	Representativity of an ecological category
REC	Ecological relevance (fauna)
REMA	MERCOSUR specialized meeting on the environment
S.T.D.	Sólidos Totales Disueltos
SCEPESCA/MS	Fishing Control System of the State of Mato Grosso do Sul
SEAP	Sensibility of endangered or threatened species by taxon (fauna)
SNLCS	National Service for Research and Conservation of Soils in Brazil
SPO	Potential sensibility by the project (fauna)
SES	Socioeconomic status (fauna)
STF	Total sensibility of the fauna
STFAP	Total sensibility of the endangered and threatened fauna
SWAT	Soil and water assessment tool
TGCC	Taylor, Golder, Consular, and Connal; consortium of consulting firms responsible for the engineering-economic analysis of the Project
THALWEG	It is the locus of deepest flow in a river channel. In a winding channel, the thalweg joins the bottoms of the pools, winding from side to side of the channel, not exactly in phase with the channel bends. It derives from the use by European boatmen referring to the navigable part of the channel.
TSS	Total suspended sediments
UE	European Union
UH	Habitat units
UHE	Seasonal habitat units
UICN	IUCN
UN	United Nations
UNDP	United Nations Development Program
UNEP	United Nations Environmental Program (PNUMA)
UNET	Hydrological model used by TGCC
UNOPS	United Nations Office for Project Services
U.S.	United States of America
VEC	Valued ecosystem components
WHSRN	Western Hemisphere Shorebird Reserve Network
WMO	World Meterological Organization
WWF	World Wildlife Fund/World Wide Fund for Nature

PANEL OF EXPERTS

ANDERSEN, Sigrid. M.A. Brazil. Ms. Andersen is currently working as an environmental consultant and professor for MERCOSUR and the environment in post-graduate courses in Brazil. With a background in sociology, Ms. Andersen is a specialist in environmental planning and management and is working toward a doctoral degree in geopolitics and the environment at the University of Aberdeen, Scotland. Ms. Andersen has carried out research for the Economic Commission for South America and the Caribbean.

DANTAS, Mário. Ph.D. Brazil. Dr. Dantas has been the director general of the Agriculture Research Center for the Pantanal (EMBRAPA) for the last five years. He received a master of science degree in ecology from the National Research Institute for the Amazonia/Amazonas University Foundation (INPA/FUA) in 1978, and a doctoral degree in plant ecology from Oxford University in 1989. He worked for 20 years in the Brazilian Amazon region carrying out research on ecology of cultivated pasture, sustainable production systems, and plant succession after clear-cutting of the tropical rain forest. More recently, he worked on an environmental impact assessment of intensive agricultural systems in Ribeirão Preto, Brazil. Dr. Dantas also takes part in two Interamerican Institute for Agriculture Co-operation (IICA) programs: Co-operative Program on Research and Transfer of Technology for the South American Tropics (PROCITROPICS), and the Co-operative Program for the Development of Agricultural Technology in the Southern Cone (PROCISUR). On the latter, he acts as the international co-ordinator for natural resources. Dr. Dantas is a member of the International Association of Environmental Impact Assessment.

DE FRANCESCO, Fernando, O. B.A. Argentina. Mr. De Francesco, Senior Professor of Geomorphology and Environmental Geology, and Director of Research Projects on Geomorphology at the National University of La Plata (UNLP), Argentina, received his bachelor's degree in geology from UNLP in 1968. He was the technical representative and chief of study commissions on the Yacyreta Project (1978-1982); a member of the consulting group for the EIA of the World Bank for Argentina's Flood Defense Projects on the Paraná-Uruguay Rivers (1995-1996); and a consultant for the EIA with regard to industrial development and geological aspects of hydroelectric projects. He has published more than 40 papers related to geology, geomorphology, and the environment.

HUSZAR, Paul, C. Ph.D. United States. Dr. Huszar is an internationally recognized expert with more than 20 years experience in natural resource and environmental economics. He is currently a professor and graduate program director in the department of agricultural and resource economics at Colorado State University. Dr. Huszar received a bachelor of science degree in mathematics and a master of science degree in economics from Colorado State University, and a doctoral degree in agricultural economics from the University of California at Berkeley. Dr. Huszar has considerable research and teaching experience in the field of economics including extensive work with international development agencies, especially United States Agency for International Development (U.S.A.I.D.). In addition to his long-standing position as professor of economics at CSU, Dr. Huszar served for three years as director of technical support to a mission for U.S.A.I.D. in Jakarta, Indonesia, and completed a number of projects analyzing the economic impacts of agricultural development in that country. He has also been involved in sustainable development research in Latin America. Dr. Huszar has published over 35 articles and books, and has presented over 40 professional papers. He has been a consultant to the Commodity Exchange Authority, the Boulder Area Growth Study Commission, the Bureau of Reclamation, the Fort Collins City Council, the Larimer-Weld Council of Governments, the U.S. Bureau of Land Management, the U.S. Environmental Protection Agency, the U.S. Soil Conservation Service, and others. He is a member of the Western Regional Science Association, the Western Regional Economica Association, the American Agricultural Economics Association, and the International Erosion Control Association. His related publications on the Hydrovia Project include.

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LEITE, André. M.A. Canada-Brazil. Mr. Leite, Director, Hydrovia Paraguay-Paraná campaign for the international conservation organization, World Wildlife Fund (WWF) Canada, holds a master of arts degree in political science with specialization in environmental studies from the University of Toronto, Canada; and a bachelor of arts degree in international relations from the University of Brasilia, Brazil; a bachelor of arts degree in business administration from the University of Brasilia; and a bachelor of arts degree in economics from the Unified Teaching Center of Brasilia. His work experience includes the management of sustainable development projects in Costa Rica, Honduras, and Brazil for WWF Canada. Formerly, Mr. Leite was responsible for the co-ordination of international development projects for the Department for International Development (DFID), based in Brasilia, as part of Britain's official program for bilateral development co-operation with Brazil. Due to his knowledge about La Plata Basin, Mr. Leite has been invited to participate as a guest speaker at a number of international conferences on river management, including "Hydrovia: Bright Future or Development Nightmare?" at Harvard University. Mr. Leite has done aerial surveys of the Paraguay River from Corumbá to Cáceres and has visited many sites of La Plata Basin. Currently, Mr. Leite is responsible for the co-ordination of a group of scientists who are identifying the number of Canadian shorebirds that migrate from Canada to the Pantanal during the boreal winter.

LOZANO, Luis Garcia. Ph.D. Colombia. Dr. Garcia is the scientific co-ordinator of the Neotropical Foundation, an environmental NGO based in Medellin, Colombia. Since 1990, Dr. Garcia has carried out a long-term project of floodplain habitat restoration on the lower Magdalena River, in co-operation with WWF-Auen-Institut (Institute for Floodplains Ecology), Rastatt, Germany. Dr. Garcia is an expert on environmental impact assessment (EIA) of development projects associated with rivers with floodplains. After earning a master of science degree in zoology at the University of Tampa, U.S., Dr. Garcia received his doctoral degree from the University of Saarlandes, Germany. Dr. Garcia has extensive experience researching the dynamics of floodplains of the Rhine River (Germany), the Magdalena, Cauca, and Sinu Rivers (Colombia) and the Paraná, Paraguay, and Uruguay Rivers (Argentina). He has evaluated over 20 EIAs and has published more than 40 papers on his field of expertise.

MORRISON, R.I. Guy. Ph.D. Canada. Dr. Morrison, a research scientist on shorebirds with the Canadian Wildlife Service (CWS), National Wildlife Research Center, Environment Canada, was educated at St. Andrew's University, Scotland (bachelor of science degree), and Cambridge University, England (doctoral degree). Dr. Morrison has carried out research on shorebirds for CWS since 1973, including extensive distributional studies in Latin America. His publications include, *Migration systems of some New World Shorebirds (1984), Atlas of Nearctic shorebirds on the coast of South America* (1989), *Atlas of Nearctic shorebirds and other waterbirds on the coast of Panama* (1998).

OBRDLIK, Petr. Ph.D. Czech Republic-Germany. Dr. Obrdlik, associate professor of ecology, was educated at the University of Brno, and Academy of Sciences, Prague, Czech Republic. His professional experience includes being the scientific officer for WWF-Auen-Institut (Institute for Floodplains Ecology), Rastatt, Germany, since 1987; scientific officer and head of the Environmental Research Laboratory National Council for Scientific Research, Lusaka; Zambia, 1982-1985; and scientific officer for Water Research Institute in Prague, Brno-Branch, Czech Republic, 1969-1982. Dr. Obrdlik has focused on limnology and biomonitoring of the floodplains of large alluvial rivers; ecology management of the floodplain landscape for flood control measures on the Upper Rhine River, Germany; environmental impact assessment study on the Loire River development, France; restoration and reintroduction of species in floodplain, Czech Republic; and invertebrate analysis as a predictor of wetland ecosystem processes and responses to anthropogenic stress (EC DGXII STEP Project-Functional Analysis of European Wetland Ecosystem), France and Ireland. Dr. Obrdlik has published over 50 papers in national and international journals.

PEDRONI, Raúl Mario. B.A. Engineering. Argentina. Mr. Pedroni is the director of Hagler Bailly & Estudio Q, in Argentina. He has a bachelor of arts degree in civil engineering with a specialization in hydraulics from the National University of Buenos Aires, and has taken many courses in Argentina and Brazil on watershed management. Mr. Pedroni has been an independent consultant for the Inter-American

Development Bank and other international organizations, and has managed hydraulic projects for more than 25 years. He has undertaken a number of technical evaluations for hydroelectric projects, dams, waterways, and flood control. Mr. Pedroni has published a number of papers on river management.

PETERMANN, Peter. M.A. Germany. Mr. Petermann is a freelance geographer and ornithologist, and collaborator of WWF-Auen-Institut (Institut for Floodplains Ecology), Rastatt, Germany. He has undertaken scientific studies in the Brazilian Amazon with the Max-Planck-Institute working group on Tropical Ecology and has been on several scientific visits to other countries in South America and Africa. Mr. Petermann was educated at the University of Saarbrucken, Germany.

RAST, Georg. B.A. Engineering. Germany. Mr. Rast is a reknowned civil engineer, specializing in hydraulics and water management. He is a staff member of WWF-Auen-Institut (Institute for Floodplains Ecology), Rastatt, Germany, where he is involved in comprehensive ecological studies on river related issues. He received his bachelor of arts degree in civil engineering with specialization in water engineering and water management from the University of Munich, Germany. He is an expert on dams, waterways and flood related issues. Mr. Rast has completed several international studies and consultancy work in countries such as Sweden, Japan, Nepal, Korea, Poland, and Romania. He is a lecturer at the University of Paderborn/Höxter (Germany) on ecological oriented river engineering and water management, and has contributed to a large number of international conferences on river management.

RESENDE, Emiko. Ph.D. Brazil. Dr. Resende works at the Agricultural Research Center for Pantanal belonging to the Brazilian Agricultural Research Corporation, EMBRAPA. She has earned a master of science degree and doctoral degree from the Oceanographic Institute of São Paulo University, Brazil, and has taken specialized courses on environmental assessment and management at Aberdeen University, Scotland, and an International Biodiversity Measuring and Monitoring course at Front Royal, Virginia, U.S. Dr. Resende's publications include 30 papers on biology and ecology of Brazilian fishes (mainly Pantanal freshwater fishes) and some papers on the impact of pesticides and heavy metals on aquatic communities. Formerly a secretary for the environment at Mato Grosso do Sul State, from 1991 to 1994, Dr. Resende has a lot of experience, especially on the impact of construction dams for hydroelectric power generation.

SCHNACK, Enrique, J. Ph.D. Argentina. Dr. Schnack is currently the principal research scientist for the Province of Buenos Aires Research Council in the Laboratory of Coastal Oceanography at the National University of La Plata (UNLP), Argentina. He received postdoctoral experience at the University of Reading, United Kingdom, and at Stanford University, California. Dr. Schnack received both his bachelor of science degree in geology, and his doctoral degree in natural sciences from UNLP, Argentina. He was the founding director of the Center of Coastal Geology, professor of geological oceanography (19791988), and professor of environmental geomorphology (1982-1983), at the University of Mar del Plata, Argentina. He was also a member of the consulting group for the EIA of the World Bank for Argentina's Flood Defense Projects on the Paraná-Uruguay Rivers (1995-1996). He has published over 40 papers on geomorphology, and coastal and quaternary geology.

SCHNACK, Juan, A. Ph.D. Argentina. Dr. Schnack is currently the principal research scientist for the Scientific National Research Council (CONICET) at Museo de La Plata, the National University of La Plata (UNLP). He received both his bachelor of science degree in zoology, and his doctoral degree in natural sciences from UNLP, Argentina. His work related experience includes being a Guggenheim Fellow at the Stroud Water Research Center, Academy of Natural Sciences of Philadelphia (1974-1975); director of the Institute of Limnology (UNLP-CONICET) (1982-1986); president of the Argentinian Association of Limnology (1981-1986); and head of the consulting group for the EIA of the World Bank for Argentina's Flood Defense Projects on the Paraná-Uruguay Rivers (1995-1996). He is the author of more than 70 scientific papers on aquatic and terrestrial zoology, and ecology.

SCHNEIDER, Erika. Ph.D. Germany. Dr. Schneider has been a staff member of WWF-Auen-Institut (Institute for Floodplains Ecology), Rastatt, Germany, since 1985. She is an expert in plant ecology, wetland conservation and restoration, and has undertaken impact assessments of rivers, such as the Rhine, Loire, Elbe, and Danube, as well as project management of the Danube River and delta. Dr. Schneider was educated at the Babes-Bolyai University of Cluj, Romania, where she received her master of science degree in biology, with a specialization in botany and vegetation science, and her doctoral degree in vegetation science and plant ecology. In addition to her employment at WWF-Auen-Institut, her work experience includes, head of the botany department at the Museum of Natural History in Sibiu, and the department of botany at the Romanian Academy of Science in Cluj. She has published several scientific papers and reports on wetland restoration, and ecological evaluations of impact studies.

WASSON, Jean-Gabriel. Ph.D. France-Bolivia. Dr. Wasson is a hydrobiologist, and received his doctoral degree in ecology of running waters at the University of Grenoble, France, in 1975. Dr. Wasson resides in La Paz, Bolivia where he is a member of the French Institute of Research for the Development in Cooperation, (ORSTOM). He is the former head of a research unit at Cemagref (Engineering Research for Agriculture and the Environment) in Lyon, France. His research projects include the influence of physical habitat on aquatic biota, and ecological impacts of river engineering; regionalization and management of large river basins; and river ecosystems in the Bolivian Amazonian basin. His publications include more than 15 recent papers and numerous public reports, including, *The impact of fluvial navigation on aquatic ecosystems* (1983); *Ecological study of the Saône River (impacted by navigation),* (1984); Integrated management of river ecosystems (1992); *Ecosystemic approach of the Loire River basin* (1993); and *Ecological impacts of river channelization* (1995).

WENGER, Edith. Ph.D. France. Dr. Wenger is the deputy director of WWF-Auen-Institut (Institute for Floodplains Ecology), Rastatt, Germany, where she is responsible for political and legal issues and for international networking related to the management of rivers and floodplains. Dr. Wenger has a doctoral degree in political sciences (University of Strasbourg, France), and her background includes degrees in environmental law, European affairs, and development issues, from the University of Strasbourg, University of Paris, and University of Piracicaba, Brazil. Dr. Wenger has contributed to a number of articles on environmental issues in scientific journals and magazines, and has participated in a series of international conferences on river related issues.

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WWF NETWORK

International Secretariat

WWF INTERNATIONAL
Avenue du Mont-Blanc
CH-1196 Gland, Switzerland
Tel.: + 41 22 363 9111

National Organizations

WWF AUSTRALIA
GPO Box 528, Sydney
NSW 2001
Tel.: + 61 29 299 6366

WWF AUSTRIA
Postfach 1, 1162 Vienna
Tel.: + 43 1489 16 41

WWF BELGIUM
608 Chaussée de Waterloo
1050 Brussels
Tel.: +32 2 340 09 99

WWF-BRAZIL
SHIS ED QL 6/8,
Conjunto E - 2 andar
71620-430 Brasília
Tel.: + 55 61 248 2899

WWF CANADA
245 Eglinton Avenue East,
Suite 410
Toronto, Ontario M4P 3J1
Tel.: + 1 416 489-8800

WWF DENMARK
Ryesgade 3 F
2200 Copenhagen N
Tel.: +45 35 36 36 35

WWF FINLAND
Lintulahdenkatu 10, 00500
Helsinki 50
Tel.: + 358 9 774 0100

WWF FRANCE
151, Boulevard de la Reine
78000 Versailles
Tel.: + 33 1 39 24 24 24

WWF GERMANY
Hedderichstrasse 110, 60591
Frankfurt a/M
Tel.: +49 69 60 50 030

WWF GREECE
26 Filellinon Street,
10558 Athens
Tel.: +30 1 331 4893

WWF HONG KONG
GPO Box 12721
Tel.: + 852 2526 1011

WWF INDIA
P0 Box 3058
New Delhi 110 003
Tel.: +91 11 469 3744

WWF ITALY
Via Garigliano 57 00198 Rome
Tel.: +39 6 844 971

WWF JAPAN
Nihonseimei Akabanebashi Bldg
3-1-14 Shiba, Minato-Ku,
Tokyo 105
Tel.: +81 3 3769 1711

WWF MALAYSIA
Locked Bag No. 911, Jun Sultan
PO 46990 Petaling Jaya
Tel.: + 60 3 703 3772

WWF NETHERLANDS
Postbus 7, 3700 AA Zeist
Tel.: + 31 3069 37 333

WWF NEW ZEALAND
PO Box 6237, Wellington
Tel.: + 64 44 99 2930

WWF NORWAY
Postboks 6784, St Olavs plass
0130 Oslo
Tel.: + 47 22 20 37 77

WWF PAKISTAN
PO Box 5180, Ferozepus Road
Lahore 54600
Tel.: + 92 42 586 2359

WWF SOUTH AFRICA
PO Box 456, Stellenbosch 7599
Tel.: + 27 21 887 2801

WWF SPAIN
ADENA, Santa Engracia 6
28010 Madrid
Tel.: + 34 1 308 23 09

WWF SWEDEN
Ulriksdals Slott, 170 71 Soma
Tel.: + 46 8 624 7400

WWF SWITZERLAND
Postfach, 8010 Zürich
Tel.: +41 1 297 21 21

WWF UNITED KINGDOM
Panda House, Weyside Park,
Godalming, Surrey GU7 1XR
Tel.: +44 1483 426 444

WWF UNITED STATES
1250 24th Street, NW
Washington, DC 20037-1175
Tel.: + 1 202 293 4800

Associates

ARGENTINA. FUNDACION
VIDA SILVESTRE
Defensa 245/51, 6 Piso, 1065
Capital Federal, Buenos Aires
Tel.: +54 1 331 4864

ECUADOR. FUNDACION
NATURA
Casilla 17-01-253, Quito
Tel.: +593 2 447 341

NIGERIA. NIGERIAN
CONSERVATION
FOUNDATION
PO BOX 74 638, VICTORIA
ISLAND, LAGOS
TEL.: + 234 1 269 4021

PHILIPPINES. KKP
9 Malingap St
Teacher's Village, Diliman
Quezon City 1101
Tel.: +63 2 433 3220

TURKEY. DHKD
PK 18, Bebek 80810, Istanbul
Tel.: + 90 212 279 0139

VENEZUELA. FUDENA
Apartado Postal 70376,
Caracas 1071-A
Tel.: +58 2 238 2930

WWF aims to conserve nature and ecological processes by

- preserving genetic, species, and ecosystem diversity;
- ensuring that the use of renewable natural resources is sustainable both now and in the longer term, for the benefit of all life on Earth;
- promoting actions to reduce, to a minimum, pollution and the wasteful exploitation and consumption of resources and energy.

WWF's ultimate goal is to stop, and eventually reverse, the accelerating degradation of our planet's natural environment, and to help build a future in which humans live in harmony with nature.

WWF

WWF – World Wide Fund for Nature – is the world's largest and most experienced independent conservation organization. It has 4.7 million regular supporters and a global network active in 96 countries. WWF is known as World Wildlife Fund in Canada and the United States of America.