WCD Case Study

Pak Mun Dam
Mekong River Basin
Thailand

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The WCD Knowledge Base

This report is one component of the World Commission on Dams knowledge base from which the WCD drew to finalize its report "Dams and Development-A New Framework for Decision Making". The knowledge base consists of seven case studies, two country studies, one briefing paper, seventeen thematic reviews of five sectors, a cross check survey of 125 dams, four regional consultations and nearly 1000 topic-related submissions. All the reports listed below, are available on CD-ROM or can be downloaded from www.dams.org

Case Studies (Focal Dams)
- Grand Coulee Dam, Columbia River Basin, USA
- Tarbela Dam, Indus River Basin, Pakistan
- Aslantas Dam, Ceyhan River Basin, Turkey
- Kariba Dam, Zambezi River, Zambia/Zimbabwe
- Tucurui Dam, Tocantins River, Brazil
- Pak Mun Dam, Mun-Mekong River Basin, Thailand
- Glomma and Laagen Basin, Norway
- *Pilot Study of the Gariep and Van der Kloof dams- Orange River South Africa*

Country Studies
- India
- China

Briefing Paper
- Russia and NIS countries

Thematic Reviews
- TR I.1: Social Impact of Large Dams: Equity and Distributional Issues
- TR I.2: Dams, Indigenous People and Vulnerable Ethnic Minorities
- TR I.3: Displacement, Resettlement, Rehabilitation, Reparation and Development
- TR II.1: Dams, Ecosystem Functions and Environmental Restoration
- TR II.2: Dams and Global Change
- TR III.1: Economic, Financial and Distributional Analysis
- TR III.2: International Trends in Project Financing
- TR IV.1: Electricity Supply and Demand Management Options
- TR IV.2: Irrigation Options
- TR IV.3: Water Supply Options
- TR IV.4: Flood Control and Management Options
- TR IV.5: Operation, Monitoring and Decommissioning of Dams
- TR V.1: Planning Approaches
- TR V.2: Environmental and Social Assessment for Large Dams
- TR V.3: River Basins – Institutional Frameworks and Management Options
- TR V.4: Regulation, Compliance and Implementation
- TR V.5: Participation, Negotiation and Conflict Management: Large Dam Projects

- **Regional Consultations – Hanoi, Colombo, San Paulo and Cairo**

- **Cross-check Survey of 125 dams**

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- ABB
- ADB - Asian Development Bank
- AID - Assistance for India's Development
- Atlas Copco
- Australia - AusAID
- Berne Declaration
- British Dam Society
- Canada - CIDA
- Carnegie Foundation
- Coyne et Bellier
- C.S. Mott Foundation
- Denmark - Ministry of Foreign Affairs
- EDF - Electricité de France
- Engevix
- ENRON International
- Finland - Ministry of Foreign Affairs
- Germany - BMZ: Federal Ministry for Economic Co-operation
- Goldman Environmental Foundation
- GTZ - Deutsche Geschellschaft für Technische Zusammenarbeit
- Halcrow Water
- Harza Engineering
- Hydro Quebec
- Novib
- David and Lucille Packard Foundation
- Paul Rizzo and Associates
- People's Republic of China
- Skanska
- SNC Lavalin
- South Africa - Ministry of Water Affairs and Forestry
- Statkraft
- Sweden - Sida
- IADB - Inter-American Development Bank
- Ireland - Ministry of Foreign Affairs
- IUCN - The World Conservation Union
- Japan - Ministry of Foreign Affairs
- KfW - Kredietanstalt für Wiederaufbau
- Lahmeyer International
- Lotek Engineering
- Manitoba Hydro
- National Wildlife Federation, USA
- Norplan
- Norway - Ministry of Foreign Affairs
- Switzerland - SDC
- The Netherlands - Ministry of Foreign Affairs
- The World Bank
- Tractebel Engineering
- United Kingdom - DFID
- UNEP - United Nations Environment Programme
- United Nations Foundation
- USA Bureau of Reclamation
- Voith Siemens
- Worley International

- Rockefeller Brothers Foundation
- WWF International

Note:
COMMENTS ON THE JUNE 2000 DRAFT REPORT BY EGAT AND THE WORLD BANK

The Electricity Generating Authority of Thailand (EGAT) and The World Bank have made extensive comments on the June 2000 version of the draft final report. All the comments were carefully considered while revising the June draft. However, divergence of views still exists.

The EGAT's and the World Bank's comments are presented in Section 10 and 11 of the main report. Response to the comments from the study team is given below each of the comments or towards end of the section.

Executive Summary

The Pak Mun report is one of 8 case studies undertaken world-wide with a common methodology and approach that sought to inform the Commission on the performance and the development effectiveness of large dams. This case study concerns the Pak Mun Hydropower project, a run-of-the-river dam located near the confluence of the Mun and the Mekong River in the Northeast region of Thailand.

The report attempts to compare the planned intended outcomes and the actual results. The case study would provide an analysis of the performance and the manner in which decision-making processes have responded to an evolving social, economic and political context since project completion. The lessons learned from the planning and decision-making process will directly inform the Commission's findings and recommendations. Six central questions have been identified that are key to the World Commission on Dams (WCD) work programme and methodology. These questions serve to structure the information collection, discussion and assessment of the topics of performance and development effectiveness. The Pak Mun case study sought to address these questions:

1. What were the projected vs actual benefits, costs and impacts?
2. What were the unexpected benefits, costs and impacts?
3. What was the distribution of costs and benefits, who gained and who lost?
4. How were decisions made?
5. Did the project comply with the criteria and guidelines of the day?
6. How would this project be viewed in today's context?

The case study has primarily used existing data sources and reports to inform its assessment. Some additional research in selected areas has been undertaken. Assessing development effectiveness entails taking account of the views and perspectives of different stakeholders and project-affected groups. As an integral part of the methodology, in parallel to the study process, two consultation meetings were included. These meetings were intended to ensure that the views of different interest groups could be considered by the study team, and provided opportunities for comments and input.

The Pak Mun Project: Description

The Pak Mun Dam is built on the Mun River, 5.5km upstream from its confluence with the Mekong, in the province of Ubon Ratchathani, in Northeast Thailand. The dam is typed as roller compacted [1] concrete with a maximum height of 17m and total length of 300. The reservoir has a surface area of 60 square km at normal high water level of 108 metres above the mean sea level (MSL) and a capacity of 225 million cubic metres. The Electricity Generating Authority of Thailand (EGAT) built and operates the dam as a run-of-the-river hydropower plant. Its operating rules are designed to ensure that the water level does not rise above 106mMSL during the dry season, from January to May and retains a maximum level of 108m MSL for the rest of the year. The storage capacity of the dam's reservoir is essentially that of the pre-existing river channel.

When the Environmental Impact Studies conducted in 1982 indicated that approximately 4 000 households would be displaced if the reservoir was impounded to a level of 113 MSL. Therefore an alternative design with a normal water level of 108 MSL was agreed upon in 1985. The relocation of the dam site significantly minimised the extent of displacement to an estimated 248 households. The original project design was further modified by relocating the dam 1.5km upstream to avoid the submergence of Kaeng Tana rapids, an important environmental and tourist site. EGAT also decided to lower the reservoir to 106 MSL during dry season from January to May and to adjust the dam's operating regime to uncover the upstream Kaeng Saphue rapids. However a new environmental impact assessment (EIA) which may have identified and anticipated some of the new environmental impacts arising from the new location was not conducted at this stage.

What were the predicted versus actual benefits, costs, and impacts?

- **Cost of the project**[2]

In May 1989 the Cabinet approved the 17m high, 136 mega watt (MW) Pak Mun project with a budget of 3.88 billion Baht (US$ 155.2 million). In 1991 National Economic and Social Development Board (NESDB) approved the modified project cost of 6.6 billion Baht (US$ 264 million). The final cost tally by EGAT in 1999 was 6.507 billion Baht (US$ 260 million). In nominal terms the project costs increased by 68% from the original estimates between 1989-99. Not including taxes and interests during construction the cost overruns in nominal terms are 91% over original estimates in 1988. However, the analysis indicates that in real terms (calculated at constant 1998 prices) the cost overun was considerably less.

Compensation and Resettlement costs increased from 231.55 million Baht (US$ 9.26 million) in EGAT's 1988 estimates to an actual expenditure of 1 113.1 million Baht (US$ 44.24 million) till 1999. In real terms resettlement costs increased by 182%. Compensation for loss in fisheries, which was unanticipated in the original estimate, accounted for 395.6 million Baht by April 1999 (US$ 15.8 million).

- **Benefits - Hydropower**

Pak Mun dam is located at the end of a large watershed where rainfall and run off vary considerably between dry and wet seasons. During wet months Pak Mun can turbine the daily inflow to serve the 4 hour peak demand and in addition can generate power in off-peak hours with surplus water available. However during the dry months the plant cannot produce its full rated capacity for the 4 hour peak demand due to insufficient water.

The output of the plant depends on the water level in the reservoir and the tailwater level. The Pak Mun Dam's power production peaks in the wet season when it is least needed in the power system and is lowest in the dry season when it is most needed. When the water levels in the Mekong river are very high, the power plant will be shutdown for lack of generating head.

The operation records from the commissioning of the plant in 1994 indicate that Pak Mun's average annual output has been 290 Giga Watt per hour (GWh). This compares with the estimated average of 280 GWh. Pak Mun dam featured as a 136 MW, run-of-the-river project, to serve peaking needs in EGAT's presentation to the Cabinet as well as World Bank documents. However following the rules based on the daily power output data betweeen 1995-99, Pak Mun plant can use only 15% of its capacity as reliable 4 hour peak capacity. The actual dependable capacity of Pak Mun project calculated from daily power output between 1995-98 assuming that all available power gets assigned to a 4 hour peak demand period is only 20.81 MW. This 21 MW is what the Pak Mun project offsets in gas turbine capacity. However the value of alternative generating capacity adopted for comparative purposes by EGAT and sanctioned by the World Bank was much higher at 150 MW.

The actual operation of Pak Mun is often different from what was assumed in the planning studies. This type of operation may be beneficial from an ancillary services point of view (such as frequency and voltage regulation, Var control etc.), but the energy benefits will be less than planned.

Recalculating the project's equalising discount rate assuming that one would need one 21 MW gas turbine to provide the dependable capacity of a 20.8 MW hydro plant, the current report reaches a value of 7.88% which is below the shadow cost of capital in Thailand. When the benefits of the ancillary electricity net support of the dam and the green house gasses reduction benefit of the dam were included in the evaluation of the dam, these benefits were not sufficient to make the project economically justifiable.

EGAT and the World Bank indicated their disagreement with the finding. They explained that they looked at the overall power system at the planning stage. In the context of the whole system, it is possible that there would be enough (hydro) storage energy in the system to be able to cope with a dry year dry season output of Pak Mun. In the dry season, Pak Mun would be able to produce 136 MW over a number of hours, and that is enough to increase the output or start a thermal plant. It may not do that over an extended period, but that may not necessary. In that case the full 136 MW could be used for the capacity benefit[1].

- **Benefits - Irrigation**

The Pak Mun project was presented for review to the NESDB in 1988 and to the Cabinet of Ministers in 1989 as a multi-purpose development project. External financing for the project was secured through the World Bank's Third Power Project in 1991, which besides hydropower and irrigation, identified fisheries as a major benefit. Irrigation benefits were not included in the economic analysis justifying the project by the World Bank in its 1991 Staff Approval Report. The irrigation benefits of a run of river project were doubtful and this was known at the time the irrigation benefits were quantified in EGAT's project document.

- **Benefits - Fisheries**

About 7% of the project benefits were attributed to Fisheries in EGAT's 1988 Project documents.

The 1981 EIA predicted that fish production from the reservoir would increase considerably, though some fish species may be affected by the blockage of river flows by the dam. The fish yield expected from the 60 square km Pak Mun reservoir was 100 kg/ha/year without fish stocking and 220 kg/ha/year with the fish-stocking programme. However, run-of-the-river reservoirs cannot sustain such high yields, as they do not provide the appropriate habitat for pelagic fish species. In Thailand even storage reservoirs that perform better under fish stocking programmes have a fish yield of about 19 to 38 kg/ha/year. The predicted fish yield from Pak Mun head pond was too high. A more realistic estimate would have been around 10 kg/ha/year. There has been no evidence to indicate that the fish productivity of Pak Mun reservoir has reached anywhere near the anticipated 100 kg/ha/year.

The 1981 EIA valued the total annual predicted fish catch in the head pond at US$ 320 000 at the rate of 20 Baht per kg, without stocking. With stocking program the predicted catch would be worth US$ 693 000 at the rate of 20 Baht per kg. The 1981 EIA underestimated the total value of fishing yields that could be obtained from the free-flowing river. After the completion of Pak Mun dam, the lower Mun River experienced a decline in fishing yields with an estimated value of US$ 1.4 million per annum at 20 Baht/kg. In addition to this the decline in fish species upstream led to the closure of 70 Tum Pla Yon traps. At the price of 18 Baht/kg at the end of 1980s, the value of annual catch from these traps is calculated at US$ 212 000 per annum (1 US$ = 38 Baht). EGAT and the World Bank expressed their disagreement with the study team's findings. A detailed basis for the conclusion is presented in the annex related to EGAT's comments.

[1] The study team could not find system planning outputs, nor was it able to obtain documents referring to system studies. Pak Mun is situated in the NE region. According to many reports this region needed peaking capacity and for this reason Pak Mun was justified. This is not in line with WB and EGAT treating Pak Mun as a component of the whole system. Even if Pak Mun was part of the whole system, better alternatives to Pak Mun at a cheaper rate were available in Thailand (see endnote 63). The study team found no reason to alter the conclusions arrived in this study but the full explanatory comment provided by World Bank has been included as an annex to this report.

- **Impacts**

The 1982-83 Environmental Planning Survey predicted 241 households as displaced people. The actual number of households displaced by Pak Mun dam was 1,700. Unpredicted by the EIA, a large number of households were adversely affected due to declining fishing yields. Until March 2000, 6,202 households were compensated for loss in fisheries during the 3-year construction period. Compensation for the permanent loss of fisheries has not been given.

What were the unexpected impacts, if any?

- **Impact on Fish Migration & Fish diversity**

Of the 265 fish species recorded in the Mun-Chi watershed before 1994, 77 species were migratory and 35 species are dependent on habitat associated with rapids.[3] Available evidence does not indicate disappearance of any species before 1990, and nearly all species are very common ones to the region. Out of 265 species, about 10 were introduced species.

The decline has been higher in the upstream region. The latest survey recorded 96 species in the upstream region. Out of 169 species not found in the present catch, 51 species have been caught less significantly since the completion of the project. At least another 50 species of rapid dependent fish have disappeared, and many species declined significantly. Migratory and rapid dependent species were affected seriously as their migration route is blocked in the beginning of the rainy season, the head pond has inundated their spawning ground and the fish pass is not performing. Long-term studies are required to arrive at a firmer conclusion on the exact number of species that disappeared from Chi - Mun river basin after the construction of Pak Mun dam. The fish catch directly upstream of the dam has declined by 60-80% after the completion of the project.

There are divergent views on the extent that the decline in fish species could be attributed soley to the dam with the view being proposed that the reduction in fish species might have started prior to the study.

The Pak Mun case study concludes that the difference in number of species in fish surveys before and after dam construction may well be exacerbated by the cumulative impact of many different developments in the watershed. These include: water resources and hydropower development in Chi-Mun river watershed, deforestation, domestic waste water discharge, agriculture intensification and development, fisheries, industrial waste water discharge, saline soils and enforcement of water quality standards and classification. All these developments have contributed to a decline in fish species in the Mun/Chi watershed as a whole. The Pak Mun Dam cannot be blamed for the apparent disappearance of all these fish species. Cumulative impacts of all developments including the Pak Mun Dam have led to disappearance of fish species. Downstream of the Pak Mun project, one or two species of fish have completely disappeared from the catch after the dam construction.

Location of the dam on the Mun river 5.5 km upstream from its confluence with the Mekong has affected several migrating and rapid-dependent fish species. Thus, decline in and disappearance of several migrating and rapid-dependent fish species are directly attributable to the Pak Mun dam.

- **Performance of Fish Pass**

The project provided several mitigation measures, including a fish ladder to facilitate fish migration. Provision of a fish ladder was based on very little knowledge and experience. This mitigation plan came out at the time the dam construction was almost completed; and even then this important plan was not well prepared.
The 1981 EIA did not consider the construction of a fish ladder necessary for the Pak Mun dam but recommended the feasibility study of a fish way. The plan for a fish pass came at a time when dam

construction was almost completed. In effect, the fish pass was constructed after the completion of the dam at the cost of 2 million Baht (US$ 0.08 million). The fish pass has not been performing and is not allowing upstream fish migration. The project authorities have discontinued monitoring of the fish pass.

A vertical slot fish pass or a Denil fish pass instead of a pool and weir fish pass may have been more effective.

- **Reservoir Stocking as Mitigation**

Reservoir fishery was developed by EGAT in response to claims of declining fish catch. Total cost of stocking the head pond with fresh water Prawn (*Macrobrachium rosenbergi*) ranged between US$ 31 920 and US$ 44 240 annually between 1995-98. The Department of Fisheries estimates the total annual revenue of fishing yield to range between 1.2 to 3.2 million Baht. However the estimated annual catch and revenue for fishermen are too high. The Department of Fisheries in their revenue estimate included the naturally occurring Macrobrachium species that can breed in fresh water. The M. rosenbergi spawns in salt water and migrates to fresh water and therefore cannot establish a population under reservoir conditions. For this reason it may well turn out that the stocking of M. Rosenbergi in Pak Mun head pond is not generating any income for the fishermen. The project has discontinued fish and prawn stocking.

Impact on Livelihood

In the post-dam period fishing communities located upstream and downstream of the dam reported 50-100% decline in fish catch and the disappearance of many fish species. The number households dependent on fisheries in the upstream region declined from 95.6% to 66.7%. Villagers who were dependent on fisheries for cash income have found no viable means of livelihood since the dam was built, despite efforts to provide training opportunities. As their food security and incomes destabilised they sought various ways to cope including out migration to urban areas in search of wage labour.

Some households had to settle in forest reserve areas or on other common property as the compensation money was insufficient to buy alternate land. The Thai economic crisis affected households that did not use the compensation money to buy productive assets. Cropping incomes have declined and there has been a reduction in livestock as people are selling both due to a shift from farm based occupations as well as reduced grazing land.

Next to fisheries, loss of access to common property such as forest and grazing land has been among the other adverse impacts. Forests and riverbank dry season gardens were not compensated.

Since the completion of the project several committees were set up to assess the number and extent of households affected by loss of fisheries income. In all, over 6 202 fishermen demonstrated to the committee that they were engaged in fishing and their income affected following construction and operation of Pak Mun dam.

Based on the committee's findings, EGAT paid 90 000 Baht to each of the 3 955 fishermen in 1995, and it approved payment of 60 000 Baht each to another 2 200 fishermen in March 2000. Still, a large number of households located upstream of the dam are still waiting to be recognised for compensation. Unexpected costs of the project included the compensation for fisheries (488.5 million Baht had been paid up to March 2000) and investment on fish and prawn stocking programme. Till March 2000, 488.5 million Baht (US$ 19.5 million) had been paid as compensation for loss of fisheries livelihood.
While the government acknowledged the impact on fisheries and agreed to compensate eligible households at the rate of 90 000 Baht as compensation for loss of income during the three-year construction period, mitigation for the long-term loss of fisheries livelihood is under negotiation. On

January 25, 1997, the villagers from Pak Mun joined the 99-day protest in Bangkok demanding fair compensations for the permanent loss of their fishing livelihood. Land and cash compensation promised by the government in April 1997 was retracted under a new political regime in 1998. From March 1999 villagers began demonstrations to be compensated by the Government and the World Bank for permanent loss of income from fisheries.

- **Decision Making and Conflict**

Assessment of project impacts, like the assessment practices in past dam projects, remained focused on inundated areas and resettlement issues. Pak Mun project happened to be the first run-off-river type dam, with no reservoir and thus impacts due to flood and resettlement were not assumed to be as serious as those of other big dam projects in the region. Thus, fisheries impacts were overlooked. No study ever predicted that fisheries issues would become problematic, during construction or implementation though this issue was raised with the World Bank as early as October 1991 and prior to that with EGAT.

It has been realised by almost all of the stakeholders that planning, decision making, implementation and mitigation were done with inadequate base-line information, especially on fisheries, the most serious and most controversial of the issues. The project authorities considered that it was not possible to determine the number of fishermen actually affected or the extent of loss suffered and there was a perception of exaggerated and ever-increasing claims for compensation. ? The absence of a proper baseline meant that claims for compensation by a large number of families would not be considered legitimate which meant that the only possible recourse for the affected villagers was prolonged protest.

Thus, the Pak Mun project becamemired in a protracted process of conflict between the adversely-affected villagers, the project developers and the Government. Exclusion of affected people from the decision-making process gave rise toprotracted protests, demonstrations and confrontations. These actions were taken in order to seek recognition and settlement of compensation and rehabilitation entitlements. This resulted in very strong negative perception within the community for the project.

- **Impact on Rapids**

The height of the dam was reduced and its location changed from the initial plan to drastically reduce resettlement of persons and to preserve the Kaeng Tana and Kaeng Saphue rapids that are tourist attractions. This was done at a substantial sacrifice in power benefits. Nevertheless, more than 50 natural rapids were permanently submerged by the project. These rapids served as the habitat of a number of species of fish, and thereforeseveral rapid-dependent fish species seem to have disappeared. The implication of the loss of rapids for fisheries was not assessed in the project's environmental impact study.

- **Other Environmental impacts**

The project has resulted in the loss of riverbank vegetation, natural forest and community forest. In the pre-project period, the women in the community harvested 40 edible plants, 10 bamboo species and 45 mushroom species for household subsistence and small income. A number of medicinal plants were also found near the Mun riverbank. Loss of these plants and vegetation through inundation has implications for biodiversity and household food security. These aspects were overlooked in the environment assessment study in 1982 and in the absence of a new EIA for the redesigned project.

What was the distribution of costs and benefits: who gained and who lost?

Pak Mun project was a part of EGAT's least cost development plan to serve the peaking needs of Northeast Thailand. However as the project cannot function as a reliable peaking plant of 136 MW due to a number of constraints; the nature and extent of gain to Thailand's Northeast region from the power contribution of the Pak Mun project remains a matter of diverging opinion. The changing mix of technologies for generation since 1988, indicates that hydropower is gradually playing a less important role in power provision. From the data on contribution of different power generation to the seasonal peak load, it can be seen that hydropower contributes significantly during the hottest and driest months in Thailand. These are also the months when the Pak Mun hydropower plant is least able to have the water resources to contribute because it has no storage reservoir.

Communities dependent on the fisheries for livelihood in the upstream and downstream of the Mun River experienced an ongoing decline in fish catch. The Royal Thai Government had to recognise and pay compensation to 6 202 fishermen for the unanticipated loss in fisheries income. While compensation settlement has been reached with over 6 202 households regarding loss in income during the three years of construction, compensation for permanent losses in livelihood remains under negotiation.

Despite the cash and credit compensation, permanent loss of fisheries cannot be replaced by a one-off cash compensation. As a result of the project and in the absence of baseline information, the Thai Government is left vulnerable to ever-increasing claims for compensation for the loss of fisheries livelihood. Regarding the issue of fisheries, all stakeholders stand to lose, not only from a disrupted ecosystem but also from increased expenditure on mitigation efforts that are unlikely to mitigate the losses.

Villagers who owned some land on slightly higher elevations were able to grow some rice prior to the dam construction. Villagers who were dependent largely on fisheries for cash income, however, have found no viable means of living since the depletion of fish in the reservoir. The changes were particularly acute in paddy production. Along the Mun River, swamps and wetland forests, are parts of the riverine ecosystem. During the rainy seasons, these are flooding areas and places for fish to spawn. In the past, villagers used the area along the river to find bamboo shoots, mushrooms, native plants and vegetables that they depend on for their subsistence. During the dry seasons, they also developed narrow patches of land along the riverbanks for growing vegetables. In the upper part of the lower Mun, where banks were not steep, land along the river was developed as paddy fields. These have brought drastic changes in the way that villagers use natural resources. As their food and income security has been destabilized, villagers have sought different ways to cope with the changing conditions. Some of them and their children began to leave their villages to look for alternative employment opportunities, such as working in construction or in factories. Compensation was not invested in productive assets. Many affected people who were given compensation used the money to build their new house or change their roof. Many also have debts, borrowing from their cooperative as well as local moneylenders. Short-term wage opportunities and one-off cash compensation cannot replace the loss of a productive resource base by the community.

After resettlement, villagers have witnessed many social and cultural problems. The new social arrangements have disrupted former social relations and changed patterns of interaction among the villagers. In the pastthe Mun river served as the stage for their social life. The river was where villagers met, interacted, and developed social networks of exchange. The traditional communal ceremony had usually been organized on the riverbank, but now could not be held due to the submergence of the ceremonial site and, in part, due to the social disintegration of the communities. Since the beginning of the Pak Mun project conflicts of ideas and interests arose between those who opposed the dam and the kamnan and headmen group. The conflict was intensified during protests and demonstrations for compensation. Those who were opposing the dam were often discriminated against. The conflict over the dam project at the local level created mistrust and deep social rifts.

The local community and adversely-affected villagers have expended considerable time and effort over nearly ten years in protests, demonstrations and negotiations with the government and project authorities. What became an issue of lost livelihood and a conflict over compensation was initially a demand for a role in the decisionmaking processes pertaining to the development, utilisation and transformation of natural resources that form the livelihood base of the community. The process has created bitterness and negative perceptions withinthe community at being excluded from critical stages in the decision-making process.

The World Bank and EGAT have suggested that the income level of the families in the region improved significantly since the completion of the Pak Mun project. The National Rural Development Committee (NRDC) data waspresentedas evidence. The NRDC data wasanalysed and inferences drawn (see Annex 3 for details). However, the data wasnot used in drawing conclusions. See Section 11.6; Annex 3 for an understanding on the NRDC data.

The study team finally based its conclusions on the primary data generated by the study as well as other studies conducted specifically in relation to the Pak Mun project. Thus, the 1996-97 Operations Evaluation Department of the World Bank (OED) study was also used as a benchmark.

How were the decisions made?

The National Energy Authority (NEA) initiated development of the water resources of the Chi-Mun watershed. The preliminary feasibility study completed in 1970 selected the Kaeng Tana rapids as the possible dam site. By May 1979 the project was transferred to EGAT for further feasibility studies.

Environmental Impact Studies conducted in 1982 indicated that approximately 4000 households would be displaced if the reservoir were impounded to a level of 113 MSL. In order to reduce the project's environmental and social impacts, after a new feasibility study an alternative design with a normal water level of 108 MSL was agreed upon in 1985. The relocation of the dam site significantly reduced the extent of displacement from the project to an estimated 248 households. The original project design was further modified by relocating the dam 1.5 km upstream to avoid the submergence of Kaeng Tana rapids, an important environmental and tourist site. EGAT also decided to lower the reservoir to 106 MSL during dry season from January to May and to adjust the dam's operating regime to uncover the upstream Kaeng Saphue rapids, a popular tourist destination. It should be acknowledged that EGAT and the Thai government made substantial sacrifice in power benefits in order to minimise social and environmental impacts.

However a new EIA was not conducted at this stage that may have identified and anticipated some of the new environmental impacts arising from the new location of the Pak Mun project.

In April 1989 the project was presented by EGAT to the Council of Ministers of the Thai Government (the Cabinet). Nearly one year later the Pak Mun Hydropower Project was presented as part of a loan package to the Board of Governors of the World Bank. In 1991 when it appeared that project costs would have to be increased, it was presented to NESDB for re-approval. In each of these occasions costs and benefits were presented.

The Pak Mun dam was described as a multipurpose development project by EGAT in the project document dated March 1988. Claims of associated and attributable benefits from the project, which were modest relative to the value assigned to electricity generation, included irrigation, fishery, navigation improvement and recreation enhancement. Only the benefits of power, irrigation, and fishery were quantified in EGAT's project document. The project later qualified for World Bank loan financing as part of Thailand's Third Power System Development Project. The World Bank's Staff Appraisal Report (SAR) was completed in July 1991; the Bank's Board of Directors approved the project in December 1991.

In August 1991 when EGAT resubmitted the project to the NESDB for the endorsement of a 70% increase in estimated investment costs, along with the expected annual energy output, the irrigation and fishery benefits remained unchanged. The revisions showed that the Pak Mun dam as a multipurpose development project including resultant irrigation and fishery potentials was still worthwhile. NESDB accepted the project as proposed and endorsed EGAT's revisions. The project's Economic Internal Rate of Return (EIRR) changed from 18.71% in 1988 to 17.35% in 1991- irrigation benefits were quantified. Neither the SAR nor the revised NESDB application in 1991 identified how the irrigation components were going to be financed but benefits were included in both and quantified in the latter's presentation.

In a recent communication with the Pak Mun study team EGAT has indicated that the power benefit of the Pak Mun Dam is the core benefit of the project. Other benefits such as fishery, irrigation, etc. are secondary, and were not necessary for project justification.

The conceptual economic benefit of avoided costs for power generation from the next best alternative, was used in the project's economic evaluation (the power only component). The actual hydropower benefits of the dam were not used by EGAT or the World Bank in the economic justification of the project. Both institutions limited their analysis to a switching value analysis, also called Equalising Discount Rate analysis. Such an analysis is used to rank projects by priority once they have been estimated to be economically viable. The lack of proper ex-ante economic analysis means that it is not possible to conduct a comparison of Projected and Actual Economic Value of the project.

The Cabinet mandated EGAT to establish eligibility criteria and finalise the process of compensation to the affected people. The Governor of the Province of Ubon Ratchathani, the Director-General of the Department of Fisheries, and the Permanent Secretary of the Prime Minister’s Office were put in charge of the compensation process. The focus of the process shifted from lost assets like land and other properties to decline in fisheries affecting livelihood.

Affected villagers were not consulted at the early stages of the decision-making process and there were no attempts to include them in the decision making on the project or the mitigation measures. The issues around inadequate assessment of impacts and compensation were not addressed at the outset. Negotiation on compensation began only after long protests by the affected community and NGOs. Participation of affected villagers and NGOs in the compensation process was first elicited through the Committee for Assistance and Occupational Development of Fish Farmers (CAODFF), formed by order of the Prime Minister in January 1995, eight months after completion of the dam. The Director-General of the Department of Fisheries headed the committee. EGAT remained solely responsible for all costs relating to the works of the various committees and working groups and for the compensations paid out.

Did the project comply with the criteria and guidelines of the day?

The Pak Mun project complied with the standards of the Cabinet at the time and was thus approved in May 1990.

Under the 1992 Promotion and Conservation of National Environment Act, reservoirs with capacities larger than 100 Million cubic meters (MCM) or surface areas greater than 15 square km require an Environment Impact Assessment Study. The EIA studies have to be submitted to the Office of Environmental Policy and Planning for consideration prior to being submitted to the Cabinet or appropriate authorities for endorsement for permission to proceed. Pak Mun dam with a reservoir storage capacity of 225 MCM and surface area of 60 square km would require an environmental impact study under the 1992 law. Since the Cabinet endorsed the project in May 1990, the provisions under this act did not impinge on Pak Mun dam.

The 1981 EIA produced inadequate baseline information. Baseline studies of aquatic resources need to cover the different seasons and a timeframe of at least 2 years. Assessment of natural fluctuations in abundance of fish populations as well as the cumulative impacts on aquatic resources from other development projects in the watershed was necessary. An appropriate socio-economic survey was required to identify the extent of dependency of the local population on fisheries. Further, the project that was approved by the Cabinet was different from the one for which the original EIA was conducted in 1981.

By the time the project reached implementation stage, the nature, extent and site of the project had changed and this warranted a new EIA. By 1990, the Pollution Control Department and the Office of Environmental Policy and Planning of the Ministry of Science, Technology and the Environment had also evolved an extensive set of guidelines, standards, classifications and procedures in place to carry out appropriate EIA. The World Bank too had an extensive set of procedures and guidelines in place for the Terms of Reference, implementation and review of EIA. The Pak Mun dam did not comply with the existing World Bank guidelines that required a new EIA and appropriate impact mitigation prior to the implementation of the redesigned project. If the Pak Mun project had complied with the World Bank's standards at the time of appraisal in 1990, many of the serious unexpected impacts could have been anticipated and avoided. By the time mitigation measures related to fisheries were put in place in response to people’s protests, the dam construction work was completed.

Compensatory measures apart from inundated houses and land were formulated and implemented at a later stage of the process. The monitoring of fish species and fisheries activities after the completion of the dam has been haphazard and not systematic. The performance of the fish ladder has not been adequately evaluated, and monitoring withdrawn. Adaptive management such as relocation and improvement of the fish ladder might have helped, but have not been considered.

The process of compensation of affected fisheries households has been a long and tedious process as a result of inadequate baseline studies that should have systematically defined the number and location of households depending on fisheries and also the value of their fish catch.

How would this project be viewed in today’s context?

The economic premise on which the project was justified can be questioned. The planners confused a switching value analysis, also called Equalising Discount Rate analysis, with a traditional economic benefit analysis. The former analysis should be performed to choose the best of two project implementation solutions that have already proven to be both economically viable. When applied to power projects the switching value analysis should be done on projects that have the same dependable capacity and this was not done in case of Pak Mun project.

Since the Pak Mun project was in reality conceived and operated as part of EGAT's power development plan to respond to long-term national load forecasts, its claim as a multipurpose project is misleading.

In the present context, the absence of assessment and lack of consideration of the project impact on fish and fisheries in Mun River in the initial planning and decision-making stages would be considered a critical lapse. This is more so given the fact that this World Bank funded project was approved and implemented in the early 1990s. The absence of comprehensive assessment of the households whose fishing occupation, fishing income, and subsistence was affected by the dam at appraisal meant considerable unplanned cost escalation in terms of compensation. The participation of affected communities and civil society was elicited late in the process of compensation and mitigation. Confusion resulted from lack of clear division of institutional responsibility and this was compounded by lack of clarity in eligibility criteria as a result of which affected people spent nearly ten years in negotiating compensation claims with the government.

With hindsight, as required by the World Bank guidelines, a fresh EIA for the redesigned project would have been called for whose terms of reference should have included nature and extent of impact of the project on livelihoods based on fisheries. Such a study would have been useful in making available relevant baseline for comprehensive identification of fishing villages, the extent of population affected, the level of dependency on fisheries by season, the prevailing income, and the resettlement location options allowing continued access to the riverine resources and alternatives.

If plans and policies were adequately implemented with respect to social impacts and resolution of conflicts, villagers would not have had to waste time and effort in negotiating and protesting against the dam. Nor would the country as a whole have lost an important ecosystem.

One of the key conclusions emerging from the study is that if all the benefits and costs were adequately assessed, the study team believe it is unlikely that the project would have been built in the current context.

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List of Acronyms and Abbreviations

#NA	Data not available (in a table)
CPI	Consumer Price Index
cumsec	Cubic meter per second
DSM	Demand Side Management program
EGAT	Electricity Generation Authority of Thailand
EIRR	Economic Internal Rate of Return
FIRR	Financial Internal Rate of Return
GWh	Giga Watt per hour (10^9)
ICR	Implementation Completion Report (of the World Bank)
IDC	Interest during construction
IPP	Independent Power Producer
IRR	Internal Rate of Return
Kcal	Kilo calories
Kg	Kilogram
km^2	Square kilometres
KW	Kilo Watt
KWh	Kilo Watt per hour
Lt	Litre
MCM	Million cubic meters
MEA	Metropolitan Electricity Authority
MER	Medium Economic Recovery
MSL	Meter above sea level
MW	Mega Watt
MWh	Mega Watt per hour
NEA	National Energy Authority
NEPC	National Energy Policy Committee
NEPO	National Energy Policy Office
NESDB	National Economic and Social Development Board
NHWL	Normal High Water Level
NPV	Net Present Value
O&M	Operations & Maintenance
OCGT	Open cycle gas turbine
PDP	EGAT Power Development Plan
PEA	Provincial Electricity Authority
Rpm	Revolutions per minute
SAR	Staff Appraisal Report (of the World Bank)
SOFRELEC	Societé Française pour l'Electricité
SOGREAH	Name of French engineering firm
SPP	Small Power Producer Program
TDRI	Thailand Development Research Institute
TWh	Tera Watt per hour (10^{12})
US$	Dollars of the USA
WB	World Bank
WCD	World Commission on Dams

[1]/ Ibid., p. II (Summary of Project Features) typed the dam structure as rockfill with impervious core.

[2] 25 Baht = 1 US$

[3] The result of species number at pre-impoundment is taken from surveys that used several methods - seinnets, electrofishing and especially from artisanal fishing activities that penetrated all microhabitats, nearly all year round. Survey conducted since 1990 also included results of Tyson Roberts and W.J. Rainboth in the last two decades. Due to updating of freshwater fish systematic (taxonomy) knowledge, many species from old reports (Thanthong & Siriphan, 1969 and others) are corrected.

1. Introduction

The Pak Mun report is one of 8 case studies being undertaken world-wide with a common methodology and approach that seeks to inform the Commission on the development effectiveness and on a range of issues associated with the planning, design, construction, operation and decommissioning of large dams. This case study concerns the Pak Mun Hydropower project, a run-of-the-river dam located near the confluence of the Mun and the Mekong River in the Northeast region of Thailand.

The report attempts to compare the planned intended outcomes and the actual results. The case study would provide an analysis of the performance and the manner in which decision-making processes have responded to an evolving social, economic and political context since project completion. The lessons learned from the planning and decision-making process will directly inform the Commission's findings. To structure the information collection, discussion and the assessment of development effectiveness to be provided in the report, six central questions have been identified that form a key component of the WCD work programme and methodology. The Pak Mun case study seeks to address these questions:

7. What were the projected vs actual benefits, costs and impacts?
8. What were the unexpected benefits, costs and impacts?
9. What was the distribution of costs and benefits, who gained and who lost?
10. How were decisions made?
11. Did the project comply with the criteria and guidelines of the day?
12. How would this project be viewed in today's context?

The case study has primarily used existing data sources and reports to inform its assessment. Some additional research in selected areas has been undertaken. Assessing development effectiveness entails taking account of the views and perspectives of different stakeholders and project-affected groups. As an integral part of the methodology, in parallel to the study process, two consultation meetings were included. These meetings were intended to ensure that the views of different interest groups could be considered by the study team, and provided opportunities for comments and input.

1.1 Context of the Pak Mun dam and Mekong river basin

Between 1986 and 1991 Thailand was among the fastest growing economies in the world. The period of economic growth continued through 1990s, though at a slower pace. Since 1993, foreign investment started declining and overseas debt increased and by 1996 the rate of growth of export earnings had contracted sharply. These issues came into prominence with the 1997 financial crisis. Economic growth was closely paralleled by improvements in most indicators of living conditions such as provision of electricity in rural areas, housing, health facilities, piped water and sanitation, particularly in rural areas. The rapid rate of industrial growth that Thailand experienced since the early 1980s did not result in a reduction in the proportion of the work force employed in agriculture. The volume of seasonal migration of rural labour force remained high and expanded rapidly in the 1990s. Thailand continues to have a large rural population with much of the urban population and an unusually large share of Kingdom's service provision, manufacturing output, infrastructure and foreign investment concentrated in Bangkok and nearby regions. The Kingdom is characterised by a strikingly high level of regional income inequality. The proportion of people living in poverty in 1992 was 15.5% and 10.2% respectively in rural and urban areas.

The Mekong basin is spread over an area of 169 000km^2 comprising the entire Northeast Region and a small proportion of the Northern Region, of Thailand. In 1991 the population of Northeast Region was 18.9 million compared to Thailand's total of 46.9 million. Nearly 88% of the population within Mekong basin are rural. The highest density of rural population is along the Chi valley, followed by the Mun valley. The Mekong is among the poorest regions in the country.

The Mun and Chi rivers, with a basin area of 117 000 sq km and flowing through 11 provinces are the lifelines of Northeast Thailand. The Mun River flows through the lower Northeast from west to east meeting the Chi River at about 10km west of Ubon City and the Mekong in Amphoe Khong Chiam. The total length of the Mun River from the upper catchment to the Mekong is over 600km. The average annual runoff of the Mun River is 24 000 MCM. There are three densely populated communities located on the Mun riverbanks: Warin Chamrab, Ubon Municipality, and Phibun Mangsahan. Inhabitants on both banks are dependent on the Mun River for domestic uses, agriculture, livestock raising, fisheries, industries, transportation, recreation, etc. All the rivers are highly seasonal in their flow patterns, with 90% of natural runoff occurring in the wet season in direct response to rainfall.

For the people in the Northeast region, subsistence agriculture, fishery and seasonal migration for employment in Bangkok and other major urban and industrial centres are the major sources of livelihood. The financial crisis in the later half of 1990s contributed to the decline of opportunities in Bangkok and other large urban centres. This has put enormous pressure on agriculture and fishery for livelihood.

1.2 Water Resources Development Projects on Mun - Chi Basin

The Chi-Mun river basin, situated in the northeast of Thailand, is relatively poor region compared to other region in the country. This area is subjected to considerable fluctuations in wet season rice yields, as a result of inadequate supplementary irrigation during drought periods. Farmers are unable to develop year-round cultivation, because of incomplete distribution systems for delivering available water to the farm. In many areas remote from available water resources, water is insufficient for meeting the minimum requirements of domestic supply for people and animals, subsistence agriculture and related activities.

In 1978, a study of "Water for the Northeast: A Strategy for the Development of Small-Scale Water Resources" was conducted by AIT and was proposed to the Water Resources Planning Subcommittee of National Economic and Social Development Board. A Water policy for the Northeast, as a result of this study, was followed as a National Master Plan. It followed a two-pronged approach: the effective distribution of available water resources from large reservoirs and reliable rivers to the people adjacent to these sources, and the development of small water resource projects to meet basic water requirements which are away from large reservoirs and reliable rivers.
The two-pronged water policy can be summarised as follows:

Emphasis on distribution from existing sources – Rapid development of distribution systems from reservoirs and rivers, capable of actual deliveries of water to the maximum number of farm families; and
Meeting basic requirements – Rapid development of small water resources projects in every village capable of meeting the basic subsistence requirements for domestic water needs, for minimal supplementary irrigation, and for minimal dry season irrigation of garden plots.

Water resources development in the Chi-Mun river basin followed such scheme. Recently, a study of potential development of water resources in the Chi river basin and that of the Mun river basin were conducted by Khon Kaen University, submitted to Office of the National Economic and Social Development Board in 1994. A future water resources development plan in the Chi-Mun river basin in the next decade, as a result of study, still confirms a strategy for the development of small-scale water resources (AIT, 1978).

Tables in Annex 5- Hydrology summarise water uses situation over the Chi and Mun river basins respectively (KKU, 1994). It reveals that for the Chi river basin (Table 2.34), average annual water resources availability is about 11 187 MCM. It shows that about 90% of total water demand are for

agriculture and related purposes. Based on projection of future water demand in the year 2006, there are still water resources available for far future development (i.e. only 40% of available water resources are needed for development in 2006). Figure 2.7(a) presents locations of large scale (i.e. Chulaporn Dam, Ubolratana Dam, Lam Pao Dam, etc.) and medium-scale water resources development projects including major irrigation area over the Chi river basin.

The average annual water availability in the Mun basin is about 21 092 MCM. About 80% of water demand is for agricultural purposes. The projection of water demand in the future until 2006 shows that there are still water resources available for development in the far future (i.e. only 18% of available water resources are needed in 2006). Annex 5 - Figures 1 and 2 shows the location of large scale (i.e. Sirindhorn Dam, Lam Dom Yai Dam, etc.) and medium-scale water resources development projects including major irrigation area over the Mun river basin.

However, in term of distribution of water resources development over the whole basin, it was found that some sub-basins were already fully developed, e.g. Phong River Upper Ubolratana Dam Sub-basin (04-01) and Lam Takhong Sub-basin (05-02). But most of sub-basins still require development of water resources projects with available water resources to be utilised. Most of irrigation project areas are located upstream of Ubon Ratchathani; downstream of Ubon to Pak Mun Dam, there is no major irrigation area.

1.3 State of Aquatic Bio-diversity, Water quality and Fisheries on Mun-Chi Basin

During the construction of the Pak Mun Dam in 1992 and 1993, aquatic biodiversity and fish populations in the Mun /Chi watershed already were under severe stress. Partly from factors such as, (i) water resources development, including hydropower development, (ii) deforestation, (iii) water pollution including from domestic wastewater disposal, (iv) saline soils and (v) fishery practices.

1.3.1 Development of Water Resources

Before the Pak Mun Dam was completed in 1994, the Mun/Chi watershed already housed the following hydropower dams and reservoirs: Ubolrathana, Sirinthorn, and Chulaphon, and a number of irrigation dams and weirs, including: Lam Pao, Lam Phra Phloeng, Lam Takhong, and Lam Nang Rong.

Table 1.1: Major Dams and Reservoirs in the Mun/Chi Watershed Completed before the Year 1994

Name	Primary Purpose	Year of Dam Closure	Reservoir Area at Upper Storage Level (km^2)	Catchment Area (km^2)
Ubolrathana	Hydroelectricity	1965	410	12,000
Sirinthorn	Hydroelectricity	1970	288	2,097
Chulaphon	Hydroelectricity	1972	12	545
Lam Pao	Irrigation	1968	400	5,964
Lam Phra Phloeng	Irrigation	1968	19	807
Lam Takhong	Irrigation	1969	45	1,430
Lam Nang Rong	Irrigation	1991	25	453
Pak Mun	Hydroelectricity	1994	60	117,000

(Source: MRC, 1997).

Apart from these major dams and reservoirs, numerous small dams and weirs have been built in the Mun/Chi watershed prior to construction of the Pak Mun Dam. Currently the total number of dams and weirs in the Thai area of the Lower Mekong Basin has been estimated at 4 000. In 1994, 5 770 km^2 of the total Mun/Chi watershed area of 117 000 km^2 had been developed as irrigated agricultural area fed by gravity flow (Vongvisessomjai, 1999). To induce gravity flow, dams, weirs and reservoirs have to be constructed. Dams and weirs, particularly for water storage reservoirs and flood protection, change the hydrological regime of streams and rivers leading to modification of aquatic habitats. Reduction of floodplain area as a result of changes in hydrological regime is strongly correlated with reduction of fish production and reduction of fishing yields. Aquatic habitats such as rapids and riffles that are important in sustaining aquatic biodiversity and that contribute to high fishing yields may be drowned by reservoirs or modified through changes in the hydrological regime of the river. Dams and weirs block off fish migration and result in fragmentation of aquatic habitats. Fish nursery and spawning grounds may be blocked off or inundated.

Water resource development projects generally lead also to increased fishing pressure by improvement of access. Subsistence fisheries may turn into full time fisheries with the new fish trading opportunities resulting from improvement of access.

1.3.2 Hydropower Development

Hydropower dams and reservoirs as Chulaphon and Ubolrathana have significant downstream effects on water quality and consequently on aquatic biodiversity and fisheries by releasing water with low dissolved oxygen content or even anaerobic water associated with Hydrogen Sulphide. Release of water with low dissolved oxygen from hydropower reservoirs particularly occurs during times in the year when reservoir levels are close to upper storage level. Water reservoirs with sufficient depth are subject to stratification. The surface water layer (epilimnion) with high water temperature is separated from the bottom layer (hypolimnion) with low temperature. A thermoclyne in which the temperature is sharply dropping separates the epilimnion from the hypolimnion. The water temperature of the epilimnion is influenced by air temperature and by the absorption of sunlight. If there is little wind and wave action, surface water with similar or higher temperature than ambient air temperature does not mix with deeper and colder water. Sun light does not penetrate deeper than the epilimnion. Air temperature and absorption of sunlight induce a temperature difference between surface water and deep water if wind and wave action are limited. The difference in temperature creates an epilimnion and a hypolimnion, each with different water temperature and thus with different density. The epilimnion with low water density is floating on top of the hypolimnion with higher water density.

The epilimnion is in contact with air and therefore generally contains high dissolved oxygen content. Photosynthetic activity of algae and phytoplankton may even push DO levels in the epilimnion to over saturation. No photosynthetic activity takes place in the hypolimnion by lack of sunlight. The epilimnion and the hypolimnion do not mix and thus the hypolimnion is not aerated. Lacking aeration, oxygen consumption by decomposing organic matter can create low DO concentrations or even anaerobic conditions in the hypolimnion. Due to the effect of stratification in Chulaphon and Ubolrathana reservoirs, other water quality parameters than temperature and dissolved oxygen also change according to water depth. In the hypolimnion, values of hardness, conductivity, alkalinity, turbidity, ammonia, and iron are higher than in the epilimnion. Values of pH are decreasing with water depth, due to photosynthetic activity in the epilimnion. Under anaerobic conditions hydrogen sulfide can be formed in the hypolimnion.

Due to stratification of the reservoir the intake of reservoir water at the dam to the powerhouse can be from the epilimnion or from the hypolimnion depending on the reservoir level. If water from the hypolimnion is taken into the powerhouse, downstream effects from low water quality on aquatic biodiversity and fisheries can be expected. Figure 4.1 shows the annual fluctuations of Chulaphon and Ubolrathana reservoir levels and the elevations of the center of the intake to the powerhouses. Due to the fluctuation of the reservoir level, the elevation of the hypolimnion will rise during the wet season

above the elevation of the water intake to the powerhouse (Annex 6 - Figure 1). At this time of the wet season anaerobic water will be released from the hypolimnion influencing water quality and aquatic ecology downstream of the powerhouse. Figure 1 shows also the reservoir level in the dry season when water is released from the epilimnion, causing no major effects on downstream water quality and aquatic life, although water temperature downstream may be higher than before dam construction.

In addition to the Mun/Chi watershed with Chulaphon and Ubolrathana reservoirs, the Lower Mekong Basin in Thailand, Lao PDR and Vietnam and the Chao Phya Basin in Thailand house numerous hydropower projects that periodically release anaerobic water with highly toxic hydrogen sulphide affecting downstream aquatic ecology and fisheries.

Possible environmental mitigation measures to avoid intake from the reservoir hypolimnion into the powerhouse are: (i) design and construction of variable water intake devices, (ii) aeration of water released from the powerhouse, (iii) installation of airlift pumps in the reservoirs to avoid stratification, and (iv) relocation to higher elevation of water intake to the power house (Schouten, 1998).

None of the hydropower dams with stratified storage reservoirs in the Lower Mekong Basin have been designed with a variable water intake to minimize downstream effects on water quality.

During impoundment of reservoirs, organic carbon from uncleared vegetation and organic carbon from plant and tree roots under ground will decompose. The decomposing material generates a high BOD load and additional loads from humic and fulvic acids. If water retention time is high, water quality in the reservoir is affected, if water retention is low downstream effects of water quality on aquatic biodiversity and fisheries can be expected. During the first 5 years after impoundment in the early 1970s of the Nam Ngum hydropower reservoir located in the Mekong River Basin in Lao PDR, at a distance of more than 100 km from the reservoir in the capital of Vientiane the smell of hydrogen sulphide could be noticed. The Nam Ngum reservoir was not cleared of trees and vegetation before impoundment. Another hydropower reservoir, Nam Leuk, also in he Mekong Basin in Lao PDR has been filled in September 1999. Despite clearance of trees at the impoundment area, water in the reservoir turned anaerobic. Water released from the bottom of the reservoir smells ugly.

1.3.3 Deforestation

Map 1 Annex 6 based on Landsat images made in 1993 shows the forest cover of the Lower Mekong Basin (Mekong River Commission, 1997). The Mun/Chi watershed has been drawn in the map to show the location of Pak Mun and the relative importance of the Mun/Chi watershed in the Lower Mekong Basin. Thai watersheds contribute 18 % of the total flow to the Mekong River. The Mun/Chi watershed forms the highest contribution to the Mekong River flow in Thailand. The large hydropower and irrigation reservoirs within the Mun/Chi watershed are indicated on the map. The map clearly shows that forest cover in the Mekong Basin within Thailand is significantly less compared to forest cover in Laos and Cambodia.

Logging, agricultural encroachment and development of water resources have led to deforestation. Before the 1950s Thailand had a thick forest cover of heterogeneous trees. Timber used to be the main export commodity after rice. More than half of the kingdom's area at that time was covered with forests. A rapid depletion of forest resources occurred after the 1950s. Over the past four decades farmland in Thailand increased five times and forested areas have shrunk as a result (Gray et al, 1994). The North East, known as one of the highly populated and poorest regions in Thailand, has particularly seen much development of irrigation schemes. Despite the declaration of the Thai logging ban in 1988, deforestation was ongoing mainly through agricultural encroachment and development of water resources.

Deforestation and degradation of forests in the North East of Thailand has led to a less than pristine aquatic environment in the Mun/Chi watershed at the time of construction of the Pak Mun Dam. Deforestation and forest degradation changes the hydrological regime of streams and rivers, may alter water temperature and provides less leave litter to the aquatic food chain.

Clearing of trees and vegetation in impoundment areas removes only partially organic carbon. During impoundment, decomposition of organic carbon is consuming Dissolved Oxygen and producing humic and fulvic acids. Depending on reservoir operation management, water quality in the reservoir and/or downstream water quality is affected by direct oxygen consumption and pollution loads through decomposing organic material.

1.3.4 Domestic Waste Water

With the growing population in the North East of Thailand, many water supply projects have been developed. Typically, the construction of domestic wastewater treatment plants did not keep pace with water supply development. The discharge of untreated or poorly treated wastewater has caused deterioration of water quality in streams and rivers. Particularly downstream of municipalities, water in the Mun/Chi watershed is of low quality.

1.3.5 Agriculture

Agriculture runoff containing fertilizers, pesticides and insecticides is another source of water pollution. Fertilizer runoff results in eutrofication of receiving waters. Eutrofication may increase fish production, but generally is accompanied with decline in number of fish species. The increase in agricultural area has also increased the use of insecticides and pesticides. An analysis of 20 fish samples of 2 fish species in the Mekong Basin in Thailand in June 1988 showed that all samples were contaminated with at least one type of organochlorine pesticide. Dieldrin, DDT and its metabolites were the most encountered substances. DDT and Dieldrin are both on the list of toxic substances that are not allowed to be imported into Thailand. DDT was put on the list of forbidden imported products at 4 March 1983, and Dieldrin on 16 May 1988 (MRC, 1994).

1.3.6 Fisheries

During interviews held in October 1999, fishermen in the Mun River admitted that fishing with ichthyocides (rotenon or pesticides mixed with sand) was commonly practiced. Upstream of rapids and riffles, toxic substances were thrown in the river and downstreams afflicted fish were scooped out of the water. Apart from the impacts of pesticides on aquatic biodiversity and fish production, consumers of fish would have been at risk as well.

At the end of the 1980s, the fish disease Epizootic Ulcerative Syndrome (EUS) caused high mortality of fish in natural waters and culture ponds in Lao PDR, Myanmar, and Thailand (ADB/NACA, 1991). The disease outbreak caused considerable economic losses to fresh water fisheries and most probably has affected aquatic biodiversity. No direct cause has been found for the EUS outbreak, but deterioration of water quality increases susceptibility of fish to various diseases.

1.3.7 Industrial Waste Water

In March, 1992 a 7 000m^3 molasses spill from a sugar cane processing factory occurred in the Pong River. Along a 340 km long river stretch in the Pong, Chi, and Mun rivers an estimated 400 tons of fish died. Table 1.2 shows the number of fish species killed and the estimated total weight of killed fish.

Table 1.2: Number of Fish Species and Estimated Weight of Fish killed by the Molasses Spill in March, 1992

River	No. of Fish Species Killed	Estimated Weight of Killed Fish (1,000 kg)
Pong River	52	20
Chi River	65	358
Mun River	83	20

(Source: Duangswasdi, M. and S. Duangswasdi, 1992).

A pulp and paper factory also located in the Pong River has caused water pollution during the years 1992-1993 and 1995-1996. During both periods fish kills occurred in the Pong River. However, the incidents have not resulted in fish kills as high as during the molasses spill.

1.3.8 Saline Soils

Saline soils in the North East of Thailand have caused impacts by salinization on agriculture and forest growth by dam construction in the past. Changes in the ground water table by increased pressure from the reservoir has increased effects of salinization in areas near reservoirs. In 1995 concentrations as high as 75mg/L have been measured in the Mun River close to Pak Mun Dam. A year later in the Mun River upstream of Ubon Ratchathani, chloride concentrations as high as 600mg/L have been measured in the dry season. Bio-diversity and fish production in supposedly freshwater environments can be significantly impacted by effects of chloride on fish itself, particularly in the early stages of its life cycle, or by impacts on production of phytoplankton and zooplankton, which are important as a feed source for fish.

1.3.9 Water Quality Standards

Table 1 in Annex 6 shows the fresh water quality standards and classification of surface waters in Thailand. According to the water classification, class 1 is categorized as water quality that supports “ecosystem conservation, where basic aquatic organisms can breed naturally”, and class 2 is categorized as water quality supporting “fisheries”.

According to a study in the north-eastern Basin initiated by the Pollution Control Department (PCD) and carried out from 1991 to 1995, water classification in the Pong River, immediately downstream of Ubolrathana reservoir was class 5, improving to class 4 downstream. Upstream in the Mun River immediately downstream of Lam Takhong Dam, water quality in the river was also classified as class 5, improving downstream to class 4. After passing the municipality of Nakhon Ratchasima water quality in the Mun River drops back to class 5. In the stretch of the Mun River downstream of Ubon Ratchathani to Pak Mun Dam, water quality has not been classified better than class 3.

By applying the water classification of surface waters in Thailand, water quality in the Mun/Chi watershed cannot be considered as optimum for ecosystem conservation and fisheries before and at the time of construction of Pak Mun Dam. Deterioration of water quality in the Mun/Chi watershed is exacerbated by the development of dams and weirs, influencing the retention time of water in the watershed. Nutrients and pollutants formerly more quickly flushed out of the watershed to the Mekong River are now trapped in reservoirs and ponds increasing the accumulation of toxic compounds in sediments and increasing deoxygenation within the watershed. Through the increase of retention time, a higher percentage of the total BOD load discharged in the watershed is reduced within the watershed. This percentage of the BOD load before construction of numerous dams and weirs would have been reduced downstream in the Mekong River. Pollution loads in the Mun/Chi watershed are generated by different pollution sources as (i) hydropower development, (ii) domestic

wastewater, (iii) agriculture, (iv) fisheries, (v) industrial wastewater, (vi) saline soils, and (vii) deforestation.

The same PCD study predicted a considerable increase in pollution loads in the near future, which would cause even worse water quality conditions in the Mun/Chi watershed, if no immediate action was undertaken. Other irrigation dams and reservoirs in the watershed are planned or under construction.

If Thailand's surface water quality standards are compared with surface water quality standards for fisheries and aquatic life in the European Community and Canada, Thailand ignores standards for Total Suspended Solids (TSS), NO_2-N, and Iron. A standard for Chloride concentrations for freshwater surface waters is recommended to define the different categories of fresh, brackish and salt water, each with their specific groups of fish species.

1.3.10 Aquatic Bio-diversity and Fisheries

In Table 1, Annex 6 the fish species are listed recorded to occur in the Mun River before and after the construction of the Pak Mun. Despite a situation with many ongoing different impacts from different developments on aquatic biodiversity and fisheries a total of 265 different fish species have been recorded in the Mun/Chi watershed before the construction of the Pak Mun Dam. Of these fish species, many have received different scientific names since Smith published the last field guide for fishes in Thailand in 1945. The lack of an updated field guide for fish in Thailand has caused a situation in which only a few renowned fish taxonomists are currently able to reliably identify fish species by scientific name in the Mekong Basin. Fish species listed in Table 4 (see Annex 6-fisheries) and recorded in cited publications have been reviewed by Chavalit Vidthayanon and given current valid scientific names where applicable.

Of the total estimated number of 1,200 fish species occurring in the Lower Mekong Basin, 265 species have been observed in the Mun/Chi watershed before construction of Pak Mun Dam. Of these 265 species, 8 are introduced and considered as exotic for the Mekong Basin, 30 are endemic for the Mekong Basin, 8 are considered endangered, 14 are vulnerable and 1 is threatened in the wild. Table 1 - Annex 6 does not include any information about relative abundance of fish species. Up till present no publications exist which give reliable baseline data about relative abundance of fish species during different seasons in the Mun/Chi watershed. Gathering of aquatic ecological baseline data for such a high number of different fish species in tropical regions is a very different type of exercise from gathering fisheries baseline data in temperate regions with a relatively very low number of different fish species.

In 1975 haul seine fishermen of the Mun River estimated that the weight of their daily fish catches declined about 50 % compared to a decade earlier (MRC, 1975). The MRC report gives three possible reasons for the declined fish catch in the Mun River at that time: (i) increased fishing pressure by an estimated 60 % increase in number of fishermen. Between 1965 and 1975, (ii) environmental change; the Mun River used to be clear and warm in earlier times and had changed to cool and muddy in 1975, and (iii) concentration of haul seine activities at the confluence between the Mun and the Mekong rivers influencing upstream fish catch.

The world over typically one of two patterns of fish exploitation has prevailed. During the early exploitation, both patterns feature a marked increase in catch with a small increase in effort. Subsequently, either the catch rates drop with increasing effort, as has most probably occurred in the case of the Mun River, or catch rates remain fairly stable despite major increases in effort. The latter holds until the continuing increase in effort ultimately leads to a drop in fishing yield, this may be the pattern that is currently occurring in the Mekong Basin.

Over exploitation is a common threat to aquatic resources. Fishermen tend to seek to maximise their catch in the short term but they end up losing in the long term. Individual fishermen are often well

aware of the risk of over exploitation, because they find they need to invest more in equipment, fuel and labour to maintain their catch level. However, their view generally is that if they did not maximise their exploitation of the resource then their neighbours would. Little incentive exists for fishermen to limit their investments and efforts.

The introduction of nylon monofil gill nets in the 1960s in Thailand made it particularly easy for people to start fishing on a subsistence level. Before the introduction of monofil gill nets, craftsmanship and special skills in making and repairing gill nets were required to start gill net fishing.

With a growing population and improved access to resources and in the absence of watershed management planning, a fisheries management plan and lack of enforcement of fisheries laws and regulations, there is an inevitable process of increasing fishing effort, decreasing fishing yield, and decrease of average size of fish caught.

Fishermen in the Mun River are generally well aware of the danger of over exploitation of fish populations, but rules and regulations put in place by the royal government of Thailand to protect the resource are being largely ignored. The potential gain to fishing communities and the fishing industry from prudent laws and regulations cannot be realised if there is a low rate of compliance.

Environmental impacts on fish populations by (i) development of water resources, including hydropower development, (ii) deforestation, (iii) water pollution and (iv) fisheries is higher than the sum of its separate impacts. This became particularly clear in March 1992. At that time a sugar mill accidentally discharged 7 000 tons of molasses in the Pong River close to Khon Kaen. During and after the time that the prop flow of molasses passed through the Mun River downstream of Ubon Ratchathani, fishermen obtained extraordinary high fishing yields never experienced before. At downstream locations, fish afflicted, but not killed by the molasses spill, could easily be caught. Many fishermen downstream in the Mun River took advantage of this situation.

The 16 haul seine operations at the mouth of the Mun River accounted in 1975 for nearly two-thirds of the total annual catch by haul seines estimated at approximately 73 tonnes. Several dozen haul seine operations further upstream on the Mun River were able to land only an estimated 19 tonnes of fish. The haul seine fisheries is normally operated only from February to July. This period is determined by changing water levels and fish migration. However in the beginning of the 1970s during the months of September continuing through November a number of haul seines were used to block and haul the mouths of tributaries leading into the Mun River.

In the dry season and for limited periods in the wet season, rapids in the Mun River formed important fishing grounds when the rapids were not drowned by high wet season flows. Migrating fish species as *Probarbus jullieni* and *Bangana behri* and all migrating species belonging to the families Pangasiidae and Sisoridae are vulnerable for changes in hydrological regime of the river and increased fishing pressure. Dams will block their migrating routes. Pangasiidae and Sisoridae are spawning in rapid areas. Rapids are an aquatic habitat, which are particularly vulnerable for inundation and changes in hydrological regime. Increased fishing pressure intervening with upstream fish migration and increased fishing pressure in spawning areas as rapid habitats will affect population dynamics in the aquatic environment. Changes in fish populations by the cumulative impacts of dam construction and fishing pressure particularly can be expected on upstream migrating fish species and on fish species spawning in rapids. Table 4 (See Annex 6-Fisheries) lists the upstream migrating species and the species, which are depending on rapid habitats. Of the total of 265 fish species recorded in the Mun/Chi watershed before 1994, 77 fish species are migratory and 35 species depend on rapid habitats.

Upstream fish migrations in the Mun river take place by many different fish species, including *Mekongina erythrospila*, *Pangasius* sp., *Helicophagus waandersi*, *Cyclocheilichtys* sp., and Pla Soy

(including *Cirrhinus* sp. and *Henicorhynchus* sp.) from the beginning of the rainy season till the end of August. Downstream migration occurs from late September continuing through to November.

Apart from haul seine fisheries, hook and line, gill net and trapping methods, a unique fish trapping method for the Mun River by 'Tum Pla Yon" (see pictures 2 - fisheries) has been operated at rapid habitats from the mouth of the Mun River to just above the rapids at Keng Sapue. These fish traps are specifically catching *Pangasius pleurotania* and *Pangasius macronema*. Both species, belonging to the family Pangasiidae, migrate upstream at the beginning of the rainy season to spawn in rapids. Before dam construction about 150 of "Tum Pla Yon" were operated in this stretch of the Mun River (personal communication with fishermen).

Recorded catches in the Mun River during the 1970s of small haul seines (up to 100 meter length) were 7.2 kg/day, ranging from 4.3 to 12 kg/day during up to 12 hauls per day. The haul seine catches in the Mekong River were consistently higher than in the Mun River. Average price per kg fish was 16 Baht (at that time 1 US$ was equivalent to 20 Baht).

MRC (1975) mentions two species which have not been recorded from fish catches in the Mun River at locations upstream of Keng Sapue since the end of the 1960s: (i) *Catlocarpio siamensis*, and (ii) *Probarbus jullieni*. *C. siamensis* is currently on the IUCN red list and also considered as endangered by the Office of Environmental Policy and Planning (OEPP) in Thailand, while *P. jullieni* is listed as vulnerable fish species by OEPP. Fishermen also reported the capture of fewer *Pangasionodon gigas* since the beginning of the 1970s. *P. gigas* is endemic for the Mekong Basin, recorded in the IUCN red list and listed as endangered by OEPP. *P. gigas*, which can reach a spectacular size of more than 200 kg can be considered nowadays as the environmental flagship species of the Mekong River.

1.4 The Power Sector in Thailand

The power sector in Thailand is constituted by three public enterprises: the Electricity Generation Authority of Thailand (EGAT), the Metropolitan Electricity Authority (MEA), and the Provincial Electricity Authority (PEA). The regulator is the National Energy Policy Committee (NEPC), which is chaired by the Prime Minster. The National Energy Policy Office (NEPO) is the secretariat. In effect NEPO is the regulator of the energy sector.

EGAT generates and transmits power throughout Thailand. MEA buys power from EGAT and distributes it to customers in the Bangkok Metropolitan Area. PEA buys power from EGAT and distributes it in all areas of the country where MEA does not sell electricity. EGAT sells power directly to a number of selected large off-takers.

EGAT has an installed capacity of about 18.2 GW. EGAT itself has about another 5.6 GW of plant under implementation, and has contracted another 6.0 GW from Independent Power Producers (IPP). These developments will increase the Minimum Reserve Margin as high as 52% by 2003, but are expected to come down to about 25% by 2009 [4]. These projections are based on Medium Economic Recovery (MER) assumptions.

Table 1.3: Generation facilities in Thailand in September 1998. [5]

	MW	%
Hydropower plants	2,873.7	15.8%
Thermal power plants	6,517.5	35.9%
Combined cycle power plants	5,073.6	27.9%
Peaking plants (gas turbines)	892.0	4.9%
Power Purchases	2,817.7	15.5%
Total	**18,174.5**	100.0%

Electricity consumption in Thailand reached 82 TWh [6]. Under MER assumptions Peak demand is expected to increase by 4% up to 2001. 6.5% from 2002 to 2006 and 6.7% from 2007-2011 [7].

Table 1.4: Electricity consumption in Thailand in 1998 by distribution area (GWh). [8]

	PEA	MEA	EGAT direct customer	Other	TOTAL
1998	47,939	30,340	1,928	1,791	**81,998**
1998 growth rate	0.10%	-5.71%	-15.93%	na	-2.56%
1999 growth rate (first 7 months)	0.69%	-6.02%	3.11%	na	-1.85%

Since 1995 the Government has invited the participation of the private sector in the power sector. It has created two programs: the Small Power Producer Program (SPP) and the IPP Program. These programs have initially been very successful and have attracted investment from some of the best international power companies.

Power demand and production have expanded rapidly in the last ten years (see Annex 7-Figure 1). The distribution of power producing types in the overall production has changed since 1988. While in 1988 conventional, boiler based thermal plant dominated the power production sector, power production by gas-fired combined cycle plants has increased significantly (Annex 7-figure 2). The amount of hydropower in total generation has stayed roughly constant during the last few years. This means that hydropower is playing a gradually less important role in power provision. The IPPs are taking on a gradually more important share of the overall power generation. This trend is expected to increase in the future, partly by the construction of new plants by the private sector, partly by the privatisation of some of EGAT power plants.

Although NEPO has been very successful in flattening the daily demand for power by the introduction of time-of-day-pricing and other DSM programmes, the seasonal variation has sharpened. The gradual introduction of air-conditioning in houses and places of work possibly causes this phenomenon. It appears that the bad economic situation in 1998 was able to lower demand after April (See Annex 7-figure 3).

Fig. 4, Annex 7 shows the contribution of the different power generation types to the seasonal peak load. The data show that hydropower contributes significantly during the hottest and most dry months in Thailand, namely from February to May. These are also the months when the Pak Mun hydropower plant is least likely to have the water resources to contribute because it has no reservoir.

2. The Pak Mun Project: Description

The Pak Mun Dam is built on the Mun River, 5.5km upstream from its confluence with the Mekong, in the province of Ubon Ratchathani, in Northeast Thailand. The dam is typed as roller-compacted [9/] concrete with a maximum height of 17 metres and total length of 300 metres. The reservoir has a surface area of 60 square km at normal high water level of 108 metres above the mean sea level (MSL) and a capacity of 225 million cubic metres. The Electricity Generating Authority of Thailand (EGAT) built and operates the dam as a run-of-the-river hydropower plant. Its operating rules are designed to ensure that the water level does not rise above 106 metres MSL during the dry season, from January to May and retains a maximum level of 108 metres MSL for the rest of the year. The storage capacity of the dam's reservoir is essentially that of the pre-existing river channel.

This would ensure that the river does not rise higher than its normal height due to the operation of the dam during the wet season. The storage capacity of the dam's reservoir was therefore essentially that of the pre-existing river channel. The operating regime ensures that the upstream Kaeng Saphue rapids as a tourist site in the dry season, when the river flow does not exceed 200 cumsec, is not negatively affected. And the location of the dam itself was moved 1.5 km upstream in order to preserve the Kaeng Tana rapids, at which site the power output of the dam would have been doubled with water retention at 112 metres MSL and a reservoir surface area of 185 square km. Apart from trading off the full benefits of power capacity for lesser environmental impacts, the relocation of the dam axis further upstream to Ban Hua Heo and the re-design of the dam also meant that fewer people needed to be displaced and resettled. The total number of displaced persons was reduced from about 20,000 persons[10/] (4,000 households) initially estimated in 1982 down to 1,500 persons (248 households) at the final chosen site and design.

In 1982, two separate reports commissioned by EGAT were completed and submitted to the authorities for determining the project feasibility: an environmental and ecological investigation (EEI), and the resettlement planning (RP) investigation for the residents that would be affected by the reservoir. These reports were based on the original plan for constructing the dam at the Kaeng Ta Na Rapids site, with a reservoir water level of 112m MSL. Considering the large amount of land that would be inundated at this water level, and the costs of providing compensation for an estimated 3 970 affected households, however, the original project plan was deemed economically unfeasible. The project design and location were consequently revised in 1985, and the alternative proposed for constructing the dam at Ban Hua Heo, 1.5km from the original site and at the water level of 108m MSL, was considered the most feasible option. It was estimated that the project would affect around 379 households[11]. EGAT then proceeded to build the Pak Mun dam at Ban Hua Heo in May 1991 without carrying out a new feasibility study. The project was completed in June 1994 with the total construction cost of Baht 6 600 million, plus Baht 113 734 for infrastructure development, and a total of Baht 491.3 million as compensation for the loss of fishing income during construction[12].

During the dam construction, 238 households who lived in the construction site, Ban Hua Heo, were affected. After impoundment of the reservoir, 705 households were relocated because their residential land was inundated or isolated by water; 706 lost their agricultural land[13]. Moreover, 6,202 households were given compensation for the lost of fishing income[14].

Since the approval by the Council of Ministers of the Thai Government (Cabinet) of the project in 1989, the project has faced resistance and opposition by the affected people, several environmentalist groups, and a number of NGOs. The villagers rejected the idea of building the dam because they thought that it would destroy the environment and deprived them of their access to the river, which has been their source of livelihood. The Pak Mun project was implemented despite this objection and resistance. Although compensation has been given to the affected villagers in several ways, negative attitude toward the compensation and conflicts between the villagers and EGAT still prevail. During the past decade of the Pak Mun project, not less than 20 mass protests and demonstrations have been organised by the affected villagers to demand EGAT and the government address their problems.

Several promises have been made by EGAT, but they have been broken. Often the government used force to end demonstrations. The history of the Pak Mun project is the history of the struggle between the affected people and EGAT over the right to livelihood and the right to the environment upon which the affected people depend for their living, and not over fair compensation[15].

Table 2.1: Design Characteristics of the Pak Mun dam.

Hydrology and Reservoir		
Catchment Area	117,000	km^2
Average Annual Inflow	24,000	MCM $(\overline{Q} = 761 m^3/s)$
Max. High Water Level	+110.0	MSL
Normal High Water Level (NHWL)	+108.0	MSL
Min. High Water Level	+105.5	MSL
Reservoir Capacity	225	MCM
Reservoir Area (at NHWL)	60	km^2
Dam		
Type	Roller Compacted Concrete	
Height	17	m
Length	324	m
Crest Elevation	+111.0	MSL
Crest Width	6.0	m
Spillway		
Chute Length	217.5	m
Type of Gate (8 nos.)	Radial	
Gate Width	22.5	m (each)
Gate Height	14.75	m (each)
Crest Level	+94.00	MSL
Capacity	18,500	cumsec
Powerhouse		
Generating Unit Type	Bulb Turbine Generator	
Installed Capacity	4×34	MW
Annual Energy	280	GWh
Turbine		
Type	Kaplan, horizontal axis	
Number	4	

Runner Diameter	6	m
Rated Output	35,400	kW (each)
Rated Head	11.60	m
Rated Discharge	330	cumsec
Min. Discharge	80	cumsec
Rated Speed	100	rpm
Generator		
Type	Horizontal axis, enclosed in bulb shaped casing	
Number	4	
Rated Output	36,000	kVA (each)
Rated Voltage	6	kV
Frequency	50	Hz
Insulation Class	F	
Cooling System	Heat transfer to water flowing around the turbine bulb	
Power Factor	0.95	
Unit Transformer		
Type	Indoor, equipped with on-load tap changers	
Number	4	
Rated Capacity	36,000	kVA (each)
Rated Voltage	6 kV/115 kV	
Cooling Method	Water Cooling	
Transmission Line		
115 kV (double circuit)	Connected to the National Network through the Ubon Ratchathani Substation II (70 km)	

3. Brief History of the Pak Mun Project

The project went through a series of feasibility studies listed in Table 3.1. In April 1989 the project was presented by EGAT to Cabinet. Nearly one year later the Pak Mun Hydropower Project was presented as part of a loan package to the Board of Governors of the World Bank. Later, when it appeared that project costs would have to be increased, it was presented to NESDB for re-approval. In each of these occasions costs and benefits were presented. In order to understand the reasoning that preceded the subsequent decisions by EGAT, by the Cabinet, and finally by the World Bank to go ahead with the project it is useful to track the evolution of the assessment of the project.

Table 3.1: Historical background of the Pak Mun dam

1967	Study on the hydropower potential of the Pak Mun river conducted by SOFRELEC, a French consulting firm, for the National Energy Authority (NEA). A dam of the following characteristics was proposed: Location: Kaeng Tana Drainage area: 185 km^2 Normal water level: 112 m
February 1970	SOFRELEC completes a Feasibility Study which concludes that hydroelectric developments on the Pak Mun river are not viable
1978	EGAT completed feasibility study. Plant defined as follows: Drainage area: 117,000 km^2 Normal water level: 108 m Estimated average flow: 713. Cms Rated head: 28.5 m Installed capacity: 108 MW Annual energy output: 376 GWh Possible irrigation area: none indicated.
1979	EGAT proceed with the updating of a feasibility study on Pak Mun.
September 1980	SOGREAH, a French consulting firm, completes Pak Mun Multipurpose Development Project: Updated Feasibility Studies. The study shows that the Pak Mun dam is technically and economically feasible.
1981	The Pak Mun dam is included in the Power Development Plan (PDP), announced to start production in 1988 and rated at 462 GWh/year.
January 1982	Team Consultants Engineers, a Thai consulting firm, completes an environmental impact study commissioned by EGAT. The dam considered in the study was located at the Kaeng Tana falls, and would have a normal water level of 112 m and would require the resettlement of 4,000 inhabitant households.
1983	Creation of a National Park at Kaeng Tana. This creation leads to the identification of an upstream site for the dam at Ban Hua Heo.
October 1984	Team Consultants Engineers, in co-operation with the Faculty of Tropical Medicine of Mahidol University, completes a revised study of environmental and ecological impacts under the assumptions that the dam could be built with a normal water height of 108 m, 110 m and 112 meter.
October 1985	SOGREAH completes a new feasibility study for a dam located at Ban Hua Heo, to avoid destroying the Kaeng Tana falls. The study, called Pak Mun multipurpose development project: Feasibility Study, proposes that the dam be built with a normal water level of 108 m.
April 1986	SOGREAH completes a study of a dam at Ban Hua Heo with a normal water level of the reservoir at 108 MSL. It includes an excavated channel downstream of the dam for the purpose of increasing the available head for power generation. The report is called: Pak Mun multipurpose development project: Outline of downstream channel, April 1986.
November 1987	SOGREAH completes the Engineering Definite Study Phase 1, which includes

	reservoir operation analysis, a hydraulic model, drawings, equipment specifications, etc.
1988	The Pak Mun dam is not mentioned in the PDP.
1988	Publication of "Involuntary Resettlement in Development Projects, Policy Guidelines in World Bank Financed Projects (WTP80) by the World Bank.
March 1988	EGAT produces a Summary Report: Pak Mun Multipurpose Development Project. This summary report is used as the basis for the project review by NESDB as well as for the presentation of the project for approval by the Cabinet of Ministers.
April 1989	EGAT submits the Pak Mun project for approval by the Cabinet of Ministers.
May 1989	The Cabinet of Ministers approves the Pak Mun project with a total budget of Baht 3.88 billion.
September 1989	SOGREAH completes the Engineering Definite Study Phase 2.
1989	The Pak Mun dam appears in the PDP as follows: Capacity: 136 MW Completion date: November 1992; Cost in US$: 149.2 million
May 1990	The Government sets up a Committee for the Compensation of Land Rights and Properties as well as a Committee for Resettlement.
June 1990	The World Bank produced an Executive Project Summary, indicating the Bank's interest in the Pak Mun project.
October 1990	World Bank staff completed the appraisal for the Third Power Project that includes the Pak Mun dam.
January 1991	Completion of Preliminary Works on the Pak Mun dam site.
July 1991	The World Bank completes the Staff Appraisal Report for the Third Power Project that includes the Pak Mun dam. The dam is defined as follows: Drainage area: 117,000 km^2 Normal water level: 108 m Nominal gross head: 11.6 m Installed capacity: 136 MW Annual energy output: 280 GWh Purpose of project: Power, irrigation, and fishery. Estimated base cost: US$ 159.64 million Estimated cost including physical and price contingencies: US$ 177.66 million. According to the SAR works had to start in June 1990 and completion was expected in early 1995.
September 1991	The modification of the project cost to Baht 6.6 billion is approved by NESDB.
December 1991	The Board of Directors of the World Bank approves a US$ 54 million loan for the Third Power System Project that includes the Pak Mun dam.
January 1992	Completion of all Bid Awards for the contracts for the dam.
1993	Publication of "Just another dammed river? Negative impacts of Pak Mun on fishes of the Mekong Basin" by Tyson R. Roberts, Research affiliate, Smithsonian Tropical Research Institute.
April 1993	Publication of "Villagers Occupy World Bank Dam Site in Thailand in Desperate Attempt to Protect the 'Kingdom of the Fish'" in Probe Alert, a US based NGO publication
November 1993	Publication of "Fish, Forests and Food: Means of Livelihood in Mun River Village Communities" by the Project for Ecological Recovery, a Thai NGO.
November 1993	Completion of the Powerhouse
December 1993	The Government sets up a Committee for Assistance to Project Affected Persons to replace the Committee for the Compensation of Land Rights and Properties as well as a Committee for Resettlement.
January 1994	Before the impoundment of the dam villagers supported by NGOs came to

	protest in Bangkok demanding compensation for households engaged in fisheries.
February 1994	Completion of coffer dams
April 1994	Roller Compacted Concrete Dam closure
October 1994	Completion and Commissioning of all 4 turbine generators and of High Voltage equipment.
January 1995	Completion and Commissioning of all works.
January 1995	The Government set up the Committee on Assistance and Occupational Development for Fish Farmers.
March 1995	The fisheries development centre is completed.
March 1995	Final disbursement of World Bank funds for the project.
June 1995	Khon Khaen University carried out a post-project implementation socio-economic survey of the affected households.
May 1996	The fisheries development centre starts to hatch and stock local and other fish into the Mun River.
June 1996	The World Bank completes its Implementation Completion Report of the Third Power System Development Project. Total project cost is US$ 233 million. Appendix D of this report handles the Resettlement and Compensation, the Environmental Impact Mitigation and the Health Impact Mitigation.
December 1996	End of the Fisheries Development implemented by EGAT with the help of World Bank funds.
September 1997	End of the Fisheries Development implemented by Department of Fisheries with the help of World Bank funds.

4. Projected Versus actual Costs, Benefits and Impact of the Pak Mun Project

This section seeks to address first set of the six question posed by WCD case study namely, what were the projected vs actual costs, benefits and impacts? The analysis includes the following:

- Economic and financial analysis
- Benefits of the project: power, irrigation and tourism
- Impact of the project: fisheries, social and environmental

This section ends with a summary table of Pak Mun project's cost, benefits and impacts.

4.1 Cost of the Project

4.1.1 The Predicted and Actual Costs

The Table 4.1 below shows a near doubling of costs between the EGAT/SOGREAH estimate of 1980 and the final cost tally made by EGAT in 1999; i.e. from 3 197.67 million Baht to 6 018.88 million Baht. The 1980 estimate refers to a dam at the Kaeng Tana site. This dam would have been much higher than the dam at the Hua Heo site, would have had a much larger reservoir surface and would have imposed much higher resettlement and other environmental expenses. It is to be noted that civil work cost estimates shows a dip in the 1985 and 1987 cost estimates.

Table 4.1: Evolution of Pak Mun Dam project costs (nominal prices, million Baht)

	EGAT/ SOGREAH 1980[16]	EGAT/ SOGREAH 1985[17]	EGAT/ SOGREAH 1987[18]	EGAT 1988[19]	EGAT/ SOGREAH 1989[20]	WB/SAR 1991[21]	NESDB 1991[22]	WB/ICR 1996[23]	EGAT 1999[24]
Civil Works & Preparatory works	935.00	748.00	228.00	880.53	1,107.00	1,387.19	1,829.59	2,146.50	2,146.84
Power plant	1,012.67	1,723.00	625.00	1,609.46	2,205.00	1,489.90	1,942.91	1,753.75	1,753.88
Spillway	181.00	#N/A	#N/A	0.00	#N/A	0.00	0.00	0.00	0.00
Substation & Transmission	106.00	#N/A	#N/A	210.05	#N/A	370.04	490.42	480.25	480.08
Engineering services	117.00	#N/A	#N/A	140.32	#N/A	294.91	221.20	524.75	192.68
EGAT Administration	75.00	#N/A	#N/A	83.21	#N/A	0.00	165.00	0.00	332.32
Resettlement	770.00	#N/A	#N/A	231.55	#N/A	623.47	640.28	807.50	1,113.10
Total	**3,196.67**	**#N/A**	**#N/A**	**3,155.12**	**3,312.00**	**4,165.51**	**5,289.40**	**5,712.75**	**6,018.88**
In Million US$[25]	**84.12**			**83.03**	**87.16**	**109.62**	**139.19**	**150.34**	**158.39**
Taxes	#N/A	#N/A	#N/A	304.88	#N/A	275.99	360.00	103.00	103.08
Interest during Construction	#N/A	#N/A	#N/A	420.00	#N/A	#N/A	950.00	#N/A	385.81
Total including Taxes & IDC	#N/A	#N/A	#N/A	3,880.00	#N/A	#N/A	6,599.40	#N/A	6,507.78
In Million US$				**102.11**			**173.67**		**172.26**

When estimates and expenses are made many years apart, or under conditions of considerable price changes it is better to compare them at constant prices. This analysis can be found in Table 4.2 below.

Table 4.2: Comparison of Pak Mun Dam project costs in constant 1998 prices

	EGAT/ SOGREAH 1980	EGAT 1988	WB/SAR 1991	NESDB 1991	WB/ICR 1996	EGAT 1999
Civil Works & Preparatory works	2,195.05	1,501.22	2,003.94	2,643.03	2,449.92	2,146.84
Power plant	2,377.38	2,743.97	2,152.31	2,806.73	2,001.66	1,753.88
Spillway	424.92	-	-	-	-	-
Substation & Transmission	248.85	358.11	534.56	708.46	548.14	480.08
Engineering services	274.67	239.23	426.03	319.55	598.93	192.68
EGAT Administration	176.07	141.86	-	238.36	-	332.32
Resettlement	1,807.69	394.77	900.67	924.95	921.65	1,113.10
Total	**7,504.65**	**5,379.17**	**6,017.51**	**7,641.08**	**6,520.29**	**6,018.88**
Index	125	89	100	127	108	100
Taxes	#N/A	519.79	398.69	520.06	117.56	103.08
Interest during Construction	#N/A	716.06	#N/A	1,372.37	#N/A	385.81
Total including Taxes & IDC	#N/A	6,615.01	#N/A	9,533.50	#N/A	6,507.78
Total In Million US$[26]		**174.08**		**251.41**		**171.26**
CPI 1998=100 [27]	42.60	58.65	69.22	69.22	87.61	100.00

Table 4.2 above shows that the real cost of the Pak Mun dam has not changed much since 1980 irrespective of the fact that the final Pak Mun dam is considerably smaller than the one proposed in the early 1980s. It also shows that, in constant terms, the cost of taxes and interest during construction was much less than anticipated. The cost of the project in 1988 was the amount approved by the Thai Cabinet. Before taxes and interest, the actual cost is 11% higher than the predicted cost. Figure 5, Annex 7, shows the evolution of the Pak Mun project costs in nominal and constant terms since 1980. While costs under Power plant and engineering services show significant decline in real terms, resettlement costs increased from 394.77 million in EGAT's 1988 estimates to 1,113.1 million by 1999, implying an increase of 182% in real terms under this head.

The project's actual costs as presented in the World Bank's Implementation Completion Report in 1996 are compared with the proposed costs at appraisal in 1991 in Table 4.3. In nominal terms, the total project costs increased by US$ 55.99 million between appraisal estimate and actual expenditure at the time of the World Bank loan closure in 1995.

Table 4.3: Pak Mun Dam: The Project Costs between SAR estimates and ICR Actual
Unit : US$ million

Item	SAR Appraisal estimate			ICR Actual		
	Local costs	Foreign exchange costs	Total	Local costs	Foreign exchange costs	Total
Preliminary Works	6.13	-	6.13	10.43	-	10.43
Compensation, Resettlement Environment	22.41	-	22.41	32.30	-	32.30
Civil Works	25.85	17.88	43.73	46.30	29.13	75.43
Hydraulic Equipment	1.28	6.15	7.43	1.38	7.64	9.03
Electro-mechanical Equipment	5.02	41.10	46.12	16.47	44.66	61.12
High Voltage System	0.41	3.85	4.26	0.12	6.12	6.24
Transmission System	3.69	5.35	9.04	5.78	7.19	12.96
Engineering & Administrative Overheads	4.64	-	4.64	13.29	-	13.29
Consulting Services	2.53	3.43	5.96	3.40	4.30	7.71
Duties & Taxes	9.92	-	9.92	4.12	-	4.12
Base Cost	**81.88**	**77.76**	**159.64**	**133.60**	**99.04**	**232.65**
Physical Contingencies	4.09	3.88	7.97	-	-	-
Price Contingencies	5.15	4.90	10.05	-	-	-
Total Cost	**91.12**	**86.54**	**177.66**	**133.61**	**99.04**	**232.65**

Source: World Bank's Implementation Completion Report (ICR), Thailand's Third Power System Development Project (Loan 3423-TH), June 18, 1996.

Table 4.4 shows in detail the actual costs by year in project implementation, compiled by EGAT, including costs incurred after the project's accounts were closed in 1995. Much of the expenditure after that was against compensation payments to villagers against claims of lost livelihood through adversely affected fisheries due to dam construction. After 1995, until 1998, 305.55 million Baht were paid against lost fisheries under Environmental Impact Mitigation plan.

Table 4.4: Pak Mun Dam: The Actual by year Costs incurred
Unit**:** Baht Million

Description	1992	1993	1994	1995*	1996	1997	1998	*1992-1998*
1. Preparation Works	4.142	22.284	8.487	226.165				*261.08*
2. Compensation, Resettlement and Environmental Impact Mitigation Plan								
2.1 Compensation	147.904	24.532	13.893	73.339				*259.67*
2.2 Resettlement	31.780	92.083	198.764	22.547				*345.17*
2.3 Environmental Impact Mitigation Plan	14.550	15.111	88.036	85.009	234.720	62.550	8.280	508.26
3. Civil Works	249.601	583.934	495.141	557.081				*1885.76*
4. Hydraulic Equipment	-	175.457	53.679	-3.391				*225.75*
5. Electromechanical	5.000	1033.057	371.708	118.367				*1528.13*
6. Main Transformer & Switchyard Equipment	-	132.437	69.479	-45.951				*155.97*
7. Transmission System	50.521	219.418	69.638	-15.465				*324.11*
8. EGAT Administration	32.518	72.769	98.702	128.329				*332.32*
9. Engineering Consulting Services	15.509	57.133	48.589	71.447				*192.68*
10. Import Duties & Taxes	6.460	88.938	13.504	-5.819				*103.08*
Sub-Total	**557.985**	**2517.153**	**1529.620**	**1211.658**	**234.720**	**62.550**	**8.280**	***6121.966***
11. Interest During Construction	19.036	164.208	206.970	-4.400				*385.81*
Total Project Cost	**577.021**	**2681.361**	**1736.590**	**1207.258**	**234.720**	**62.550**	**8.280**	***6507.780***
Total project Costs in US$[28]	**15.18**	**70.56**	**45.7**	**31.8**	**6.17**	**1.64**	**0.21**	*171.26*

Source: EGAT, October 1999- negative figures are adjustments for back-claim items against suppliers, at project account's closing date in 1995

Conclusions:

- In nominal terms total cost of Pak Mun project increased by over 90% between the 1988 EGAT estimates and the actual costs in 1999. At constant 1998 prices, total project costs in 1999 not including taxes and interests is 11% over estimated costs in 1988.

- Resettlement costs increased from 394.77 million in EGAT's 1988 estimates to 1 113.1 million by 1999, implying an increase of 182% in real terms.

- After 1995, until 1998, 305.55 million Baht were paid against lost fisheries under Environmental Impact Mitigation plan.

- In real terms the actual total cost of Pak Mun project in 1999 was not significantly different from EGAT /SOGREAH estimate of 1980, even though the new project was considerably smaller in size.

4.2 Benefits of the Project - The Predicted and Actual Benefits: Hydropower

4.2.1 Projected versus Actual Mun River Runoff.

From daily run off data supplied to the Study by EGAT[29] the average runoff in the 1996-99 period has been 675 cumsec. This is 11% lower than the 760 cumsec assumed by both EGAT and the World Bank.

Table 4.5: Comparison of Expected and Actual Average Runoff of the Mun River at the Pak Mun Dam

Predicted average run-off of the Mun river at the Pak Mun dam	760 cumsec
Actual 1996-1999 average run-off of the Mun river at the Pak Mun dam	675.53 cumsec
Difference between predicted and actual	-11%

Projected versus Actual Installed Capacity of the Pak Mun Hydropower Project.

In confirmation with its presentation to the Council of Ministers, the EGAT constructed the Pak Mun project with an installed capacity of 136 MW (Table12). That is, the power generation capacity projected and the capacity installed is the same.

Table 4.6: Comparison of Projected versus Actual Installed Capacity of the Pak Mun Hydropower Project.

	Number of Turbines	Capacity of each turbine	Total capacity
Projected in EGAT's 1988 presentation to the Council of Ministers [30]	4	34 MW	136 MW
Projected in the World Bank SAR [31]	4	34 MW	136 MW
Actual as built [32]	4	34 MW	136 MW

Comparison of Predicted versus Actual Total Power Production

Both the EGAT report to Cabinet and the World Bank assumed a total electricity generation per year of 280 GWh. Over the period 1995-1999 the production has been an average of 289.73 GWh, slightly (3.5%) more than estimated (Table 4.7). This average has been calculated only for the years for which the dam was operated during the whole year to avoid seasonal variation biases. (See Figure 6 - Annex 7)

Table 4.7: Comparison of Expected and Actual Average yearly electricity production at Pak Mun dam [33]

	Total GWh
Average yearly power production predicted by both EGAT and the World Bank	**280.0**
1994, from August onwards	102.61
1995	277.38
1996	297.86
1997	301.00
1998	282.69
1999 up to August	188.74
Average 1995-98	**289.73**
Increase over original estimate	**3.5%**
Total Pak Mun electricity generation up to August 1999	1,261.53

Examination of efficiency of the water to power conversion

The Pak Mun dam has performed better than expected in terms of average gross conversion of Mun river runoff into electricity. The yearly runoff of the dam has been so far 11% below the predictions. Since the average yearly electricity output has been 3.5% more than expected, the average gross water to power conversion has been 14% better than expected [34].

Table 4.8: Comparison of Expected and Actual Average Water to Power Conversion at the Pak Mun Dam

	Expected	**Actual**	unit
Average water runoff	760	676	cumsec
Average yearly water runoff	23,967	21,304	MCM
Yearly power production	280	290	GWh
Gross average water to power conversion	86	74	cum/kWh

The following figures clearly explain the difference between a run-of-the-river dam and a storage dam. In a storage dam water is lost through evaporation during storage, a small amount may be lost through seepage, and occasionally water is spilled when unexpected rainfall fills the reservoir faster than expected. A run-of-the-river dam such as the Pak Mun dam wastes a considerable amount of potential energy. It does so in two circumstances, first when more water arrives at the dam than can be used in the turbines, second when flooding downstream of the dam reduces the generation head to the point that power generation is impossible. Both these events occur at the Pak Mun dam. Since the rainfall in the Mun basin is restricted to the rainy season the run-off is either too low to use the full capacity of the turbines or far too much. During some years the flooding of the Mekong River is severe and the waters back up all the way to the Pak Mun dam. In such circumstances the Pak Mun dam does not have enough head to generate power. In addition, because the dam would cause flooding of upstream rapids, EGAT is obliged to operate the dam so that the water level at those rapids does not exceed the seasonal levels that existed before the dam was built. This also causes

water to be spilled. The spillage of potential energy by the Pak Mun dam is clearly illustrated in the following four figures.

Figure 4.1: Use of Mun River Water for Power Generation and spilled in 1996 (MCM/day).

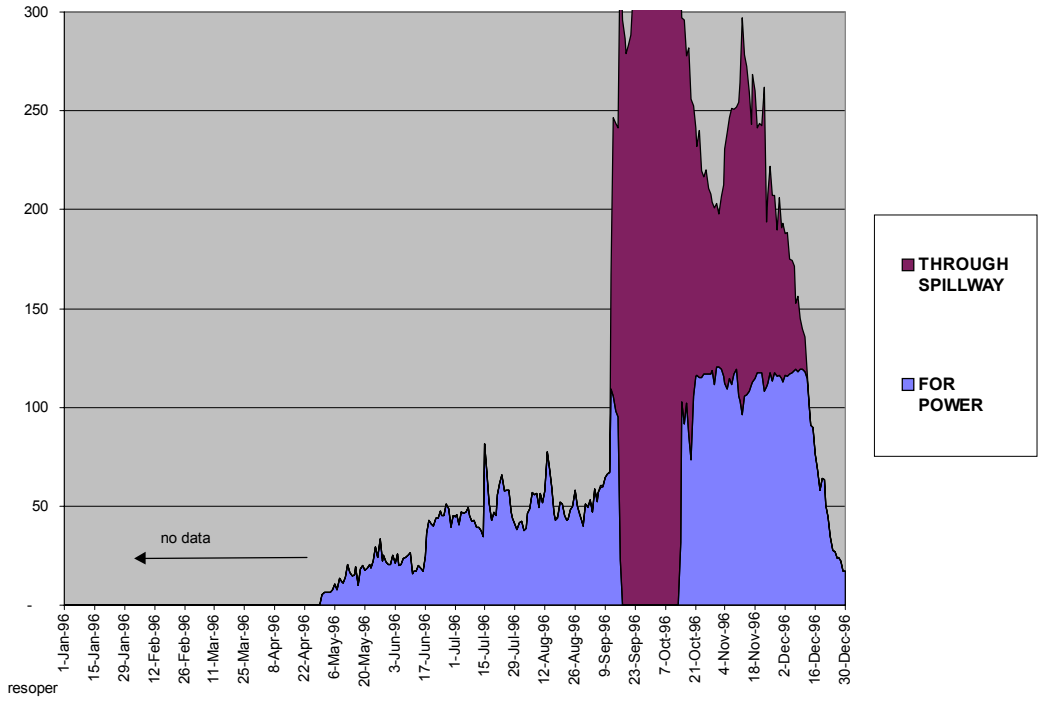


Figure 4.2: Use of Mun River Water for Power Generation and spilled in 1997 (MCM/day).

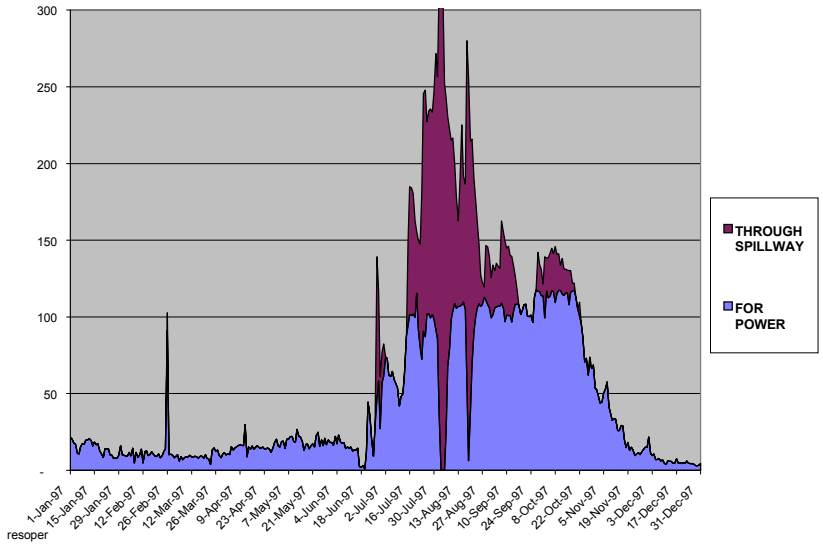


Figure 4.3: Use of Mun River Water for Power Generation and spilled in 1998 (MCM/day).

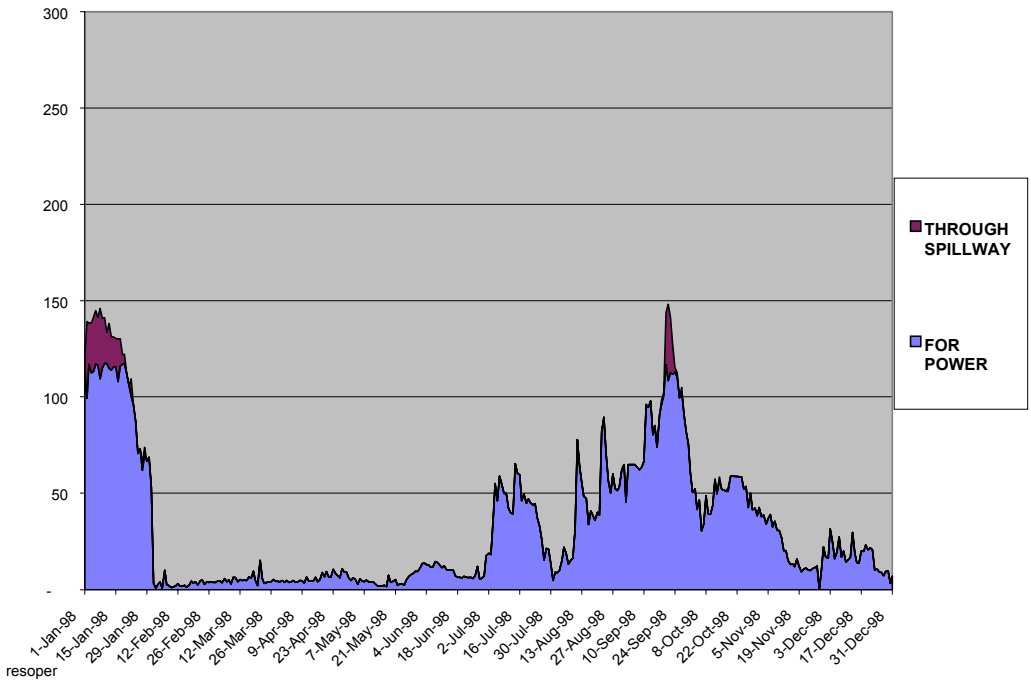
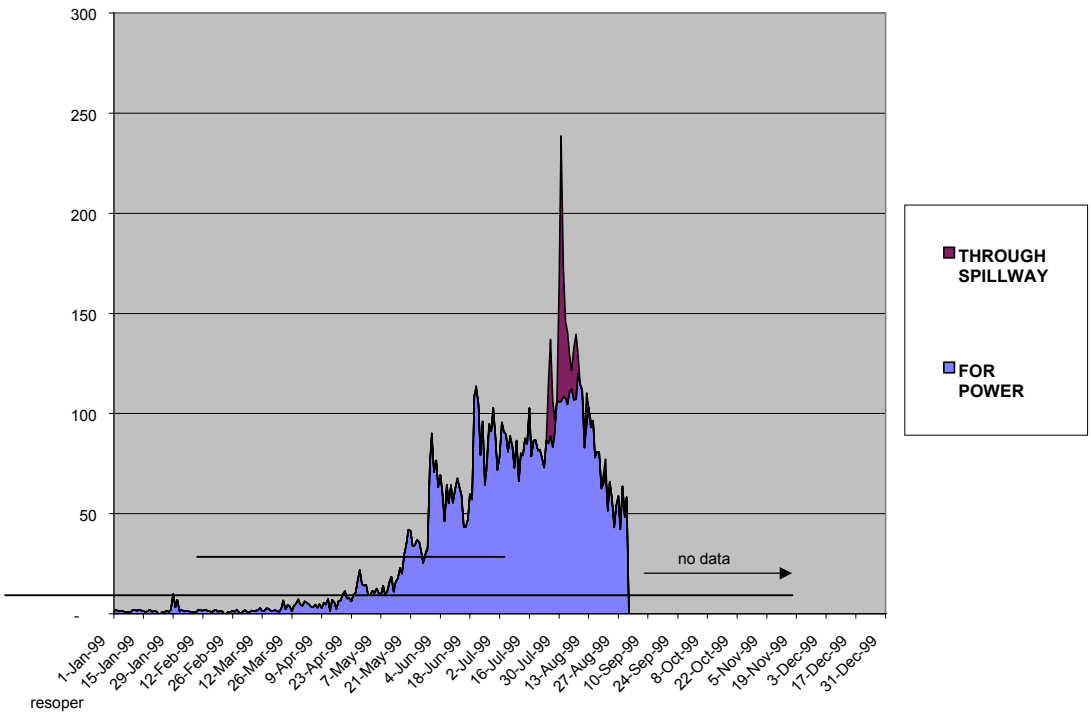


Figure 4.4: Use of Mun River Water for Power Generation and spilled in 1999 (MCM/day).



The net efficiency of the dam varies considerably during the year. It seems to be mostly a function of the head available for the turbines. To see the differences in net efficiency of the dam caused by spillage, see figures 13-16, in Annex 7).

Projected versus Actual Dependable Capacity of the Pak Mun Power Plant

The presentation by EGAT to the Cabinet of Ministers in March 1988 assumed that the Dependable Capacity of the Pak Mun dam was 75 MW. "*Dependable Capacity of Hydropower Plants* is defined as the unit output at the reservoir water levels corresponding to 90% of the water level frequency based on the long-term reservoir simulations, using historical hydrological records."[35] If EGAT's definition is applied to the simulated 1967-81 Pak Mun runoff record then the Dependable Capacity is 41 MW. This was calculated using mean monthly GWh data. Using EGAT's definition of Dependable Capacity, and based on daily power output data between 1995-98, the Pak Mun hydropower project Dependable Capacity is 20.81 MW if one assigns all available power to a 4-hour peak demand period. For detailed calculations see (Tables 6-8 and figures 17-24 in Annex 7).

This is most likely an overestimation of Dependable Capacity. The reason is that we have assumed that during each day the available GWh could be allocated by priority to peak power generation. A first set of constraints on such priority allocation to peak generation are the operating rules imposed on the plant. These demand that reservoir levels be maintained at a certain level. The second set of constraints occurs when bulb turbine operations are reaching the boundary of one of three of their operational envelopes. Water flow and head conditions can cause the bulb generators to reach turbine saturation, or the cavitation or the generator limits. In order to estimate how much these constraints influence actual performance, in the absence of real peak operations data, we have used data simulated by SOGREAH based on their knowledge of bulb generator operational envelopes and on simulated water conditions (see Table 9 -Annex 7). In comparing the results with our calculation of peak production, which assumes that all available GWh can be assigned to peak power time. The results of the above calculations are used to scale down the expected Dependable Peak Capacity to a figure that is more likely to take into account the operational constraints of the reservoir and of the bulb generator. According to the definition of Dependable Capacity used by EGAT the Pak Mun dam, and taking into account the likelihood of being able to generate Peak Power, the Dependable Capacity is 16.16 MW (for detailed expanded calculation see Table 10-12, Annex 7).

Table 4.9: Summary of Dependable Capacity calculations for 1995 – 98

Dependable capacity assumed by EGAT in its 1988 presentation to the Cabinet of Ministers	75 MW
Dependable capacity calculated from simulated mean monthly data based on the 1967-81 Pak Mun run off record assuming a 4 hour peak.	40.9 MW
Dependable capacity calculated from daily power output in 1995-98, assuming that all available power gets assigned to a 4 hour peak demand period. This calculation and the three summarised below follow the rules for Dependable Capacity Calculations officially declared by EGAT in March 1988 [36]	20.81 MW
Dependable capacity calculated from daily power output in 1995-98, assuming that as much as possible available power gets assigned to a 4 hour peak demand period, taking account the likelihood that EGAT is able to assign a maximum amount of power to the peak period.	16.16 MW

During its presentation at the second Pak Mun Dam stakeholder meeting, EGAT confirmed that it had used the "Mean net peak power output" definition to calculate the 75 MW dependable capacity presented in its 1988 report to the Council of Ministers [37]. At any rate the SOGREAH 1983 studies in which the 75 MW dependable capacity are calculated are mentioned as preparatory works in the 1988 submission to the Council of Ministers [38] The calculation method consists in taking the whole of the yearly peak production of the dam and deriving from it the average yearly power output by assuming that the available GWh can be available evenly during every 4-hour peak period of every day of the year. The mean net peak power output of a certain period is the straight average of the mean net peak power output for every year in that period. The disadvantage of this calculation method is that it completely masks the possibly large variations in monthly or daily power production. In storage dam

the variation of power output is to a great extent managed by releasing water in such a way that sufficient water will be available year-around to provide power during the peak period. Since a run-of-the-river dam does not offer the possibility of storing water and managing the time of water usage the mean net peak power output is not a good measure of its dependable capacity.

However, according to the definition of Dependable Capacity introduced by EGAT in[39] or before March 1988[40] , applied to the simulated 1967-81 Pak Mun runoff record than the Dependable Capacity is only 41 MW. If the study had been given access to the monthly simulated GWh data calculated by SOGREAH for the 1967-81 period one would most likely find that the Dependable Capacity is much lower than 41 MW. This is because it was calculated using mean monthly GWh data and that it is certain that some of the monthly GWh results were lower than the mean.

Table 4.10: Mean Peak Monthly Output 1967-81 and calculated Mean Peak Capacity ranked in descending order. [41]

Month	Peak GWh	Peak MW Assuming a 4 hours peak
Jun	13.63	112.03
Nov	13.14	108.00
Dec	12.81	105.29
Jul	12.01	98.71
Oct	10.89	89.51
Aug	8.02	65.92
May	7.87	64.68
Sep	7.05	57.95
Jan	6.31	51.86
Apr	5.67	46.60
Mar	5.42	44.55
Feb	4.98	**40.93**

Project VS Actual Assumed Power Plant type

The EGAT presentation to the Cabinet assumed that Pak Mun dam would be a 100% peaking plant and the World Bank assumed the same implicitly. The hydrology data showed that the plant could operate only 36% of the time during peak demand time assuming a 4-hour peak. The actual record, based on daily power generation data supplied to the study by EGAT, indicates that an average of about 44% of the total GWh could be generated as peak power. Based on simulations made by SOGREAH, it is more likely that only about an average of 72% of the Peak Generation can be achieved. This means that it is likely that only about 32% of the GWh are produced at peak time (see figures 37-39, Annex 7).

Table 4.11: Mean Potential Annual Energy Output [42]

Year	Peak GWh	Off-peak GWh	Total GWh
1967	106.85	159.31	266.16
1968	106.00	117.91	223.91
1969	102.42	241.47	343.89
1970	113.57	179.30	292.87
1971	113.10	229.06	342.16
1972	111.53	211.39	322.92
1973	102.91	127.60	230.51
1974	112.46	146.35	258.81
1975	122.14	254.46	376.60
1976	116.92	242.21	359.13
1977	118.62	155.70	274.32
1978	94.40	155.85	250.25
1979	111.61	243.05	354.66
1980	96.19	262.44	358.63
1981	119.48	168.43	287.91
Mean	109.88	192.97	302.85
Percent	36%	64%	100%

Table 4.12: Summary of power generation at the Pak Mun dam, May 1996-August 1999 based on daily data [43].

	Peak GWh	Off-peak GWh	Total GWh
1996[44]	113.65	160.13	273.78
	42%	58%	100%
1997	138.26	162.74	301.00
	46%	54%	100%
1998	132.64	150.04	282.69
	47%	53%	100%
1999[45]	74.54	114.20	188.74
	39%	61%	100%
Weighted average %	44%	56%	100%

Although full year daily data are available for runoff at the Pak Mun dam for 1995 to today, no long run simulation of the power generation potential has been performed. As a consequence the performance of the Pak Mun dam can only be gauged from the simulations made on 1967-81 runoff data and from the actual run-off data measured since Pak Mun dam operations started.

Table 4.13: Comparison of Peak generation simulated by SOGREAH as percentage of maximum peak generation calculated in this report

Month	Peak GWh	Total GWh	Maximum assignment to Peak Power GWh	Peak generation simulated by SOGREAH as percentage of maximum peak generation calculated in this report
Jan	6.31	8.00	8.00	79%
Feb	4.98	6.41	6.41	78%
Mar	5.42	7.01	7.01	77%
Apr	5.67	7.27	7.27	78%
May	7.87	10.07	10.07	78%
Jun	13.63	28.11	16.32	84%
Jul	12.01	42.08	16.32	74%
Aug	8.02	33.94	16.32	49%
Sep	7.05	39.55	16.32	43%
Oct	10.89	58.37	16.32	67%
Nov	13.14	41.90	16.32	81%
Dec	12.81	18.23	16.32	78%
			Mean	**72%**

Below is the analysis of the comparison between calculation of peak power MW using an artificial assignment of GWh to peak time with actual peak power capacity declared by EGAT. The check was done for the only three months for which EGAT provided data.

Table 4.14: Illustration of the manner in which EGAT is obliged to operate the Pak Mun plant in the rainy season (November 1998) to take into account plant operational limits as well as environmental requirements [46].

	Total GWh recorded	MW available if plant uses a maximum of run-off during peak time	Number of hours of generation at 136 MW during peak time	Number of hours left to generate 136 MW during off-peak time	Total number of hours the plant can run at 136 MW	MW declared by EGAT	Number of hours of declared MW can be sustained at constant rate
	#1	#2	#3	#4	#5	#6	#7
1-Nov-98	1.25667	136.00	4.00	5.24	9.24	93	13.51
2-Nov-98	1.08979	136.00	4.00	4.01	8.01	121	9.01
3-Nov-98	1.11344	136.00	4.00	4.19	8.19	124	8.98
4-Nov-98	1.01006	136.00	4.00	3.43	7.43	123	8.21
5-Nov-98	1.05564	136.00	4.00	3.76	7.76	120	8.80
6-Nov-98	1.09170	136.00	4.00	4.03	8.03	119	9.17
7-Nov-98	0.92453	136.00	4.00	2.80	6.80	119	7.77
8-Nov-98	0.98608	136.00	4.00	3.25	7.25	123	8.02
9-Nov-98	0.86386	136.00	4.00	2.35	6.35	122	7.08
10-Nov-98	0.85318	136.00	4.00	2.27	6.27	123	6.94
11-Nov-98	0.72742	136.00	4.00	1.35	5.35	118	6.16
12-Nov-98	0.53649	134.12	3.94	-	3.94	130	4.13
13-Nov-98	0.57936	136.00	4.00	0.26	4.26	120	4.83
14-Nov-98	0.42929	107.32	3.16	-	3.16	110	3.90
15-Nov-98	0.37392	93.48	2.75	-	2.75	99	3.78
16-Nov-98	0.38566	96.42	2.84	-	2.84	101	3.82
17-Nov-98	0.33863	84.66	2.49	-	2.49	90	3.76
18-Nov-98	0.41123	102.81	3.02	-	3.02	119	3.46
19-Nov-98	0.32832	82.08	2.41	-	2.41	91	3.61
20-Nov-98	0.25144	62.86	1.85	-	1.85	90	2.79
21-Nov-98	0.29030	72.58	2.13	-	2.13	90	3.23
22-Nov-98	0.31236	78.09	2.30	-	2.30	91	3.43
23-Nov-98	0.28624	71.56	2.10	-	2.10	89	3.22
24-Nov-98	0.27243	68.11	2.00	-	2.00	90	3.03
25-Nov-98	0.30231	75.58	2.22	-	2.22	90	3.36
26-Nov-98	0.31569	78.92	2.32	-	2.32	90	3.51
27-Nov-98	0.33971	84.93	2.50	-	2.50	90	3.77
28-Nov-98	-	-	-	-	-	-	-
29-Nov-98	0.29586	73.97	2.18	-	2.18	119	2.49
30-Nov-98	0.58811	136.00	4.00	0.32	4.32	118	4.98

Column 1 of Table 4.15 above contains a record of the total GWh generated by the Pak Mun dam on a given day. Column 2 contains the number of MW that can be attained if all the GWh available for one day are used to reach 136 MW for the 4-hour peak if this is possible. Or to even out the available GWh over the four hours to produce as high a MW as possible. From 1 to 11 November the water is theoretically sufficient to produce 136 MW for 4 consecutive hours. On 24 November, if one uses up all the available GWh available on that day evenly during the 4-hour peak period, one can reach only 68.11 MW. Column 3 shows over how many hours the plant could be operated if all the GWh are used to operate the plant at the full 136 MW capacity during peak hour. One can see that from 14 to

29 November the plant could not run at 136 MW for a full 4 hours. Column 4 shows how many hours the plant could continue to operate at 136 MW after completing peak power generation at 136 MW. Column 5 shows how many hours the plant could run if kept operating at 136 MW. Column 6 shows the MW at which the EGAT plant operated during each day. Column 7 shows the number of hours the plant would operate if all available GWh were used at the constant MW declared by EGAT. The comparison of data in Columns #2 & #6 as well as #5 & #7 shows that EGAT chooses or is obliged by operational and environmental constraints to operate the plant at lower MW and for longer time.

Table 4.15: Illustration of the manner in which EGAT is obliged to operate the Pak Mun plant in the dry season (February 1999) to take into account plant operational limits as well as environmental requirements.

	Total GWh recorded	MW available if plant uses a maximum of run-off during peak time	Number of hours of generation at 136 MW during peak time	Number of hours left to generate 136 MW during off-peak time	Total number of hours the plant can run at 136 MW	MW declared by EGAT	Number of hours of declared MW can be sustained at constant rate
	#1	#2	#3	#4	#5	#6	#7
1-Feb-99	0.03125	7.81	0.23	-	0.23	20	1.56
2-Feb-99	0.06142	15.36	0.45	-	0.45	25	2.46
3-Feb-99	0.04336	10.84	0.32	-	0.32	18	2.41
4-Feb-99	0.03561	8.90	0.26	-	0.26	19	1.87
5-Feb-99	0.03928	9.82	0.29	-	0.29	20	1.96
6-Feb-99	0.02889	7.22	0.21	-	0.21	10	2.89
7-Feb-99	0.02873	7.18	0.21	-	0.21	10	2.87
8-Feb-99	0.02683	6.71	0.20	-	0.20	15	1.79
9-Feb-99	0.02683	6.71	0.20	-	0.20	19	1.41
10-Feb-99	0.05873	14.68	0.43	-	0.43	20	2.94
11-Feb-99	0.05163	12.91	0.38	-	0.38	15	3.44
12-Feb-99	0.04608	11.52	0.34	-	0.34	15	3.07
13-Feb-99	0.05941	14.85	0.44	-	0.44	15	3.96
14-Feb-99	0.04607	11.52	0.34	-	0.34	15	3.07
15-Feb-99	0.04246	10.62	0.31	-	0.31	15	2.83
16-Feb-99	0.02408	6.02	0.18	-	0.18	15	1.61
17-Feb-99	0.04247	10.62	0.31	-	0.31	15	2.83
18-Feb-99	0.06053	15.13	0.45	-	0.45	15	4.04
19-Feb-99	0.03049	7.62	0.22	-	0.22	15	2.03
20-Feb-99	0.03694	9.24	0.27	-	0.27	15	2.46
21-Feb-99	0.03694	9.24	0.27	-	0.27	19	1.94
22-Feb-99	-	-	-	-	-	-	-
23-Feb-99	-	-	-	-	-	-	-
24-Feb-99	0.02851	7.13	0.21	-	0.21	15	1.90
25-Feb-99	0.02868	7.17	0.21	-	0.21	15	1.91
26-Feb-99	0.04516	11.29	0.33	-	0.33	15	3.01
27-Feb-99	0.02500	6.25	0.18	-	0.18	10	2.50
28-Feb-99	0.06263	15.66	0.46	-	0.46	15	4.18

The above Table 4.16 can be analysed following the explanations given for the previous table. It shows clearly that the Pak Mun dam has only enough water to operate a few hours per day at a very

low level of MW. In the month of February 1999 the plant was actually able to operate only about two and one half-hour at less than 15 MW.

Table 4.16: Illustration of the manner in which EGAT is obliged to operate the Pak Mun plant in the flood season (August 1999) to take into account plant operational limits as well as environmental requirements.

	Total GWh recorded	MW available if plant uses a maximum of run-off during peak time	Number of hours of generation at 136 MW during peak time	Number of hours left to generate 136 MW during off-peak time	Total number of hours the plant can run at 136 MW	MW declared by EGAT	Number of hours of declared MW can be sustained at constant rate
	#1	#2	#3	#4	#5	#6	#7
1-Aug-99	1.56000	136.00	4.00	7.47	11.47	70	22.29
2-Aug-99	1.71003	136.00	4.00	8.57	12.57	73	23.43
3-Aug-99	1.70996	136.00	4.00	8.57	12.57	73	23.42
4-Aug-99	1.78920	136.00	4.00	9.16	13.16	78	22.94
5-Aug-99	1.94269	136.00	4.00	10.28	14.28	79	24.00
6-Aug-99	1.81753	136.00	4.00	9.36	13.36	78	23.30
7-Aug-99	1.80877	136.00	4.00	9.30	13.30	76	23.80
8-Aug-99	1.80215	136.00	4.00	9.25	13.25	78	23.10
9-Aug-99	1.91333	136.00	4.00	10.07	14.07	80	23.92
10-Aug-99	1.87601	136.00	4.00	9.79	13.79	80	23.45
11-Aug-99	1.41756	136.00	4.00	6.42	10.42	78	18.17
12-Aug-99	1.59088	136.00	4.00	7.70	11.70	79	20.14
13-Aug-99	1.73711	136.00	4.00	8.77	12.77	80	21.71
14-Aug-99	1.64143	136.00	4.00	8.07	12.07	83	19.78
15-Aug-99	1.67818	136.00	4.00	8.34	12.34	80	20.98
16-Aug-99	1.39585	136.00	4.00	6.26	10.26	92	15.17
17-Aug-99	1.43024	136.00	4.00	6.52	10.52	90	15.89
18-Aug-99	1.38479	136.00	4.00	6.18	10.18	79	17.53
19-Aug-99	1.11466	136.00	4.00	4.20	8.20	91	12.25
20-Aug-99	1.23124	136.00	4.00	5.05	9.05	93	13.24
21-Aug-99	1.25408	136.00	4.00	5.22	9.22	92	13.63
22-Aug-99	1.09255	136.00	4.00	4.03	8.03	99	11.04
23-Aug-99	1.32494	136.00	4.00	5.74	9.74	93	14.25
24-Aug-99	1.17315	136.00	4.00	4.63	8.63	96	12.22
25-Aug-99	0.89359	136.00	4.00	2.57	6.57	98	9.12
26-Aug-99	1.08247	136.00	4.00	3.96	7.96	91	11.90
27-Aug-99	1.15827	136.00	4.00	4.52	8.52	92	12.59
28-Aug-99	0.86907	136.00	4.00	2.39	6.39	70	12.42
29-Aug-99	1.23652	136.00	4.00	5.09	9.09	92	13.44
30-Aug-99	0.91589	136.00	4.00	2.73	6.73	90	10.18
31-Aug-99	1.08609	136.00	4.00	3.99	12.20	89	12.20

The above Table 4.17 can be analysed following the explanations given for the previous two tables. This table shows that while theoretically the plant could be operated at 136 MW during nearly 11 hours, EGAT is forced to operate it at an average of about 18 hours at about 84 MW.

This shows clearly that the Pak Mun dam cannot function as a traditional reliable peaking plant. Because it is a run-of-the-river hydro plant it is constrained by the vagaries of water runoff as well as by operational constraints that force it to be operated significantly below its theoretical capacity. This phenomenon is well illustrated in the three scatter graphs, 25-27, found in Annex 7. They show how in August 1999, during the flood season, EGAT chose to run longer and at a lesser MW than theoretically possible. It shows how in February 1999, during the dry season, EGAT chose to run around 15 MW for about two and one half hour instead of less than one hour at peak time at 136 MW. The same is shown in the figure for November 1998, during the wet season.

Avoided cost Calculation: Assumption of dependable capacity in Alternate power plant

The SOGREAH 1985 report mentions[47] that EGAT calculates the Dependable Capacity of a hydropower plant as "the half-sum [the average] of the installed capacity and of the minimum capacity generated over the whole length of hydrological records". The same report adds that in 1983 EGAT decided to calculate the Dependable Capacity as "the average capacity generated during peak hours (4 hours a day), using day-to-day simulation over the whole period of records (15 years)".

Since during the whole 15 years one can assume that at least one day the Mekong flooded sufficiently to bring the heads below the 4.3 meter minimum head limit[48] the Dependable Capacity according to EGAT's pre-1983 definition would have been 68 MW (or 50% of 136 MW). According to the 1983 rule this Dependable Capacity was 75 MW.

During its presentation at the second Pak Mun Dam stakeholder meeting, EGAT confirmed that it had used the "Mean net peak power output" definition to calculate the 75 MW dependable capacity presented in its 1988 report to the Council of Ministers [49]. At any rate the SOGREAH 1983 studies in which the 75 MW dependable capacity are calculated are mentioned as preparatory works in the 1988 submission to the Council of Ministers [50] However, if the definition of Dependable Capacity introduced by EGAT in[51] or before March 1988[52], is applied to the simulated 1967-81 Pak Mun runoff record then the Dependable Capacity is only 41 MW. Following EGAT's rule for dependable capacity calculation declared in March 1988, the current report calculates dependable capacity from daily power output in 1995-98, assuming that all available power gets assigned to a 4 hour peak demand period as 20.81 MW.

Neither EGAT's presentation nor the World Bank SAR shows the portion of total energy production that would be available for peak load as calculated from daily runoff simulations. This is peculiar since all reports prepared by SOGREAH for EGAT have this information. The SOGREAH data show clearly that the proposed plant cannot operate as a 136 MW peaking plant in any month of the year. On an average, only 110 GWh out of 300 GWh, or about 36% can be supplied during the designated peak period. This confirms that it is not justified to assume that the Pak Mun dam replaces a 136 or 150 MW turbine peaking plant. The estimation of the Dependable Capacity of the Pak Mun Hydropower plant is important because it allows a comparison with the Dependable Capacity of the alternate source of peak power.

4.2.2 Projected versus Actual Economic Benefits of the Pak Mun Hydropower Project [53]

One of the main problems in comparing the projected and the actual benefits of the hydropower component of the Pak Mun project is that no proper economic analysis was conducted of the project. EGAT presented to the Council of Ministers the IRR, B/C ratio[54] , and Net P.V.[55] of the Pak Mun project. The calculations were made for three cases: Total Multipurpose Project, Power Only (Compared to Pak Mun Project cost), Power Only (Compared to allocated Cost for Power). The economic justification presented was called by EGAT itself an "economic comparison" [56]. In reality

the analysis presented was not based on an economic cost /benefit analysis. The reason being that although the analysis set out the cost side, presenting not only the original investment costs, but including replacements and O&M costs, it does not compare them with the value of the output of the project. It does not compare the costs with the value of the electricity produced.[57] Instead the alternative gas turbine capacity was used in the project document to quantify the conceptual economic benefits of the project as the avoided costs for power generation of the next best alternative. The IRR calculated by EGAT was actually the Equalising Discount Rate similar to the analysis conducted by the World Bank in its SAR. The Equalising Discount Rate Analysis consists in comparing the costs of the proposed project with the costs of the next best alternative project producing the same electricity as the project. This report has reproduced the calculations made by EGAT according to the World Bank Equalising Discount Rate Analysis. (See Tables in Annex 7 -The columns in Italics are calculated by this report).

It is interesting to note that the economic justification in the World Bank SAR of the Khao Laem Hydro-electric project [58], and of the Bang Pakong Thermal Power Project [59], both in 1979, contained both a traditional IRR calculation comparing costs and benefits as well as an equalising discount analysis. The IRR calculations used the expected power revenues as benefits. It is therefore strange that the World Bank in its 1988 analysis of the Pak Mun Hydropower project did not use conventional IRR calculation. The lack of proper ex-ante economic analysis means that it is not be possible to conduct a comparison of Projected and Actual Economic Value of the project.

Comparison of Projected versus Actual Equalising Discount rates

Table 4.17: Comparison of Projected versus Actual Equalising Discount rates

Equalising Discount rate calculated by EGAT (mistakenly called IRR), Power Only Option (in 1987 constant prices) [60]. The comparison plant is a 136 MW open cycle gas turbine fuelled with diesel.	19.81%
Equalising Discount rate calculated by the World Bank in the SAR in 1991 (in 1991 constant prices) [61]. The comparison plant is a 150 MW open cycle gas turbine fuelled with Heavy Fuel.	15.7%
Equalising Discount rate calculated by the World Bank in the ICR in 1996 (in 1995 constant prices) [62]. The comparison plant is a 150 MW open cycle gas turbine fuelled with Heavy Fuel.	11.92%
ICR Equalising Discount rate re-calculated in this report in Table 4.23 in Annex 7 (in 1995 constant prices). The comparison plant is a 21 MW open cycle gas turbine fuelled with diesel.	7.88%
ICR Equalising Discount rate re-calculated in this report in Table 4.25 in Annex 7 (in 1995 constant prices). The comparison plant is a 21 MW open cycle gas turbine fuelled with diesel for the peak power portion, and a conventional heavy oil fired boiler for the non-peak (non-firm) portion of the dam's power production	7.68%
ICR Equalising Discount rate re-calculated in this report in Table 4.27 in Annex 7 (in 1995 constant prices). The comparison plant is a 21 MW open cycle gas turbine fuelled with diesel for the peak power portion, and a conventional heavy oil fired boiler for the non-peak (non-firm) portion of the dam's power production. The benefits of the green house gas savings of the hydropower plus the ancillary services (such as VAR support) of the power plant are included.	9.24%

This report assumes that the one could use a 21 MW gas turbine to replace the dependable capacity provided by the Pak Mun Dam. The Equalising Discount rate calculated is 7.88%. Such a rate is below the shadow cost of capital in Thailand, which is around 12%.

The Pak Mun project was mentioned in the 1988 Power Development plan and presented to the Cabinet of Ministers and NESDB as a multipurpose project during the same year. This time the project was presented by EGAT to the Cabinet of Ministers, EGAT did not use the type of overall system planning tools that can calculate the system-wide benefit of a power-generation investment. Based on this premise TDRI has calculated the project's direct benefit from power including irrigation and fishery benefits as originally estimated by EGAT. The findings question the economic justification of the project assumed and presented to the Cabinet of Ministers in 1989. According to TDRI a financial analysis of the project based on its anticipated benefits from expected power sales could have been used to determine its feasibility as an investment rather than simply relying on the proxy power benefits to justify the project's economic feasibility. (For detailed calculations see Annex1). This analysis was contested in the stakeholder meeting by the WB and EGAT. The World Bank is of the view that such a financial analysis is not appropriate for an isolated power project and the World Bank standard methodology is to do a financial analysis of the utility as a whole, which was done at appraisal and found to be acceptable. (For details see Sections 10 and 11)[63]

Conclusions:

- The first conclusion is that as far as purely technical performance, the hydropower aspects of the Pak Mun dam have been very close to predictions.

- The second conclusion is that the irregularity and unpredictability of the runoff of the Mun River result in a small amount of Dependable Power produced by the dam. Operational constraints and other limits set to mitigate the environmental impact of the dam further restrict the dependability of the power output. The Pak Mun Hydropower plant can be compared to an SPP producing power that varies according to the season. The Pak Mun Dam's power production peaks in the wet season when it is least needed in the power system and is lowest in the dry season when it is most needed. Applying the definition of Dependable Capacity introduced by EGAT to the simulated mean monthly generation based on 1967-81 Pak Mun runoff record the Dependable Capacity of the project is only 40.93 MW. The current report also calculates the dependable capacity from daily power output between 1995-98, assuming that all available power gets assigned to a 4 hour peak demand period as 20.81 MW which is lower than the estimated dependable capacity of 75 MW and the installed capacity of 136 MW. Thus, it is not justified to assume that the Pak Mun dam replaces a 136 or 150 MW turbine peaking plant that was the main criteria in the economic analyses at appraisal.

- Recalculating the equalising discount rate assuming that one would need one 21 MW gas turbines to provide the dependable capacity of a 21 MW hydro plant the current report reaches a value of 7.8% which is below the shadow cost of capital in Thailand.

- The benefit of the ancillary support to the electricity net and the Green house gasses reduction benefit of the dam were included in the economic evaluation of the dam. These benefits were not sufficient to help make the project economically justifiable.

4.3 The Predicted and Actual Benefits: Irrigation

At full development, EGAT's project document estimated the project's annual benefits from irrigation to be 105.48 million Baht at constant 1987 prices. But the assumptions regarding Pak Mun's irrigation benefits are dubious. EGAT's project document claimed irrigation potential for a total area of 64,000 acres about 50 km upstream from the dam site, of which only the benefits accruing to 18,000 acres were actually considered[64/]. The inclusion was part of the project's multipurpose benefits, comprising a possible initial pilot development area of dry season pumping irrigation in Kanthrarom district of the adjoining Si Sa Ket province. But the riverbed at the proposed pumping station, at 106 meter MSL, would have been at the same elevation as the 106 meter MSL water level of the Pak Mun reservoir

under the dry season operating rules from January to May[65/]. There would have been no appreciable differential in the respective elevations to allow for effective intake of water pumped from Pak Mun dam's reservoir during the critical months of dry season cropping. The irrigation benefits of a run-of-river-project were doubtful and this was known at the time the irrigation benefits were quantified in EGAT's project document.

4.4 Predicted and benefits – Tourism

Resources for tourism in the project area include sites of natural beauty, historical, religious and cultural significance. Among the well-known sites are the two famous rapids: Kaeng Saphue (Phibun Municipality) and Kaeng Tana (downstream form the dam site). A large number of Phibun and nearby residents (ca. 123,000 tourists/year) visit Kaeng Saphue especially during the weekends in the dry season. Kaeng Tana besides being a National Park is also well known for its large Sandstone with numerous potholes created by river currents. It was estimated that if the project did not save Kaeng Saphue and Kaeng Tana from the inundation, it would result in an economic loss of about 2.5 million Baht annually from tourism (EIA of 1982).

Natural tourist sites flooded by construction of the Pak Mun dam included 50 natural rapids, 9 beaches along the mid-river-dune or island, 3 mid-river islands or dunes including Don Klang, Don Nok Iang, and Don Non Soong. Man-made tourism sites that have been created after the Pak Mun dam construction, besides the dam itself, are Pataya Noi located near the drawdown area, Sirindhorn dam, and Had (Beach) Thrai Kaew.

Number of tourists at Kaeng Saphue in 1981 numbered around 123 000. This study found that in 1999 there were about 140 000 tourists. The number has seemed to increase, but the rate of increase is very low considering that several facilitating factors are provided. It was indicated that the following the construction of the dam, the number of tourists is likely to have decreased because the rapids are not as beautiful owing to sedimentation. Even though the Municipality has attempted rehabilitate the area, with the construction of a park and installation of the sanitary facilities; the beauty of Kaeng Saphue is not what it was. Not only has the number of tourists has decreased but the tourists also tend to spent much less time at Kaeng Saphue.

The number of tourists at Kaeng Tana National Park before the construction of Pak Mun dam in 1990 was 165 630 and 248 516 respectively. In the period following the construction, during 1993 – 1999, the number of tourists per year varied between a low of 92 279 and a high of 159 935. There seems to have been a marked decline in the number of tourist visiting the KTNP since 1991. It indicates that even though there is a new tourist destination (Pak Mun dam) and new facilities have been provided for enhancing tourism such as a hanging bridge, access roads and guest houses the number of tourists was not as high as had been expected.

During the survey, for the current study, people expressed that they used to have an average income of 4 800-6 000 Baht a year from engaging in activities related to tourism. After the construction of the dam, they have experienced losses in their income, especially due to the loss of natural rapids that are a major tourist attraction. It appears that the Pak Mun dam did not help increase the household and community income related to tourism.

4.5 Impacts of the Pak Mun Project - Aquatic Bio-diversity and Fisheries aspects

Predicted Impacts of Pak Mun dam on aquatic biodiversity and fisheries as expected by the 1981 environmental impact assessment

The Mun/Chi watershed forms the largest watershed draining into the Mekong River in Thailand. The large catchment area of 117 000 km^2 of Pak Mun Dam by its location close to the confluence between the Mun and the Mekong rivers virtually covers the whole Mun/Chi watershed. The Pak Mun Dam

was the first hydropower dam in the Lower Mekong Basin situated at a downstream location of a large watershed. Hydropower dams previously constructed in Thailand have always been located at upstream locations of watersheds. Compared to the Pak Mun dam and reservoir, upstream dams and reservoirs are less likely to affect fish species migrating from the Mekong River upstream into the tributaries. By the location of the Pak Mun Dam only 4km from the Mekong River, many different upstream-migrating species are affected.

Historically hydropower schemes in Thailand have been designed with storage reservoirs with a considerable draw down zone (difference in elevation between upper storage level and minimum operation level of the reservoir). The Pak Mun hydropower scheme was the first run-of-the-river hydropower dam in the Lower Mekong Basin with a reservoir (head pond) that by definition has only a small draw down zone.

The new features of the Pak Mun Dam for Thailand and the impacts of existing and ongoing developments and activities in the Mun/Chi watershed, all in a situation where there is little knowledge of aquatic ecology in the Mekong Basin had implications for the quality of the environmental impact assessment of the dam and reservoir.

The environmental impact assessment (EIA) of the Pak Mun Dam was carried out in 1981. The EIA made the following conclusions and recommendations:

1. "The Pak Mun reservoir would alter existing conditions of fisheries and aquatic biology to some extent. The impoundment by itself would cause changes in aquatic populations in the Lower Mun River as a consequence of changes in the river flow regime. Fish production from the reservoir is expected to increase considerably, but some fish species may be affected by the blockage of river flows by the dam. Socio-economically, fishing occupation would become more important to subsistence fishermen than at present, and a great number of households may be converted from rice farmers to full-time fishermen, depending on the extent to which fish production will increase."

2. The Pak Mun reservoir fishing yield was predicted at 16 kg/rai/year, but could be increased to 35 kg/rai/year through additional stocking of fish (1 hectare = 6.25 rai).

3. The EIA considered a fishladder not necessary for the Pak Mun Dam. Although through public pressure and on the advice of the Department of Fisheries and the National Environment Board a detailed study for including a fishladder in the Pak Mun had been proposed.
4. Finally a fisheries management plan was proposed, based on stocking and enhancement of aquaculture. To support fisheries activities at the reservoir the construction of a few fish landing places was recommended.

Since the 1981 EIA, the design parameters and location of the dam changed considerably meriting fresh EIA. However, no fresh EIA was done, and the Pak Mun project was implemented with the aid of 1981 EIA.

4.5.1 Actual Impacts on Fishing Yields

Table 4.19 shows the EIA-predicted total reservoir fishing yields and their value in Baht, based on 15 Baht per kg fish (EGAT, 1982). Table 4.19 also shows also the established mean stabilised catch in the other hydropower reservoirs in the Mun/Chi watershed and their value based on 15 Baht per kg fish. Projected benefits predicted by the EIA of 1981 included increase in fish catch in the Pak Mun head pond. The EIA predicted that through stocking of fish in the head pond, the benefits could be raised even higher. Increased fish catch would benefit local fishermen in the head pond area. Without additional stocking the total fish catch in the head pond was predicted to reach 600 000 tonnes with a value of 12 Million Baht (320 000 US$) at a price of 20 Baht per kg fish. With additional stocking the

total fish catch in the head pond was predicted to reach 1 314 tonnes with a value of 26 Million Baht (693 000 US$) at a price of 20 Baht per kg. The storage reservoirs of Ubolrathana, Chulaphon and Sirinthon have an annual fishing yield ranging from 19 to 38 kg per ha. Regular stocking has been taking place in all three reservoirs. The EIA predicted an annual fishing yield in Pak Mun reservoir of 100 kg/ha without stocking and of 219 kg/ha with stocking. The predicted yields appear too optimistic compared with the actually obtained fishing yields in Ubolrathana, Chulaphon and Sirinthon reservoirs. All three are storage reservoirs where pelagic fish as *Clupeichthys aesarnensis* can make up to 70 % of the total fishing yield (MRC, 1997).

In run-of-the-river reservoirs as Pak Mun, where there is still a considerable flow of water in the reservoir (therefore, run-of-the-river reservoirs are generally called "headponds"), pelagic fish species as *Clupeichthys aesarnensis* will not easily establish a significant population. Moreover, run-of-the-river reservoirs have a low retention time by sending the average river flow through the turbines and by opening the spillway gates if the river generates higher than average river flow. Assessments of standing stock in the Mun River before construction of Pak Mun Dam have shown a significant less fish standing stock in the wet season compared to the dry season.

The height of the Pak Mun Dam and the operation of its spillway gates are such that in the wet season a normal water elevation of the Mun River is obtained. Boats pass the dam at high floods during the months of August and September. Before construction of the dam, catch of fish in the Mun River was much less during the wet season than during the dry season. If rivers are turned into impoundments, loss of fish productivity occurs. The main losses in fish productivity originate from (i) migrating fish species and (ii) rapid-dependent fish species. In storage reservoirs loss of fish productivity can be compensated by the establishment of pelagic fish populations, however headponds do not provide habitats for pelagic fish species. Fishing yields in headponds of run-of-the-river dams as the Pak Mun Dam are of the same order as fishing yields in rivers during the wet season and can not be compared with fishing yields in storage reservoirs. Fishing yields and standing stocks in the Mun River during the wet season are low.

In the head pond of the Theun-Hinboun run-of-the-river dam (located in the Mekong Basin in Lao PDR), fishing yields are also notoriously low. Annual fishing yields at Theun Hinboun have not yet been reliably estimated, but fishing yields in the headpond area are less than before dam construction.

Table 4 -Annex 6 lists also the fish species that are able to establish populations in storage reservoirs in Thailand. As can be concluded from comparing the fish species listed as riverine and migratory with the list of fish species recorded from impoundments, some migratory species are able to establish populations in storage reservoirs. Despite carrying out stocking trials, fish species belonging to the families Pangasiidae and Sisoridae have not been able to establish populations in Thai storage reservoirs.

A more realistic, but still speculative prediction of the total annual fishing yield in Pak Mun headpond would have been 60 tonnes, based on 10 kg/ha, instead of the EIA predicted 1 314 tonnes, based on 219 kg/ha. The value of the total annual headpond fishing yield would than have been estimated only at 0.9 million Baht, instead of 19.7 million Baht.

Annual fishing yields of 200 kg/ha have been obtained in reservoirs in PR China and the Socialistic Republic of Vietnam, however these high fishing yields only can be achieved in small sized storage reservoirs where fish production and fishing are nearly completely aquaculture based. Despite regular stocking, the large storage reservoirs in Thailand have never been able to achieve such high fishing yields.

Table 4.18: Comparison between reservoirs in the Mun/Chi watershed and predicted fishing yields for Pak Mun reservoir and established fishing yields in Ubolrathana, Chulaphon and Sirinthorn reservoirs (Sources: EGAT, 1982 and MRC, 1997)

Reservoir	Reservoir Area (km^2)	Reservoir Management	Annual Reservoir Fishing Yield per ha (kg)	Predicted Annual Reservoir Fishing Yield (tonnes)	Predicted Value* of Annual Reservoir Fishing Yield (million Baht)
Pak Mun	60	no intervention	100 (predicted)	600 (predicted)	9.0
Pak Mun	60	additional stocking	219 (predicted)	1,314 (predicted)	19.7
Ubolrathana	410	additional stocking	38 (established)	1,544 (established)	23.2
Chulaphon	12	additional stocking	25 (established)	30 (established)	0.5
Sirinthon	288	additional stocking	19 (established)	539 (established)	8.2

Note: * 1 kg of fish has a value of 15 Baht (EGAT, 1982

The EIA carried out in 1981 predicted changes in aquatic populations as a consequence of the river flow regime. Even without installation of a fishpass, the EIA predicted an increase in fishing yields in the reservoir area. Based on the predicted increase in fishing yields in the reservoir are, the EIA expected a great number of households to change their income source from rice farming to fisheries. The EIA recommended also the construction of fish landing places

Carrying out an EIA for complicated developments such as hydropower projects and addressing the issues of aquatic biodiversity in a short available time frame is a task not easily accomplished. An EIA for the Pak Mun Dam is even more complicated by (i) little available background data addressing separately and accumulatively the environmental impacts of many different other ongoing developments on aquatic biodiversity, (ii) new features of run-of-the-river dam, which never has been built before in the Mekong Basin, and (iii) for the total of 265 recorded fish species in the Mun River little information exist about their taxonomy, seasonal behavior, food and water quality preferences and adaptation capacity. Prediction of fishing yields for each different fish species is by nature speculative with such high number of fish species under increasing fishing pressure as in the Pak Mun River. However, the value of each annual fishing yield of a run-of-the-river reservoir as Pak Mun headpond should have been estimated only at 0.9 million Baht, instead of the by the EIA predicted 19.7 million Baht. Annual fishing yields in reservoirs as predicted in the EIA can only be reached by stocking small, storage reservoirs as has been proven in PR China and Vietnam. Stocking of large reservoirs such as the headpond of Pak Mun generally does not lead to improved fishing yields. The production of stocked fish in large reservoirs replaces existing natural production of indigenous fish species. In addition stocking of fish in run-of-the-river reservoirs does not lead to increased reservoir fishing yields if no fish screen is installed at the spillway gates. Stocking of run-of-the-river reservoirs is not comparable with stocking storage reservoirs, where penstock intakes are located deep in the reservoir and where water rarely leaves the reservoir over the spillway. Stocking of fish in run-of-the river reservoirs seldom leads to positive results.

The high percentage of migrating fish species of the total number of fish species occurring in the Mun/Chi watershed before construction of the Pak Mun Dam as well as the existing fishing gears and methods specially used for intercepting fish migration should have lead to the proposal of a fish pass by the EIA. The EIA ignores the impact on downstream aquatic biodiversity and the dependence of

the rural population on fisheries downstream of the dam in the Mun River, and also in the Mekong River.

Based on the much lower annual fishing yields in the headpond no fish landing places should have been proposed. Low fishing yields in the headpond should have been predicted which in turn should have lead to negative impacts on the local social economy.

The fisheries aspects of the Pak Mun EIA has been largely approved by the review committee, although an additional fish pass study has been to asked to be implemented. This study has led to the construction of the fish pass at Pak Mun, the first fish pass at a hydropower dam in South East Asia.

Terms of Reference for the fisheries aspects of hydropower EIAs in developing countries in tropical regions need to allow a long time frame to assess the impacts on aquatic biodiversity and fisheries. The time needed for an appropriate assessment of impacts on fish and fisheries should be at least 2 years in order to cover the seasonal and migrational behavior of fish as well the socio economic impacts on capture fisheries. The EIA review committee needs to include specialists well versed in fish taxonomy, water quality, fisheries biology, and socio-economics.

4.5.2 Actual Impact: Bio-diversity Aspects of Fisheries

It has been common practice for academics and fisheries officials to try to obtain baseline data by starting individual research activities that need periods of a number of years. Such lengthy fisheries surveys generally obtain only scientific confirmation of information and knowledge what dedicated fishermen already possess. Fishermen, through their daily observations at work develop a knowledge and common sense. In the engineering world such knowledge of fishermen or common sense is often falsely identified as anecdotal evidence. In the Mekong Basin where limited fisheries research has been carried out, and research activities have produced little fisheries base line data, all existing fisheries laws, rules and regulations are therefore based on anecdotal evidence or common sense.

The existing fisheries laws, rules and regulations for Thailand and the Mun River make common sense, but are only based on anecdotal evidence. The main fisheries laws and regulations prohibit:

1. practising destructive fishing practices (explosives and electric fishing)
2. using ichthyocides; penalty 10 000 to 100 000 Baht or 6 months to 5 years prison term
3. blocking of rivers and streams
4. fishing or raising fish in conservation areas
5. fishing without license
6. importing certain fish species
7. introducing certain fish species
8. constructing in conservation areas
9. extracting water in conservation areas, penalty 10,000 Baht or 6 months prison term
10. using haul seines in swamps or reservoirs
11. using bagnets with a mouth of more than 2 meters wide in any stream or river
12. fencing off of water bodies
13. using push nets or trawls
14. using other fishing gears than hooks, scoop nets, lift nets from 16 May till 15 September; penalty 5 000 to 10 000 Baht or 1 month prison term.

The Thai fisheries law is explicit in prohibition of blocking off rivers and streams. Additional fisheries rules and regulations specific for the Pak Mun Dam consist of delineation of zones downstream and upstream of the dam where no fishing is allowed.

The results of interviews of fisherfolk along the Mun River stretch between Ubon Ratchathani and the confluence of the Mun with the Mekong River presented in Table 4.1 are obtained by showing

fisherfolk colour pictures of most common fish species caught in the Mekong River Basin. The photo flipchart has been produced by Mekong River Commission.

Gill net fishermen confirmed deterioration of water quality between Ubon Ratchathani and the Pak Mun Dam by their observation that fish caught in gill nets die before lifting the nets. Gill nets are generally set at sundown and taken out of the water early in the morning. Before construction of the dam, this problem did not exist. After getting in contact with water by swimming or working in the Mun River, fisherfolk often develop a skin rash. This phenomenon did not happen in the beginning of the 1990s. Both problems point to the deterioration of water quality after the construction of the Pak Mun Dam. It is probable, however, that other factors cause the water-quality problem and that the problem is exacerbated by changes in the flow regime brought about by the Pak Mun Dam.

While stakeholders generally accept that over-exploitation may be occurring, there is a lack of hard evidence to support this hypothesis. Such evidence could be obtained by additional fisheries surveys, including the consistent monitoring of fishing yield by each different catch method and the monitoring of catch per unit effort (catch per unit effort reflects the amount of time and energy needed to catch a certain quantity of fish). Close monitoring of this parameter can provide a good indication about the sustainability of fisheries and will lead to implementation and enforcement of adaptive fisheries management to avoid over exploitation of aquatic resources in times that aquatic populations can be fluctuating by natural circumstances as extreme floods or droughts and/or through such man-made disasters as modification of aquatic habitats and water pollution. There has been made an attempt by Department of Fisheries and EGAT to start an extensive fisheries monitoring program. The results of the two-year monitoring program were published in 1985. Despite presenting many findings derived from different sampling stations up and downstream of Pak Mun Dam, the report does not indicate the differences in findings between the locations up- and downstream of the dam.

It is recommended that the Fisheries Conservation Unit should start a community-based monitoring program, including taxonomy, water quality and catch per unit effort per individual fisherman, household and per village in order to arrive to an adaptive fisheries management plan. The plan can be implemented and more easily enforced by involvement of local communities and public participation.

During interviews, fishermen estimated their decline in fish catch upstream of the dam in the Mun River since the completion of the Pak Mun Dam between 60% and 80%. Many different developments are ongoing in the Mun/Chi watershed, each with their specific impacts and all with their cumulative impacts on aquatic biodiversity and fisheries (see pages 8-10 for enumeration of various developments on Chi - Mun river basin upstream of Pak Mun dam with implications for fish). Therefore, it has been difficult to estimate the specific impacts of the dam on each of the different fish species. Currently the daily catch per fishermen upstream of the dam is estimated at averaging 2kg per fishing day. Downstream of the dam the catch is estimated at 10 - 12 kg per fishing day. Downstream of the dam fishing activities are depending on the operation of the spillway gates. Particularly in the illegal fisheries zone immediately downstream of the dam virtually no fishing activities are possible when the spillway gates are opened, due to the high water currents. Further downstream of the dam fishing is more or less on a daily basis.

Table 4-Annex 6 shows that before dam completion 265 fish species have been recorded in the Mun River, the latest survey after dam construction recorded only 96 species upstream of the dam. The calculated loss of 169 fish species is exacerbated by the difference in efforts and number of sampling points of the fish surveys before and after dam construction. Upstream, midstream and downstream of large tributaries of the Mekong River as the Mun and the Chi rivers the compostion of species is changing. Most of the species can be found downstream. Going upstream the species composition changes and the number of fish species declines, according to water quality and the status of aquatic habitats. The majority of sampling points of the fish surveys carried out after construction of the dam are located in downstream areas. Table 4 shows also the species occurring in another watershed of the Mekong River in Thailand: Songkram River. 198 fish species have been recorded for the Songkram

river, but the watershed covers a much smaller area and also the Songkram river houses a hydropower project in the upstream watershed.

Table 4.25 shows the results of interviews with fishermen fishing upstream and downstream of the dam. Fishermen were asked if they recognized fish species from photos as occurring in their catch before and after construction of the dam.

During interviews with fishermen, 149 different fish species were recognized from the photo flip chart as currently occurring in their catch upstream of the dam. Only one species disappeared from their catch since the construction of Pak Mun. Not surprisingly, this species is *Pangasionodon gigas*, the threatened Mekong giant catfish. *P. gigas* is endemic for the Mekong River Basin and is also the Mekong environmental flagship species. Still more than 100 fish species are not accounted for upstream of the dam since dam construction, compared to fish surveys before dam construction.

Fish catch below the Pak Mun Dam is currently much higher than the fish catch upstream of the dam. Fishermen interviewed downstream of the dam recognized 146 species from the photo flipchart as currently occurring in their catch. They recognized 148 fish species as occurring in their catch before dam construction. The two species that disappeared from the fish catch downstream of the dam are *Leptobarbus hoeveni*, and *Aaptosyax grypus*. Both species are riverine migrating species. Downstream of the dam only 3 interviews have been held. Both species were recognized during one interview only.

From the fishermen interviews held at downstream areas of the Mun River it can be concluded that only 1 or 2 fish species have disappeared completely from the catch. However, the fish survey shows that the catch of many fish species declined considerably in the Pak Mun River upstream of the dam. Fishing gears specifically designed for catch of Pangasiidae, migrating from the Mekong into the Mun River and spawning in rapids have completely disappeared upstream of the dam. More systematic fish surveys during all seasons are needed to provide hard evidence that fish populations have been wiped out or will become extinct. The difference in number of species in fish surveys before and after dam construction may well be exacerbated by the cumulative impacts of many different developments in the watershed, including the construction Pak Mun Dam.

More interesting conclusions regarding decline in fish populations can be made from the interviews. Upstream of the dam fishermen have been interviewed at 10 different villages between the dam and Ubol Ratchathani. Comparing the total score of fish species caught at 10 villages upstream of the dam before dam construction with the total score after dam construction, conclusions can be made in declining fish populations. A selection has been made of those fish species that are caught presently at least in two villages less compared with the catch before construction of the dam. There are 56 fish species that have disappeared from the catch in at least 2 villages since the construction of the dam. Of the 56 species there are 5 species that have not been recorded during the fish surveys. Some species look very similar and are easily confused when only a picture is shown. Of the remaining 51 species, 35 species are migrating species.

Of the total of 149 fish species recognised as occurring in the present catch at least 51 fish species have been caught significantly less upstream of the dam since the construction of Pak Mun Dam. The decline of catch of these 51 species may be caused by the cumulative impacts of ongoing developments in the Mun/Chi watershed. Specific impacts of Pak Mun Dam on fisheries can be expected to affect both migrating speciesand rapid-dependent fish species. Most of the rapid habitats upstream of the dam, in downstream areas of the Mun River, have been inundated by the Pak Mun headpond. The fish speciesthat migrate from the Mekong River into the Mun Riverand depend on rapid habitats as spawning grounds mainly include: *Helicophagus waandersi*, *Pangasius bocourti*, *Pangasius djambai*, *Pangasionodon hypothalmus*, *Pangasius conphophilius*, *Pangasius larnaudei*, *Pangasius krempfi*, *Pangasius macronema*, *Pangasius micronema*, *Pangasius pleurotaenia*, *Pangasius polyuranodon*, and *Pangasius sanitwongsei*, all belonging to the family Pangasiidae, and *Bagarius bagarius*, *Bagarius suchus*, and *Bagarius yarelli* belonging to the family Sisoridae, and

Probarbus jullieni and *Bangana* sp. belonging to the family Cyprinidae. The Pak Mun Dam particularly impacts these 17 fish species, because their migration route is blocked off in the beginning of the rainy season, the fish pass is not functioning and their respective spawning grounds are inundated by the headpond.

Around August the difference in elevation of tail and headwaters at the dam is small enough to allow fish to migrate through the spillway gates. Monitoring studies of the fish pass did not record any of the 17 fish species ascending the fish pass during 1999. Fishermen admit that they still encounter the 17 species in their catch, but quantities have declined significantly since dam construction. This is confirmed by the disappearance of the unique fish trap operations (Tum Pla Yon) upstream of the dam. This trapping method mainly catches *Pangasius micronema*, and *Pangasius pleurotaenia*.

The Lower Mun River area under pre-dam conditions appears to be much more productive and provides much higher fishing yields than was estimated in the EIA. The current catch by the remaining fishermen of the affected 5 000 households is roughly estimated at 38.1 million Baht = 1.0 million US$. The annual fishing yields of the affected households before completion of the dam is estimated at 90.9 Million Baht = 2.4 Million US$. Fishing yields declined from 929 kg/year per household before dam (1982) to 507 kg per year per household after dam (1999). If the total number of affected households is 5 000 and the average price per kg of fish is set at 20 Baht per kg, the total value of the 1982 annual fish catch is conservatively estimated at 90,9 million Baht, equivalent at 2.4 million US$. Since the construction of the dam the number of fisheries households declined by 24%. In 1999 the total value of the annual fishing yield can be estimated as 3 760 households * 507 * 20 = 38.1 million Baht, equivalent with 1.0 million US$. The value of the decline in fish catch after construction of Pak Mun dam is therefore roughly estimated at 2.4 - 1.0 = 1.4 million US$ per year.

About 70 of Tum Pla Yon traps positioned close to Kaen Sapue before dam construction have ceased operation. These traps were in operation during 5 months per year, catching on average 35 kg/day. For 24 days per month operation, the annual catch per trap totals 4 200 kg. For 70 traps the annual fishing yield of *Pangasius micronema*, and *Pangasius pleurotaenia* is 294 tonnes. At a price of 18 Baht per kg at the end of 1980s the value of annual catch of these 70 traps is calculated at approximately 5.3 million Baht (212 000 US$). The construction of Pak Mun Dam and the consequent decline in fishing yield of only two species caused this annual loss in revenues,.

Through making use of fishermen's knowledge, common sense or anecdotal evidence the impact of Pak Mun Dam on 17 fish species has been demonstrated. According to fishermen the catch of another 34 fish species (51 - 17 = 34) has considerably declined, most of which are migrational species. For these 34 fish species no hard evidence exists for the exact reason for decline. The Pak Mun Dam could be the main cause of the decline in catch, or the cumulative impacts of developments including increase in fisheries pressure and dam construction could be the cause of the decline.

Table 4.19: Fish Species as Observed by Fishermen to Have Declined in Their Catch Upstream of Pak Mun Dam

Fish Species	Migrating	Depending on Rapids
Amphotistius laosensis		
Anguilla marmorata		
Tenualosa thibaudeaui	+	
Macrochirichthys macrochirus	+	
Raiamus guttatus	+	
Leptobarbus hoeveni	+	
Neolissochilus blanci		
Probarbus jullieni	+	+
Probarbus labemajor	+	
Tor sp.	+	
Cosmochilius harmandi	+	
Poropuntius deauratus	+	
Systomas binotatus		
Catlocarpio siamensis	+	
Bangana behri	+	+
Bangana sp.	+	+
Cirrhinus jullieni	+	
Cirrhinus microlepis	+	
Cirrhinus mrigala		
Cirrhinus prosemion		
Osteochilius microcephalus	+	
Osteochilius waandersi		
Crossocheilius siamensis		
Garra fasciacauda	+	
Mekongina erythrospila	+	
Bagrichthys macropterus		
Belodontichthys dinema		
Hemisiliurus mekongensis		
Wallagu attu	+	
Wallago leeri	+	
Laides hexanema		
Clupioma sinensis		
Helicophagus waandersi	+	+
Pangasionodon gigas	+	
Pangasius bocourti	+	+
Pangasius conphophilius	+	+
Pangasius djambai	+	+
Pangasius krempfi	+	+
Pangasionodon hypothalamus	+	+
Pangasius larnaudei	+	+
Pangasius macronema	+	+
Pangasius micronema	+	+
Pangasius pleurotaenia	+	+
Pangasius polyuranodon	+	+
Pangasius sanitwongsei	+	+
Bagarius bagarius	+	+
Bagarius suchus	+	+
Bagarius yarelli	+	+

Trichogaster trichopterus		
Osphronemus exodon		
Osphronemus goramy		

No data could be obtained in number of gears and number of fishermen and the exact decline of catch per fish species per amount of effort. An economic analyses of decline in fish catch would also be complicated by the high number of subsistence fishermen compared to full professional fishermen, or fishermen who in fact are fishing only seasonally. There are many different approaches to fishing being practiced along the Mun River. There is often a complementarity between fishing and rice farming and according to the seasons fishing is variously used for consumption and commerce. Moreover these different objectives inform the use of different fishing gears. Processing of fish by fish fermentation has declined as a household activity. Aquaculture activities have increased.

4.5.3 Unpredicted Outcome: Mitigation and Compensatory Measures

- **Fishpass**

After completion of the special study of the need of a fishpass at Pak Mun Dam, it was decided to include a fish pass at Pak Mun Dam. During periods of high flooding boats can pass the dam. During this time, mostly in August or September, the dam is not obstructing river flow or fish migration. The other months of the year Pak Mun Dam is obstructing upstream fish migration. The peak fish migration period at Pak Mun is at the beginning of the rainy season from May till July.

Different designs exist for fish passes: (i) Denil fishpass, (ii) Vertical slot fishpass, (iii) Pool and weir fishpass, and (iv) Pool and weir fish pass combined with submerged orifices. Also fish locks and fish elevators have been designed outside Asia. For the Pak Mun Dam the combined pool and weir type fish pass with submerged orifices has been designed and constructed. The Pak Mun fishpass was the first fish pass constructed in South East Asia at a hydropower dam.

A general lack of knowledge of special requirements of the fish species involved and lack of application of all the criteria needed for good fishpass design has led to large variations in success of fish passes the world over. Successful fish passes have mainly been achieved in North America and Europe to accommodate migrations of salmon and trout. Long-term programs of basic biological research on the physiology and behavior of migrating fish species is needed to arrive to an understanding of the biological requirements of the relevant migrating fish species, which would enable engineers and biologists to design fish facilities at dams that would potentially protect valuable fish migrations. For the Mekong River Basin a program is needed to study in more detail the migratory habits and locations, life history, swimming ability, size of fish runs, and size of fish, before design and construction of fishpasses can guarantee success.

Even after fishpasses have proven to be successful at dams, they do not guarantee that all impacts of dams on migrating fish species have been mitigated. Changes in hydrological regime and modification of aquatic habitats up and downstream of a run-of-the-river hydropower project still may form significant impacts on aquatic biodiversity and fisheries. In case of the Pak Mun Dam, rapids upstream of the dam, which are important spawning areas of Pangasiidae and Sisoridae are inundated by the headpond. Migrating fish species belonging to these families may pass the dam through a well-designed fishpass, but would not be able to find their spawning grounds.

Fish species in temperate regions such as most salmons and trout are able to jump over the weirs from pool to pool and ascend considerable difference in elevations if enough pools are included in the fishpass and if the water velocity in the pools is not too high. For fish species migrating upstream in the Mun River as *Mekongina erythrospila*, *Pangasius* sp., *Helicophagus waandersi*, *Cyclocheilichtys* sp., *Bangana behri, Probarbus jullieni* and Pla Soy (including *Cirrhinus* sp. and *Henicorhynchus* sp.) there was no specific information available for the detailed design of the Pak Mun fishpass. The

orifices in the weirs of the Pak Mun fishpass have been designed to accommodate migrating fish species that are not able to jump over the weirs from pool to pool. The submerged orifices have a square shape, each orifice measuring 15 by 15 cm. Other migrating species recorded in the Mun River, including *Amphotistius laosensis*, *Wallago* sp., *Catlocarpio siamensis*, and *Pangasionodon gigas* are not able to enter the fishpass because of their large size.

The main failures of the Pak Mun fishpass are the location of the pass, and the location of the fish pass entrance. The operation schedule of the turbines and the spillway gates generate a flow pattern defining the location where fish penetrate closest to the dam. In case of the Pak Mun Dam this location is near the turbines. When no water is released through the turbines, fishermen gather close to the turbines to illegally fish with gill nets. During turbine operation fishermen also illegally cast netting at the turbine outlet. (see pictures). The Pak Mun fish pass is located at the left bank and the turbines are at the right bank of the river. Between the turbines and the fish pass, a series of spillway gates are located. The entrance to a fish pass should be constructed as close as possible to the point or line to which the migrating fish penetrate. At the design stage, a plan should have been made based on the operation of turbines and spillway gates to define the probable directions of currents below the dam. Based on such a plan the optimal location of the fish pass and its entrance can be defined.

Monitoring studies of fish migration through the Pak Mun fish pass have been carried out. Table 4-Annex 6 shows the fish species recorded as able to ascend the fishpass. In the earlier monitoring studies more species have been recorded to pass the dam than the later monitoring studies. Illegal fisheries are operated on a large scale downstream of the dam in the prohibited zone. Fishing at the fishpass entrance and even in the fishpass has been observed (see pictures). Monitoring studies cannot make a detailed evaluation of the fishpass performance under these circumstances. During monitoring activities in 1999, no spawners have been recorded in the fish pass. If spawning migration of fish species has been blocked off by the dam, these fish species certainly will be wiped out.

Despite the fact that many different fish species are known to be able to access the fish ladder, the monitoring studies never found many fish in the fish ladder. In the early years after dam completion the highest quantity of fish found in the fish ladder was 200 kg/day during peak migration time. The latest monitoring results of 1999 show maximum quantity of fish at the top of the fish ladder of 12 kg/day, and average quantities of 2 kg/day. After completion of the dam, the fishladder never has been able to accommodate migration of large fish populations.

Definitive proof that the number of fish species has been reduced upstream of the Pak Mun Dam cannot be given without a long-term monitoring program, although fish species composition in the catch of fishermen has been dramatically changed, particularly a decline of migratory fish species in the fish catch has been reported. *Catlocarpio siamensis*, and *Pangasionodon gigas* have disappeared from the fish catch upstream of the dam.

The fishpass is not well located and well designed. A vertical slot fish pass or a Denil fishpass instead of a pool and weir fishpass most probably will be much more effective, particularly when this fishpass entrance is located at the turbine outlets. Although no fishpass will ever perform well, if fishermen are intercepting migration downstream or upstream of the fishpass or when migrating fish populations as Pangasiidae and Sioridae have lost their spawning grounds upstream of the dam through inundation by the headpond.

- **Drawdown of Reservoir Level**

The Tourist Authority of Thailand has requested that EGAT lower the reservoir level to expose the rapids at Keng Sapue during the tourist season. Keng Sapue rapids form a tourist attraction in the region. EGAT has agreed to the request. The tourist season occurs during the dry season. If reservoir levels were also lowered during the beginning of the rainy season, the rapids could once again become a spawning ground for fish species of the families *Pangasiidae* and *Sisoridae* if successful performance of the Pak Mun fishpass can be guaranteed.

- **Reservoir Stocking**

Regular stocking of prawn and fish has been carried out in the headpond to boost the long-term fishing. Particularly freshwater prawn *Macrobrachium rosenbergi* has been stocked by the Department of Fisheries as a consequence of good fishing yields obtained after stocking Ubolrathana reservoir with *M. rosenbergi*. This freshwater prawn spawns in salt water and migrates into freshwater. Therefore this prawn is not able to multiply in reservoirs. To sustain fishing yields regular stocking of the species is required. Table 3.1 shows the stocking quantities, estimated fishing yields, and estimated revenues of M. rosenbergi in the headpond of Pak Mun Dam.

Table 4.20: Main Stocking Parameters of the Freshwater Prawn *Macrobrachium rosenbergi* at Pak Mun Headpond

Year of Stocking	No. of Individuals Stocked	Cost per Individual [Baht]	Total Cost of Stocking [Baht]	Estimated Annual Fishing Yield [kg]	Estimated Revenue for Fishermen [Baht]
1995	6,000,000	.14	840,000	7,300	1,247,000
1996	5,700,000	.14	798,000	14,600	3,195,000
1997	7,900,000	.14	1,106,000	11,700	3,038,000
1998	7,000,000	.14	980,000	6,300	2,083,000

The total cost of stocking ranges between 798 000 and 1 106 000 Baht per year. The Department of Fisheries estimates the total annual revenue of fishing yield to range between 1,2 and 3,2 million Baht. The stocking costs are covered by EGAT. At first sight stocking of Pak Mun headpond with *M. rosenbergi* appears cost effective. However, the estimate of the annual catch and revenue for fishermen is inflated. Naturally-occurring *Macrobrachium* sp., which is a species different from M. *rosenbergi* and which is able to spawn in freshwater, has been included by the Department of Fisheries in the total annual estimated catch and revenue. It may well turn out that stocking *M. rosenbergi* at Pak Mun headpond does not generate additional income for the fishermen.

- **Establishment of Fishing Conservation Unit**

Close to the Pak Mun Dam site along the headpond the Department of Fisheries has established a Fisheries Conservation Unit. This Conservation Unit is mainly active in public relations, dissemination of information, but also carries out extension and training programs if required. The Conservation Unit has identified 3 386 fishermen in the watershed, operating 3 087 cast nets, 12 802 gill nets, 197 haul seines, 2 878 hook and lines, and 969 traps.

The Conservation Unit has not been successful in convincing dam protesters not to fish immediately down and upstream of Pak Mun Dam in the prohibited zones. The Conservation Unit is not responsible for overall water management and cannot prevent aquatic habitat modification and water quality deterioration in the Mun/Chi watershed, because it does not belong to the Unit's mandate. Reforestation, wastewater discharge as well as irrigation and hydropower development are under the responsibility of other governmental agencies.

- **Aquaculture**

Cageculture of Tilapia, hybrid catfishes (*Clarias* sp.) and *Pangasius larnaudii* has rapidly increased in the Mun/Chi watershed since the construction of Pak Mun Dam. The number of cages between Yasothorn to Pak Mun growing Tilapia in 1999 is estimated at 1 000. The number of cages culturing Pangasius in Amphur Varin (District Varin) is estimated at 240, while there are 4 cages culturing hybrid catfishes.

There are a number of problems involved in cage culture of fish. The cage culture of *Pangasius larnaudi* is encountering marketing problems. And fishfarmers of monosex Tilapia are struggling with being situated close to an aquaculture feed, as well as the equipment and trade monopoly by Thailand's biggest fish feed supplier. Another problem amay rise with the increased pollution load to the Mun River from the increased number of fish cages.

Although there is an increase in aquaculture activities in the Mun/Chi Watershed since the beginning of the 1990s, the increase is not caused by the Pak Mun Dam and associated change in water levels. Much of the fish culture activities are located upstream of Keng Sapue where water levels in the Mun River are not influenced by the Pak Mun Dam.

Conclusions:

- It appears that the EIA has grossly underestimated the existing fish catch and its value under no dam conditions. It predicted an increase in fish catch in the head pond of the to-be-constructed dam, which even under conditions of fish stocking of the head pond never could match the existing fishing yields under natural river conditions. The Lower Pak Mun River experienced after completion of the dam a decrease in annual fishing yields conservatively estimated at 1.4 million US$, which is much higher than the by the EIA promised annual fishing yields in the head pond of only 693 000 US$.

- Predicted benefits turned out to be actual losses to fishermen. The decline in fish catch and the decrease in fisheries income has led to compensatory measures to affected fishing households adding up to 356 940 000 Baht = 9.5 Million US$ of which 1/3 is in cash and 2/3 is credit provided by newly established co-operatives.

- The unexpected impacts (decline in fish populations and decline in fish catch) have been caused by the confusion between storage reservoirs and run-of-the-river head ponds. The EIA predicted viable fishing management procedures for storage reservoirs such as Sirinthorn and Ubolrathana reservoirs also located in the Mun/Chi watershed that are not valid for run-of-the-river head ponds. Pelagic fish species that can form up to 70 % of the fishing yields in Thai storage reservoirs are not able to establish large populations in run-of-the-river head ponds.

- The EIA grossly undervalued the existing fishing yields at the Lower Mun River, but also undervalued the contribution of migrating fish in the existing fishing yields. As a result the EIA also did not consider a fish pass necessary.

- Impacts of upstream development in the watershed of water resources leading to modification of aquatic habitats and deterioration of water quality have not been considered an issue during the implementation of the EIA. Inundation by the head pond of rapids, which used to be significant spawning areas for migrating species forming an important part of the annual fishing yields has been overlooked. Aquatic biodiversity issues have not been addressed.

- The effect of the Pak Mun Dam on downstream fisheries has been neglected.

- The fish pass ultimately installed after a special study has not proved to be performing well in accommodating upstream fish migration.

- Fishermen experienced an ongoing decrease in fish catch after completion of the dam. The Royal Thai Government surprised by the actual negative impacts of the dam on income for fishermen had to make provision for compensatory measures.

- Fishermen lost their occupation or supplementary income source. Despite compensation provided, total annual income from fisheries over the long term is worth more than the cash and credit compensation per affected household of 90 000 Baht.

- In respect of fish and fisheries issues all stakeholders lost.

4.6 Impact of Pak Mun Project - Social Aspects

The Pak Mun project is probably the most controversial dam construction project in Thailand. It is the project, which has generated conflicts between the government and the affected villagers. The conflicts have originated from the divergent views held by Electricity Generating Authority of Thailand (EGAT), an executing agency, and the villagers in the project area on the project's environmental, social and economic consequences.

4.6.1 Predicted Impacts

EGAT's prediction of project impact was largely based on the EEI and the RP reports of 1982, which valued hydroelectric power development, irrigation and fishery development after project completion quite highly[66]. While admitting that some environmental and social impacts were inevitable, mitigation measures are proposed to counter their effects, while some impacts were even viewed as beneficial to the villagers[67].

- **Fisheries**

EGAT acknowledged that, once completed, the dam would disrupt the migration patterns of fish from the Mekong River. However, according to the EEI report, the lower Mun had less plankton and aquatic food as compared to other rivers. In addition, only few economic fish and no rare species were found. Although fish, which migrate from the Mekong to spawn upstream in the Mun River, were identified, they did not include the long-distance migratory fish. The report contended that the blockade of the river by the dam would disable fish from the Mekong to spawn upstream. The construction of a fish way was not considered to be necessary as a solution for facilitating upstream migration of several fish species, although the report recommended that a Feasibility Study of an aquatic corridor should be conducted[68]. It further predicted that the water in the reservoir "is well-suitable for the propagation and reproduction of aquatic lives"[69].

It should be pointed out that the data on fish in the Mun River in the EEI was collected on two occasions, in February and April 1981[70]. During these two months, fish in the Mun River usually go downstream to the Mekong River. It is unlikely to find the same variety and amount of fish in the Mun River during the rainy season.

- **Employment opportunities**

In EGAT's presentation of social impacts, the impoundment of the reservoir despite some adverse effects on aquatic life and the ecosystem, would create a large, but shallow reservoir that would allow for fisheries production and recreation development. The EEI report asserted that after the impoundment of the reservoir, the fish and the fingerlings remaining in the river above the dam would multiply. It claimed that the favorable reservoir ecology in the post-impoundment period would substantially increase the fish yields in the reservoir[71]. In the long term, fish yields in the reservoir were expected to be about 16 kg/rai/year. It is further suggested that fish production in the Mun River would be increased through employing a stocking program. With reasonable degree of management, and including wild species, the stocking program was predicted to yield as much as 35 kg/rai/year[72]. Based on the above assumptions, the EEI report confidently predicted that villagers who lived along the reservoir shoreline may convert themselves from subsistence rice farmer into full-time fishermen due to the increased fish yield, which will be available all year round[73].

- **Income**

The EEI report was very optimistic toward fishery development in the reservoir. With fish stocking program together with wild species and reasonable degree of fishery management, fish yield can increase as high as 35/kg/rai within one year. If it was maintained, total annual fish production could increase to about 4 050 Tonnes with a value of 61 million Baht obtained by fishermen and 100 million Baht at the retail price[74].

- **Environment**

According to the EEI report, the reservoir would cause several natural rapids to be permanently submerged, including the two famous rapids Kaeng Saphur and Kaeng Ta Na, both of which were tourist attractions in the past[75]. The loss of the rapids was to be traded off by the recreation areas created by the reservoir. The report did not project any blasting of rocks or rapids, except removal and excavation of rocks and earth in preparing the foundation of the dam. It did not discuss any environmental impacts on the riverine ecosystem, particularly swamps, wetland forest in the tributaries, which serve as breeding and spawning areas for fish. The report predicted the blockade of the river by the dam, and anticipated the disruption of fish migration and the decline of wild fishes in the river. However, the report suggested that the reservoir ecological system could be used for fish stocking program. In addition, the report did not mention the damage of the wetland forests caused by the impoundment of the reservoir, a unique riverine ecosystem, which are spawning ground for fish and food bank for villagers.

- **Community Relations**

The EEI report predicted psychological and social effects from resettlement. And that the settlers would feel inconvenient due to their separation from their friends and relatives, a well as from the farm land. An influx of villagers from other areas to benefit from reservoir fisheries forming highly populated areas around the reservoir was expected.

4.6.2 Actual impacts: Fresh assessment and affected people's views

- **Fisheries**

In contrast to EGAT's projection of the social effects, the villagers' view the impacts of the dam project on their livelihoods as much more serious than the problem of resettlement. The villagers perceived themselves as fishermen who depended on fishing as their major source of income[76]. Before the Pak Mun project was implemented, they caught fish in the river both for consumption and for selling at the market. They also traded their fish with rice, which was mainly grown for consumption. Fishermen from upstream and downstream villages regarded the fishing grounds and fish in the Mun River as their common property. They had developed extensive knowledge of fish migratory patterns and were skilled in choosing appropriate fishing tools to catch certain species of fish at different time of the year.

During the field study undertaken in 1999[77], over 80% of the surveyed households indicated rice-farming as their primary source of livelihood, both for supplementary income and subsistence, and fishing as the second most important source of livelihood. In households living close to the riverbank at least one family member, but normally more than one, would fish daily for subsistence. In the case of a good catch, fish were either preserved as fish paste for household consumption or sold for cash. In the case of subsistence rice-farmers annual income from fishing could exceed their income from agriculture.

Household dependency on Fisheries for Income and Livelihood

Table 4.21: Percentage of Households involved in fisheries

Period	Upstream/Dam site
During construction, 1995	83.11
Post Dam, 1995	97.78
1997	67.00
1999	73.02

Source: Faculty of Fisheries, 1982, Khon Kaen University, 1995/ 1997, DOF, 1995, Choowaew, 1999

The proportion of households involved in fisheries, prior to the completion of the dam could be as high as 95%. After the completion of the dam, the proportion of households dependent on fisheries as primary or supplementary source of livelihood and income declined substantially. According to the current survey, in the post dam context, the proportion of households dependent on fishing for livelihood, in the upstream region, have undergone a significant decline: from 95.6% to 66.7%. The TDRI report based on the biannual National Rural Development Committee census concludes that during the years 1992-1996 there was an improvement in the general quality of life and economic opportunities for the core project area of 11 villages adjacent to the reservoir, with markedly risen fishing income. The number of households in project area listing fishing as their occupation doubled during that period with income from fisheries contributing 58% of all the total reported income from all occupations as against 8% in 1982. This may have been initial short-term impact of the reservoir-stocking programme. (For details see Annex 3)

Before the dam was constructed, the stretch of the river between Kaeng Saphur and Kaeng Ta Na consisted of several rapids, islands, shallow water with rock bed and "wang" (sections of deep still water between rapids). Rapids form in the river where rocks partially emerge above the water surface. According to the villagers, rapids help "clean" the river water and reduce sedimentation in the river. Rapids also provide habitat for fish and plankton, a necessary part of the food chain. A "wang", with its deep water, crevices, under water caves, and channels, is a natural habitat for fish and fingerlings[78]. When the dam was built, this fishing terrain for the villagers was drastically impacted and villagers could no longer fish at the rapids or channels like they used to. The villagers noted that after the dam had been completed, in the rainy season, various kinds of fish from the Mekong River were unable to migrate up the Mun River to spawn because of the of the dam blockade. This has resulted in the decline of fish in the river. Although a fish ladder was installed, after it was discovered that fish could no longer migrate upstream, the situation did not improve as the construction of the fish ladder was too steep for fish to negotiate.

Table 4.22: Comparison on average annual fish catch per household (kg).

Period	Upstream/Dam site	Downstream
Pre-dam, 1982	1170	688
During construction, 1995	652	
Post dam, 1997	421	

Source: Faculty of Fisheries, 1982, Khon Kaen University, 1995, 1997

After the completion of the Pak Mun Dam, fishing communities located upstream and downstream reported 50-100% decline in fish catch and the disappearance of many fish species. The average annual fish catch per household decreased. The decline was especially significant in the upstream region.

Table 4.23: Percentage of households and types of fishing gears used before and after dam.

Nature of Fishing gear	Proportion of Households	
	Pre-Dam	1999
Bet khan : set pole & line	26	14.29
Bet loh : pole & line	17	1.59
Bet rao : long line	63	28.57

Bet toom	5	
Toom of various types : upright basket traps	33	13
Lob : horizontal cylinder trap	14	5
Mong : gill net	71	59
Yoh	2	11
Son : triangular scoop net	2	
Kha : fish-attractant basket	2	
Ngaeng : bait net, shrimp net	17	5
Chan : drop-door basket, box trap	14	6
Sai : funnel basket trap	6	5
Lan : bamboo tube eel trap	10	3
Cha muak : harpoon gun	2	2
Hae (2-5cm) : cast net	63	38
Hae (5-10cm) : cast net	29	11
Hae (>10cm) : cast net	11	3
E-rhong	3	2
Oxygen tank		11
Row boat	22	11

Source: Choowaew, 1999

In the Pak Mun region, households involved in fisheries used over 30 different types of fishing gear and equipment. In the post dam context, traditional trap fishing gear has largely disappeared amongst villagers who fish upstream of the dam. With the significant decline of yield from traps, trap fishing method was not worth the effort anymore. Currently nearly every household owns fishing boats. According to a community leader in Amphoe Phibun Mungsaharn, within 2-3 years after the completion of the dam, some fishing gears used for catching large fish were not required anymore. The number of households using diverse varieties of fishing gears showed a declining presence of aquatic species and trend in the post dam context.

Table 4.24: Comparison on average annual total household income and average annual household net income from fisheries (Baht)

Period	Upstream/Dam site			Downstream		
	Fisheries	Total HH	% fisheries	Fisheries	Total HH	% fisheries
Pre-Dam, 1982	13872	21301	65.12	9146	13281	68.86
During construction, 1995	13428.29	62665.04	21.43			
Post Dam, 1997	8694.84	69871.33	12.44			

Source: FOF (1982), Khon Kaen University, 1995, 1997.

In the composition of total average annual household income, the share of fisheries has declined significantly in the post-dam context. Before the construction of the dam a Mun River fisherman would earn at least 100-200 Baht per day from fish catch, but currently 20-30 Baht/day was considered a fortune (interview, 25 April 1999).

Table 4.25: Proportion of fishermen who changed occupation after the dam

	Proportion fishermen who changed occupation (% of total population)
Upstream	31.2
Dam site	15.4
Downstream	16.7

Source: Choowaew, 1999

Before 1991, the fishing season could be divided into 3 periods. The first, during January-April when the Mun reached its lowest water level and most rapids could be seen, fishermen used their rowboats to catch fish around the rapids. Fish caught included Pla I Tu, Pla Tong, Pla Boo, Pla Kot, Pla Lad, Pla Lod, Pla Nam Nguen, Pla Sakang, Pla Sa E, Pla Soi, Pla Tab, Pla Kae, Pla Ko. The second period during May-August in the rainy season was the breeding and spawning season when the fish would migrate up from the Mekong to breed and spawn in the Mun. This used to be the most productive period of the year for fishermen. Fishermen at Pak Mun would catch the first fish coming upstream and then follow them upstream until they earned enough to cover their household expenses for the whole year. Big fish caught included Pla Kaman, Pla Khwao, Pla Sa-Ngua, Pla Luem, Pla Joke, Pla Kapua, Pla Mak Phang, Pla Earn, Pla Thepho, Pla Sue, Pla Nam Nguen, Pla Noo. The third and the last fishing period was during September-December, when the Mun River started to recede. During this period the fish on its migratory route up the Mekong would be caught at the rapids in the Mun River. The way of life of the local community revolved around the seasonal behavior and general abundance of fish. The Mun River fishermen learn to fish during their childhood. During peak fishing season, all fishermen in the village community would go fishing together. Temporary camps were set up beside the Mun River as if for an annual festival. Fish was the principal offering in religious and cultural ceremonies. The abundance of fish ensured household subsistence and nutrition. The surplus income from fishing supported rice farming. In the post dam context the social and cultural activities related to fisheries along the lower Mun River are disappearing.

Villagers of the Mun River have been unable to catch the same amount of fish as they used to resulting in a loss of their fishery income. They were often blamed for the disappearance of fish because of their own overexploitation of fish resource. The villagers' argument was that the decline of the fish population was due largely to several factors. First, the decline of the fish population began during the blasting of the rapids, which diverted natural water channels and destroyed natural fish habitats. Second, the blockade of the Mun River by the dam disrupted the regular migratory patterns of fishes. The spawning areas in the river were submerged under the water. If some species of fish could migrate upstream, they could no longer find breeding and spawning areas. In addition, they argued that despite no change in fishing methods, the decline of fish population did not begin until after the dam was completed. The abundance of fish for sale in local markets, as reported in the World Bank Report 1998[79], comes largely from imports from Laos and Supanburi[80]. It was found that more than 30% of the respondent fishing people located in the upstream region changed their occupation after the completion of the dam. Some have also migrated to other river basins for the hope that there will be more fish for them to catch.

For the villagers, the decline of fish catches is also due to difficult fishing conditions and the highly restricted and reduced fishing time and space after the dam has been in operation.. Fishermen claim that the water in the reservoir is too deep, causing changes in the currents of the river, and making the conventional fishing equipment impractical. Because of the impoundment of the reservoir, there are no rapids where they can catch fish. The huge twenty-meter-long, vertical fish traps can no longer be used.

Fishermen below the dam have had to adjust fishing patterns to coincide with the management of the dam and cannot move from up to down stream. In the dry season, more water is retained in the reservoir reducing down stream flow, except at the spillway where the current is too strong for them

to set their fishing equipment. During the rainy season water is released from the dam creating strong currents. An agreement has been reached that EGAT will close the dam for approximately 30 minutes to 1 hour twice a month to accommodate fishermen. The fishermen have to quickly catch fish during the limited time before the dam gates will open again. During the first two years after the dam was completed, the control of water through the dam gates was on time, but lately they find that it was unpredictable. They have had to adjust their methods to the control of water flow regulated by the dam and sometimes have to wait at night.

Villagers below the dam also claim that they hardly catch any fish because their fishing gear is often damaged by the operation of generators, making the discharged water highly turbulent and dangerous to fish. They have to wait until midnight when the generators stop. Villagers of Ban Hua Heo located at the first rapids or the "capital of fish" cannot use their conventional fishing gears anymore because the blasting of rapids and rocks have destroyed fertile fishing ground.

The Fisheries Conservation Unit at Pak Mun has set up a water boundary in the reservoir, where fishing is prohibited during spawning season. This has limited the access to water for the Mun river fishermen and become a source of conflict between fishermen in the Mun River and the Fisheries officials. The former claim that they had the right to the fishing ground in the Mun River before and now their right has been denied. They have to fish for their survival. There is less fish in the reservoir and the fish-stocking program fails to produce enough fish in the reservoir.

- **Employment Opportunities**

Many affected villagers basically rely on farming, but they cannot earn a large income. However, at the beginning, it was difficult for them to change from fishing to farming. Employment opportunity in the area and in Khong Chiam district is quite limited. Since the project was completed, there has not been any investment in the area to generate employment. Tourism has not increased. For most affected villagers, non-farm employment in urban areas is their strategy. They tend to work as wage labour in construction sites. But during the economic crisis (1997) many were unable to find construction work. Some villagers also work as sugar cane cutters or farm laborers. Since they are fishermen, they have skill in weaving baskets, fishnets and fish traps. However, the local market is limited. Young men and women who are more mobile look for employment in Bangkok and other major cities.

4.6.3 Incomes

Villagers who were interviewed said that the projected prosperity after the dam completion has never materialized. Villagers who owned some land on slightly higher elevations were able to grow some rice as prior to the dam construction, and adapt more easily to the new socio-economic conditions generated by the dam. Villagers who were dependent largely on fisheries for cash income, however, have found no viable means of living since the depletion of fish in the reservoir. Villagers from Ban Weun Buek on the Mekong to those from villages above Kaeng Saphur in Pibun Mungsahan District could not catch any fish during the construction period. They lost their income during the three years of construction. This view differs from the TDRI report which uses the biannual National Rural Development Committee (NRDC which since 1984 has been undertaking village censuses throughout rural Thailand) data to conclude that in the period between 1992-96 there were positive changes, in absolute as well as relative terms, in the general quality of life and economic opportunities for the core project area of 11 villages adjacent to the reservoir, with markedly higher fishing income. Although the proportion of single occupation households reduced from 30% in 1992 to 18% in 1996, there was an increase in mean income estimated at 20%. However a general and progressive decline was evidenced in other main and supplementary occupations. The changes were particularly acute in paddy production. This may reflect the good economic climate in Thailand prior to the economic crisis in the mid-1990s which enabled people from the project area to seek wage labour opportunities in the urban areas, as well as the initial productivity (for a year or so) of the stocking of shrimp for project-affected people. (For detailed analyses of this aspect see Annex- 3)

Along the Mun River, *Pa Bung-Pa Tham*, swamps and wetland forests, are parts of the riverine ecosystem. During the rainy seasons, these are flooding areas and places for fish to spawn. In the past, villagers used the area along the river to find bamboo shoots, mushrooms, native plants and vegetables that they depend on for their subsistence. During the dry seasons, they also developed narrow patches of land along the riverbanks for growing vegetables. In the upper part of the lower Mun, where banks were not steep, land along the river was developed as paddy fields or *Na Rim Mun* and *Na Tham*. After the dam was built, not only the rapids and "wang" were lost, but also swamps, wetland forests, cultivation strips and paddy fields were submerged under the reservoir.

These ecological changes have brought drastic changes in the way that villagers use natural resources. As their food and income security has been destabilized, villagers have sought different ways to cope with the changing conditions. Some of them and their children began to leave their villages to look for alternative employment opportunities, such as working in construction or in factories. As an example, many of the older villagers' children started to look for employment in the urban centres such as Bangkok, Chonburi, and Phuket. Some of them found work in factories, while others worked as commercial sex workers. It has been reported that a few young men and women returned home to the villages being HIV positive.

It may appear that the affected villagers became economically better off after the Pak Mun project was completed, if material indicators, such as, house structure, galvanized or factory-made asbestos rooves, motorcycles, etc. are used to measure their wealth. This surface phenomenon must be looked carefully. Many affected people who were given compensation used the money to build their new house or change their roof. Economically, galvanized or asbestos roof is cheaper than thatch roof in the long run anyway. Motorcycles can now be purchased through credit system. Therefore, owning a motorcycle does not indicate wealth of the owner, but a status symbol of those who work as wage laborers. Our informants told us that many villagers sold their cattle in order to have cash in hand. Many also have debts, borrowing from their cooperative as well as local moneylenders. In any case, since fishing in the Mun river has drastically declined and there has not be any job opportunity created for the affected people in the area, it is not possible for them to become as economically well off as suggested by NRDC 2 data.

- **Environmental**

The change in dam site location, from Kaeng Ta Na to Ban Hua Heo, along with modifications in the engineering design, still cause many rapids to be submerged under the reservoir. Kaeng Ta Na has not been submerged under the water due to the dam construction, but its rapids were nevertheless destroyed. Kaeng Saphur, on the other hand, has by 1999 been submerged under water for nine months. By controlling the water level during the dry season, the rapids can be seen during March to May. The submerged rapids at Kaeng Saphur are now covered by sedimentation, and do not attract many visiting tourists as before.

During the construction of the dam, villagers of Ban Hua Heo were greatly affected by the blasting of the rapids. They were not told about the impacts. Rocks pounded their house rooves and dust and flying debris covered their belongings. The blasting, which was carried out during a period of two years, created disturbingly loud noise levels, and yet was not mentioned in the EEI report, nor explained to the villagers beforehand. Although the affected villagers tried to negotiate with EGAT to stop the blasting, this did not happen until the villagers decided to occupy the blasting site. After negotiations, 49 households were relocated to a resettlement area, while another group of affected villagers chose to move into a forest reserve area[81].

Villagers also complained about the quality of the river water. Since the impoundment of reservoir, the Mun River flows slowly and is practically still above the dam. They believe water stagnation may have caused new kinds of aquatic weeds, Hyacinth and Lemnaceae, to rapidly spread in the reservoir[82]. The Mun River below the dam is also contaminated with loose roots of Hyacinth, which

are regularly cleared out from the reservoir by opening the dam gates to make them pass through. Villagers claim that now they cannot use the shallow wells near the riverbank for drinking water because they have all been submerged by the reservoir. The water from the well below the dam at Ban Hua Heo is no longer drinkable[83].

The environmental change caused by the Pak Mun dam has immensely altered the way of life of the Pak Mun villagers. This is because the riverine ecological system, which was suitable as a fish habitat and spawning ground has been destroyed. Villagers who had adapted to the ecological system and developed their knowledge on how to use its natural resources now have no access to these resources. Abundant fishes are no longer available for the people of Pak Mun.

- **Community Relations/impacts**

After resettlement, villagers have witnessed many social and cultural problems. Although the new resettlement areas are not far from their former villages, the new social arrangements have disrupted former social relations and changed patterns of interaction among the villagers. They can no longer fish together or work together on their shoreline vegetable plots as they used to do. Before the Mun river serve as the stage for their social life. Villagers met, interacted, developed social networks of exchange, and helped each other. For the younger generation, the river is where they learned fishing skill and where they met and courted their lovers.

The traditional communal ceremony usually organized on the riverbank, where villagers came together to offer food to Buddhist monks and celebrate the traditional Thai New Year, is no longer held. This is due, in part, to the submergence of the ceremonial site and, in part, due to the social disintegration of the communities. Most of families interviewed reported that their children had gone to work in Bangkok or many cities after the dam was completed. Villagers have no space to interact and exchange as before. Family ties are weakened. Community participation also decreases.

Since the beginning of the Pak Mun project, community relationships have become problematic. Conflicts of ideas and interest arose between those who opposed the dam and the kamnan and headmen group. The conflict was intensified during protests and demonstrations for compensation. Most kamnan and headmen in the project area took sides with EGAT and thus disagreed with the affected villagers on the Pak Mun project. In some villages, the conflict became intensified and extended into everyday life activities. Those who were opposing the dam were often discriminated against. Oftentimes, they were not invited to attend village meetings nor told about community development activities. Some leaders of the dam protesters were ridiculed and sometimes labeled as "mobsters." Their children were also called "the children of the mobsters"[84] and sometimes, after having joined their parents in protests or demonstrations, were subsequently harassed in school by their teachers. The conflict over the dam project at the local level thus led to mistrust and deep social rifts. As one village elderly woman expressed, "We spoke to each other, but we did not communicate with each other[85]."

- **Analysis of divergent views**

Based on their own observations and practical experiences prior to and after the dam construction, the villagers' view is clearly contracticts that of EGAT. The divergent views have led to disagreement and conflicts in assessing the environment and social impacts of the Pak Mun project and the number of people affected by the project.

The EEI report, and hence EGAT's perspective failed to recognize the villagers' loss of their main source of income from the fisheries. The report assumed that villagers were predominantly rice farmers, fishing only for subsistence. It did not recognize that fishing constituted an important source of income, as well as a way of life, for the villagers living along the Mun River. Indeed, it did not investigate the complex relationships between villagers and fish, and between fish and the ecosystem of the Mun River. Thus, the EEI report was inadequately prepared and based on flawed

understanding of the villager livelihood systems, while oversimplified in terms of the post-impoundment fishery situation. It failed to identify how the project affected people and to assess their loss of income, and thus could not help EGAT and involved agencies to appreciate the possible negative impacts of the project upon the life of the people.

Based on the villagers' accounts of how the project has created impacts upon their livelihoods, it is quite clear that the EEI report did not accurately predict the number of affected people. Nor did it anticipate the extent to which fish and other natural resources, including private and public land, plants, herbal plants, and so on, would be lost during and after the project construction. It wrongly predicted that the fish in the reservoir would multiply, allowing more people to be involved in fishing as an occupation. In reality, the decline of fish in the reservoir was the main reason why many of the affected villagers have converted from being fishermen to being subsistence farmers or wage laborers.

It should be pointed out that although the OED report was largely based upon the Khon Kaen University study[86], it was very supportive of EGAT's position and viewed the affected villagers as endless claimants of compensation. It contends that the villagers have overexploited the fish resource in the Mun River as if the resource is openly accessible for all. There may be some element of truth in this argument during the post-impoundment of the reservoir because the villagers were in an "insecure" situation. However, the report should point to other factors that may also have contributed to the decline of fish resources, such as the mistaken assumption about the increase in fish population in the reservoir and the failure of the fish way. The OED report fails to mention the significant impacts of the blasting of the rapids - the incident that disrupted fish migration for a certain period of time, destroyed the ecosystem, and affected the life of villagers at Ban Hua Heo.

4.7 Resettlement: projected and actual impacts

- **Projected**

The Resettlement Planning (RP) or the baseline survey of the resettlement and relocation of the affected people, by TEAM Consulting Engineers, Co. Ltd. was completed in 1982. In this survey, the reservoir water level at 113 m MSL was considered as an upper boundary in the compensation/ resettlement investigation. The survey covered 60 villages along the Mun River to be affected by the Pak Mun project, in Warin Chamrab, Pibun Mangsahan and Khong Chiam Districts. For its purpose, it contained comprehensive information useful for compensation and resettlement planning and implementation. When EGAT decided to reduce the reservoir water level to 108m MSL, however, the survey became almost entirely irrelevant. Only information pertaining to some villages to be inundated in Khong Chiam District could be used as baseline data.

EGAT's perspective on social effects recognized that some villagers would need to resettle, as their land along the river would be submerged by the reservoir and backwater effect. By altering the dam site location from the original Kaeng Ta Na site to the present Ban Hua Na site, the number of households needing resettlement was reduced from 3 970 to 379. Some agricultural areas would be inundated as well. EGAT, however, would give compensation for the loss of land and crop trees and would arrange for new land for resettlement – in other words, the common measures employed for previous development projects. The EEI report estimated an average of compensation cost per family at 129 440 Baht and a total of 724 million Baht as the resettlement cost for the whole project[87].

- **Actual Effects**

According to EGAT's Report on Mitigation of Environmental Impacts of the Pak Mun Hydropower Project, 1994, people who were affected by the project are divided into seven categories:

Table 4.26: Categories of affected people

SN	Nature of categories	Village	Number of Households
1	Affected by construction	Ban Hua Heo	11
2	Affected due to blasting of rapids	Ban Hua Heo	227
3	Living in area below 108m MSL		136
4	Living in area between 108.-108.5 m MSL		96
5	Living in area above 108.5 m MSL		473
6	Agricultural land inundated		706
7	Loss of fishing occupation		2140
	Total		**3789**

Source: EGAT, 1994

It should be pointed out that not all of these affected villagers were predicted or anticipated in the EEI report. However, when EGAT decided to change the dam site, it was predicted that only 379 cases would be affected fully or partially by inundation. The number of affected cases reported by EGAT represents the cases that were given compensation, when in fact, the actual number of affected cases is higher. The discrepancy here is due to the difference in perception between EGAT and the affected villagers with regards to who is really affected. Some groups that have not been accounted for by EGAT include the following:

a) A former headman and a group of villagers in Ban Huay Hai who were advised by EGAT personnel to move out from their inundated land in order to set an example for the other villagers. After having resettled, however, they could not receive any compensation, reportedly on the grounds that they resettled before an agreement about compensation between EGAT and the affected villagers had been made. This group of villagers has since taken their case to court. The case has not been settled as of 1999;

b) Villagers whose land was almost surrounded by water after the impoundment. Although their land was not inundated, these villagers found the situation very inconvenient for themselves and their cattle. They were afraid that their children might fall into the water. They decided to resettle in a new area;

c) Villagers who permanently lost income from fisheries. The number of households affected in this manner, was finally determined to be 6 202. The increase in the number (originally estimated to 2 140 households) was due, in part, to the re-investigation undertaken by the Committee for Assisting and Developing Fishing Occupation in the Pak Mun Project Affected Area, which came up with 3 179 households who lost their income from fishing during the dam construction. In addition, the kamnan and headman group, who did not join the demonstration but submitted their petition for the compensation later, which was also taken into consideration.

Table 4.27: Number of Affected fishing households.

Source	Number of affected fishing households
Three NGOs (no date : before 1991)	> 3,000
Wongsena (1992)	3,424
Sudara et al. (1994)	3,300
World Rivers Review (1994)	ca. 4,000
Pak Mun Fishery Conservation Unit (pers.comm.. 1999)	3,386
Pak Mun Cooperatives (pers.comm. 1999)	ca. 5,000
Committee for Assistance and Development of the Fishing occupation in the affected area. April 19, 1999	6,202

Choowaew, 1999

- **Analysis of discrepancies between predicted and actual resettlement**

First, the RP report was written almost ten years before the Pak Mun dam was completed. During this time, the number of villagers changed, and also the members of their households, making the data collected in 1981 obsolete for the planning of resettlement and for redressing the problems faced by the affected villagers. Over time, for example, one household may have become several nuclear families as the children got married, or young families may stay with the parents in one house, while earning their own living. Defining what constitutes a household has been particularly problematic with regards to compensation. Villagers have had to negotiate many times with the committee responsible for administering compensation until an acceptable definition of a household was agreed upon.

Second, it should be pointed out that the RP report makes an incorrect assertion about the occupations of the villagers in the project area, which is divided into three zones: urban, semi urban and rural. It assumes that the occupation of the villagers was predominantly rice farming and that fishing was their supplementary occupation. It fact, with the exception of the villagers in the urban zone, villagers of the semi-urban and rural zones were primarily fishermen. Many of the villagers did indeed have some land in the upland areas where they cultivated rice for consumption. This has, as mentioned earlier, led to misunderstanding about the villagers' dependency on the Mun River and on fishing. Consequently, the loss of income from fishing was largely underestimated by EGAT and the committees appointed to redress the problem.

Third, the RP report as based on the reservoir water level of 113 m MSL predicted that the residential and agricultural areas, as well as roads below this water level in the rural zone, would definitely be submerged. However, when the water level was chosen at 108 m MSL to reduce the impacts on the affected people, the information from this RP report became inapplicable. Residential and agricultural areas were then divided into three categories: land below 108 m MSL, land between 108 and 108.5 m MSL, and land above 108.5 m MSL. Some residential and agricultural areas may belong to these categories, that is, they would be inundated or partially inundated. In some villages, certain areas would not be inundated, but would be surrounded by water. The lack of accurate data on the effects of submergence in each village became a problem in determining who would be resettled and to what extent compensation would be given. Several villagers reported that there were discrepancies in the information provided to them. Some villagers were told that their residential land was not inundated, while in reality it was.

> *Lastly, according to the resolution adopted in the meeting of the Committee for Assisting and Development of Fishing Occupation in the Affected Area, EGAT has given a total of Baht 232 635 253 as compensation for the losses of land, house and property to 1 883 households[88]. In average, then, each household has received Baht 123 545.00, which is Baht 6 000 lower than the average amount estimated in EEI.*

Conclusions:

- The history of Pak Mun is the history of struggle between affected people and EGAT, over the right to livelihood and the right to the environment upon which affected people depend for their living.

- The EIA for the project did not accurately predict the number of affected people, and the wide array of impacts experienced by the Pak Mun communities. Around 6 202 households who permanently lost income from fisheries initially were not considered affected by EGAT. The lack of accurate data on the effects of submergence in each village became problematic in determining who would be resettled and to what extent compensation would be given.

- In the Post-dam period, fishing communities located upstream and downstream of the dam reported 50-100% decline in fish catch and the disappearance of many fish species. The number of households dependent on fishing for livelihood in the upstream region also reported to have declined from 95.6% to 66.7%. According to the NRDC survey used in the TDRI report, the share of non-farm income rose and there was a general improvement in income levels in the initial period between 1992-96, prior to the economic crisis, through urban wage labour opportunities and reservoir stocking programmes.

- Many affected villagers chose to find non-farm employment in urban areas in order to gain extra income. Villagers who were dependent on fisheries for cash income have found no viable means of livelihood since the dam was built, despite efforts to provide training opportunities. As their food and income security was destabilised villagers sought different ways to cope, including out-migration in search of jobs.

- Some households had to settle in forest reserve areas or on other common property as the money given was insufficient to purchase new land. Monetary compensation resulted in acquiring of productive assets in a few households. The Thai economic downturn affected the households that did not use the compensation in acquiring productive assets.

4.8 Impact of Pak Mun Project - Ecological and Environmental Aspects

4.8.1 Key Issues

- **Soil & Land use**

Soil in the project area can be classified into 11 soil mapping units comprising ten soil series, one soil association and one soil complex. The *Si Songkhram* series covers 28% of the project area, while the *Borabu* complex coves 14%, the *Roi Et* series 12%, and the Chiang Mai series 11% respectively. Other series namely, the Phimai, San Pa Tong, Si Thon, Phen, Ubon, Phon Phisai as well as the Roi Et/Phen association are scattered throughout the project area. The Borabu complex is found in thin deposits over the bedrock and is unsuitable for cultivation area and area with this soil type is mostly covered with open dipterocarp forest. Recent to semi-recent alluvium on river levees, river basins, backswamp and flood plains are found mainly along both sides of the Mun River and the flood plains between Ban Pak Se and Ban Sawang. These areas are annually flooded by overflow form the Mun and is suitable for vegetable and orchard farming and rice cultivation. The Roi Et series, the Phen series and the San Pa Tong series consists of old alluvium on low & middle to high terraces and are suitable for cultivation. These soil areas are concentrated between Ban Sawang and the Tana cataract. Loss of fertile soil along the riverbanks due to the impoundment of water was anticipated by the EIA of 1982. The free access of local people to areas now underwater where they harvested jungle produce was lost. The total lost area of 5,700 rai included the riverine or riparian area of 525 rai (84 hectares). The riverbed areas with a high capability for agriculture that were also used for growing

vegetables during the annual dry season were also inundated. The assessment of actual losses particularly of the riverbed cultivated areas with definite implications for domestic food and income levels were not made in the previous environmental impact study (EIA or 1982). Therefore the compensation did not in effect cover the actual losses.

- **Natural and Community Forests**

The forest and other land use patterns covers approximately 202.63 km^2 of the Pak Mun project area. Dry Dipterocarp Forest account for 17.8 km^2 or 8.79% of the total project area. This forest type usually occurs on dry, shallow and lateritic soils. Trees are sparse and maximum tree height does not exceed 15 m.[89] The undergrowth is dense with saplings and seedlings of common species like *bamboo and coarse grasses.* Some dry Dipterocarp forests near the banks of the Mun have been partially cleared for paddy cultivation. The dry evergreen forests found mainly on the flat areas along the stream banks cover 4.99% of the total project area. The dry evergreen forests found near the villages were in good condition. 19.54% of the project area is covered by scrub forest. Paddy fields cover 62.58 km^2 or 30.89% of the total project area. A number of fruit trees and vegetables were also grown in the area. (Source: The Report of Archeology Pak Mun, Fine Arts Department and the Electricity Generation Authority of Thailand, 1977.)

- **Riverbank Vegetation**

At least 40 different edible plants, 10 species of bamboo and 45 mushroom species were found to be freely harvested by the locals (mostly women) for domestic consumption (Kittisiri, 1997). Women and housewives also earned a small but sustainable daily income of at least 5-10 and sometimes even up to 50-60 Baht a day from selling the harvested vegetables at local markets.

A hundred or more medicinal plants were reportedly found near the Mun riverbanks (from the interview of this study, 1999). Loss of these plants due to inundation means significant loss of biodiversity as well local food and health security. The dietary, nutritional, medicinal and economic importance of local vegetation was overlooked and ignored by almost all studies and reports.

As mentioned in the previous section, the riverbed vegetation was lost due to the impoundment of water. The actual loss of riverine and riverbed vegetation with respect to other native plants used for various purposes should be evaluated, as it has deprived the local people of their manifold benefits as well as affected their livelihoods. The fact that mitigation measures and the compensation did not make up for such losses has further exacerbated the situation for the local people.

- **Wildlife and Fauna**

The study conducted in 1979 by EGAT projected no significant adverse effects on wildlife. However, at least 20 species of mammals, 180 species of birds, 17 species of reptiles (1 of which was endangered), and 10 species of amphibians were found in the area. Potential loss of vulnerable species like the Pla Krabaen Numjued *(Himantura laoensis)* and Taphab Nam *(Amyda cartilaginea)* was anticipated due to a change in river habitats and overfishing. Among the birds sighted along the Mun river in the Park, are the Brahminy Kite *Haliastur indus* (a near threatened species, nesting on the island) and the Wire-tailed Swallow *Hirundo smithii* (a vulnerable species, feeding over the rapids), two species of great conservation value were threatened by the dam.

After the construction of Pak Mun dam, no data regarding wildlife has been collected. A study of wildlife status is required to monitor the above impacts.

- **Natural Rapids**

From Ubon Ratchathani down to the Mun-Mekong confluence, the Mun runs through a series of rapids, including the important Kaeng Saphue and Kaeng Tana rapids existing between Kaeng Saphue

and Kaeng Tana were permanently submerged. The loss of at least 14 other repids and the consequent ecological impacts were ignored. Explosions at Kaeng Khan Heo and Kaeng Tat Hua Phu, downstream of Pak Mun dam site about 2.8 km, for deepening and widening the river channel to be the drainage channel and was perhaps done without prior assessment of the impacts. It was also not expected by the local stakeholders, resulting in some controversy. Rapids are very important habitat for fish. At least 62 species were found in rapid habitats while 80 species were found in the riverine habitat.

The study of Pholprasit et al. (1997) reported that about 18 species of fish are found only in rapid habitats. Certain fish species live, feed, breed, spawn, grow, and seek refuge in rapids. Rapids were also fishing grounds for local fishermen. From the field survey concluded by the Study team (in November 1999) it emerged form the statements of the people that more than 50 natural rapids were submerged due to water impoundment. The overall impact of the project on the natural rapids in the reservoir area as well as upstream and downstream areas and the resulting ecological and other impacts were not intensively assessed.

- **Kaeng Ta Na national Park**

Kaeng Ta-Na National Park (KTNP) is located in the area of Tambon (subdistrict) Kam Kean Kaw, Amphoe (District) Sirindhorn and Tambon Khong Chiam, Amphoe Khong Chiam, Ubon Rachatani Province. The KTNP covers an area of 80 square kilometers. KTNP was established on 13th July 1981. The uniqueness of the National Park are the Don (dune) Ta-Na, Kaeng Ta-Na and other existing natural and archeological tourism spots such as a number of waterfalls, lagoons and caves. The effect of impoundment on the forest was not considered serious as the forestland flooded by the reservoir was mostly degraded. However the Kaeng Ta-Na National Park was directly disturbed as a total of 685 rai (around 274 acres) was temporarily used during construction and 125 rai (50 acres) was permanently withdrawn form the KTNP after construction was completed. The mitigation plan called for forest protection, improvement of facilities for tourists, minimization of runoff due to construction, stabilization and reclamation of spoiled areas, rehabilitation and re-vegetation.

- **Public Health**

The most significant health problem relating to the development of the Pak Mun project may be Schistosomiasis (Blood fluke disease). The beta race Neotricula aperta beta race, the snail intermediate host of Schistosomiasis mekongi was found at many places on the rocky river beds of the Mun river from Kaeng Saphue to the dam site. As there are several natural small pools where the snail could live and contact with miracidia of the parasites discharged from infected persons, it was feared that the snail would transmit the disease in the project area. According to Temcharoen et al, (2000).(Ref. 3). The life span of one generation of *N. aperta*, beta race, in the Mun River was about 1½ years and snail began to lay eggs from late June to July. They laid eggs for a period of ten months. The eggs began to hatch from July. During July to October or November, the juvenile snails could not survive and died. The study by TEAM in association with Faculty of Tropical Medicine of Mahidol University (1984) stated that indigenous cases of schistosomiasis were not present in the project area. However, recent cases have been reported in Southern Laos, an area in which Schistosomiasis mekongi is endemic. This area lies 150km from the project area. The liver fluke *(Oposthorchis viverrini)* was a common parasite in the northeast that existed in the reservoir area. Nearly 50% of the population in the area are believed to be infected, with peak prevalence in people of working age and a potential increase in its prevalence in irrigated areas.

Mitigation measures supported by EGAT implemented by the Ministry of Public Health during 1992-1995 included programs for disease prevention and control, disease surveillance and increasing the capacity of the public health service station. In 1990 NESDB's mitigation plan for epidemic disease prevention was implemented with a budget of 3 400 000 Baht. Besides, a vector survey and monitoring of the area by the Faculty of Tropical Medicine in cooperation with EGAT and the Water

Quality Monitoring Network 9 of the Mekong River Commission Secretariat (whose waterborne Disease Study Programme in currently halted) was also launched. The public health study aimed to assess the health impacts in terms of epidemics of water borne diseases, presence of endemic of parasites (blood fluke/liver fluke) and the nutrition impacts.

4.8.2 Findings

- **Soil and Land use**

Based on the study conducted by the survey subcommittee of land assets, the cultivated area along the Mun riverbank covers the flood plain area and riparian area over 5 700 rai and was compensated by EGAT during the construction of the Pak Mun Dam. Based on the current study it can be concluded that the loss of riparian cultivated area had been already assessed in the lost cultivated area of 5 700 rai, which had already been compensated. Loss of the cultivated area also included the riverbed land used for dry season cultivation. The cultivation of the riverbed area is mainly based on rainfall. The dry season of the area lasts for 5 months. The local people have to adjust their cultivation pattern by growing vegetables along the low area of ponds, swamps, and the stream bank or riverbed land. The current study calculated the lose of cultivated area for the community, as 56 hectares of riverbed area and 7.52 hectares of land near the island sand bar. The loss of riverbank and riverbed cultivation area was not assessed prior to the construction of the project. Loss of cultivated areas along the Mun riverbank resulted in the loss of local edible plants and income. From the current interviews, loss of the local edible plants in terms of cost was averaged to be 6 000 Baht per year. The average loss of income generated from natural growing plants and a cultivated plant was 4 030 Baht per year. The completely-flooded land plots were compensated by an area equal to the flooded area, but subject to a maximum compensation of 10 rai (4 acre). The partially flooded land plots were compensated by an area equal to the flooded area, but subject to a maximum compensation of 10 rai (4 acre) when combined with the rest of non –flooded area. The mitigation measures devised did not include compensation for the loss of floodplains used by the people for cultivation. This area was important to the local people' way of life and as a major source of food & livelihood.

- **Natural Forest and Community Forest**

Patches of dry deciduous dipterocarp fores exist in Ban Huai Hai, Ban Khan Puai, and Ban Wang Sabang Tai. The dipterocarp forest at Ban Huai Hai is in good ecological condition. The dry deciduous dipterocarp forest at Ban Khan Puai and Ban Wang Sabang Tai also exist in good ecological condition, but the forest area is much smaller than at Ban Huai Hai. Paddy fields with scattered woody trees occur around all the mentioned villages. The woody trees found in this area are similar to the dry deciduous dipterocarp forest. The cultivated areas with paddy fields that were inundated were transformed into permanent wetland after the construction of the dam. The depth of the water in this area is not ideally suited for fisheries. However, the wetland is beneficial in other aspects. It is the habitat for some marsh birds and amphibians e.g. Chinese Pond Heron *(Ardeola bacchus)*, *Rana tigrina and* is also the source of some edible plants. The edible plants found here are common in the swamp area or natural ponds such as *Nelumbo* sp., *Ipomoea* sp., *Marsilea* sp., etc. In general, it can be concluded that some small patches of dry deciduous dipterocarp forest still occupy as the pre Pak Mun construction. Moreover some edible plants could be found in the transformed wetland.

- **River Bank Vegetation**

From the interviews it emerged that before the construction of the dam local people practiced extensive cultivation in riverbank areas. They mostly preferred growing vegetables such as chili, egg plant, onion, cabbage for household consumption. In some areas they also had rice fields and even cultivated corn in the riparian areas. The vegetable cultivation could yield up to 40-50 Baht per day. The riverine area was a source of mushroom and bamboo shoot that was mostly used for household

consumption. Some people earned up to 150 Baht per day per person from selling edible plants gathered from the riverine areas. Moreover, these areas were also a source of a number of medicinal herbs such as the laxative herb, Luke Thrai, a pain reliever called Padong and several others.
The inundation of these areas have reduced cultivated areas and further resulted in the loss of naturally growing plants like mushroom and bamboo shoot. These were not only used for domestic consumption to meet nutrition and food need at minimum expense but were also an important source of livelihood constitution significant losses for which people have not been compensated for. The people are left with no choice but to buy their vegetables from the market at the rate of anywhere between 5 to 10 Baht per day. The loss of access to medicinal herbs is another significant uncompensated loss. People now are forced substitute freely available medicinal herbs for medicine from health stations whereas those still preferring the herbs have to buy it from across the border in the Laos PDR. Apart from the additional economic burden that this imposes on people it is also a threat to the continued existence of the indigenous systems and knowledge of medicine, fast disappearing in Thailand and elsewhere.

- **Wildlife and Fauna**

Along with the forest study an attempt was also made to assess the current status of wildlife in the area through a wildlife survey. Field observation recorded the presence of 98 wildlife species that included 77 birds, 10 mammals (4 species sighted), 6 species of reptiles (5 species sighted), and 5 species of amphibians. The species found are more or less compatible with the habitat as well as the times of the year in which the survey was conducted. Tables B-1 to B-2 in Appendix A show the list of birds, mammals, reptiles and amphibians recorded by the survey. Birds appear to be the most common group of vertebrates found. While 63 species of birds were found to be resident 14 others were visitor species. One near threatened species was found, and 5 of the recorded species were classified as “threatened”. The number of mammals actually spotted in the survey was quite small. All of them belong to the squirrel family. Other mammals listed in Table B-2 in Appendix B are from the reports of Forestry officers at Kaeng Tana National Park. The most common reptiles found in the area are lizards and snakes, while 3 species of reptiles are classified as “threatened” (again due to hunting). All of the amphibians recorded inhabit the wetland formed by the dam. One of the species is classified as “threatened” (due to hunting).

- **Natural Rapids**

The primary geological characteristic of the Northeast region is a plateau, surrounded hilly range creating a saucer-shaped basin in the middle. The Khorat Plateau forms the main catchment area of the Mun. The lower Mun flows along the hilly ranges of Phanom Dongrek and Phu Pan prior to joining the river Khong. The Mun is the only river in Thailand that flows through such distinct geological and topographical features. That is primarily season for the unique diversity in the characteristics of the Mun that, along its 641 km. length, embraces natural rapids, islands, beaches and hills. The previous study (Ref 1) completely ignored the unique features of the Mun. As a result no intensive study of the natural rapids or the ecological impacts of their losses was undertaken. Only two prominent natural rapids the Kaeng Saphue and Kaeng Tana were assessed from the narrow viewpoint of tourism.

The local people reported the existence of 57 natural rapids between the mouth of the river and Kaeng Saphue. The names of the rapids as given by the local people are listed in Table C-1 (Appendix C). The rapids that are not permanently inundated by Pak Mun dam are located downstream of the dam, with the exception of the kaeng Kan Heaw, Kaeng Hin Phon, Kaeng Tad Hua Poo, Kaeng Tad Tae and kaeng Tana. With the exception of the Kange Tana all the other natural rapids have deteriorated significantly due to the stones and debris from repeated dynamiting of the riverbed during the construction of the drainage channel. This has largely destroyed their ecological value. The dam has permanently inundated 51 rapids located upstream. The Kaneg Saphue will be inundated for about 7 months of the year. The Mun has islands or bars (referred to as Don locally) and beaches at the middle

of the river. The dam has permanently inundated 10 such islands the names of which are listed in Annex-8-Table 8.7.

From the interviews, it emerged that a large and diverse fish population inhabited the rapids prior to the dam construction. More than 50 species of fish were reported and these could be caught with relatives ease around the rapids. A list of the fish found in the rapids of the Mun River is presented in Annex 8-Table 8.6.

Interviews of 321 local people were conducted to understand their perception of the impacts of the inundation of natural rapids. 95.3% of the respondents perceived the loss of fish and other aquatic species' habitat as the most important impact. 87.3% were concerned about the pollution of rapids due to sediment accumulation. 82% of the respondents expressed concern about the loss of natural recreation and 67% were worried about the pollution of rapids due to growth of weeds. A large number of people interviewed, 80.5%, felt that in their inundated stated rapids ceased to be a major fish habitat or a productive fishing zone.

- **Kaeng Tana National Park**

Major impacts on the National Park came from the noise pollution due to repeated explosion, and machinery, dust dispersion from construction activities and from the explosion of Kaeng Kan Heaw, Kaeng Tad Hua Phu to construct the drainage channel. Inundation of the forest area in KTNP was not high as most of the forest area occurs in the higher elevations not affected by the impoundment. However about 50 acres of the Park area was permanently inundated which was the area of the confluence of the Dome Noi with the Mun Rivers.

The mitigation measures provided for KTNP were aimed primarily at the protection of forest area and tourism promotion. It involved measures for controlling and preventing encroachment on forestland and wildlife hunting in the vicinity of the construction area and the transportation routes to the project. Measures for enhancing tourism in KTNP, such as construction of a hanging bridge for linking Don Ta-Na with the Mun river's banks, establishment of a KTNP protection unit and Construction of the monitoring pathway along the Mun river from Kaeng Ta-Na to the Dome river's mouth.

These measures were implemented during 1990-1995 with the approximate budget of 16 million Baht or US$ 0.4 million. [90] This is expected to promote the tourism value of KTNP and the Pak Mun dam. According to local perception, construction of access road will have a positive impact on tourism. However people would probably spend less time at the Kaeng Ta Na than before construction of the dam as the rapids no longer constituted the primary tourist attraction. The dam construction increased water level at the rapid, causing a partial loss of natural beauty of the rapid.

- **Natural Rapids and Local Culture**

Before the construction of the Pak Mun dam, the Songkarn festival (locally known as Songkarn Wan Now) used to be celebrated by the rapids. Buddhist monks were invited to perform several religious ceremonies and related activities by the rapids, many of which were "sacred", for communities. Large number of people from the surrounding areas and the tourists came and participated in this festival. The local people helped in catching fish and cooking food for the celebration. After the permanent inundation of the 50 rapids on the river, the Songkarn festival has lost most of its traditional character, it has to be performed within the confines of the temple and the number of people who participate has also decreased, particularly the tourists.

The natural rapids of the Mun were actually also local of cultural and socio-economic centres of activity in the area. People from various communities gathered here of there to catch fish and engage in formal and non-formal exchange of goods/services at the rapids. They come in a group or individually and relationships grew out of these interactions. This generated a feeling of community and cultural and social networks. The inundation of the rapids has at one stroke virtually destroyed

these cultural and socio-economic networks. Dam induced inundation of sandbars and islands have adversely affected local culture. For instance the practice of Sand Piling was affected as the beaches around the island or dune have been flooded.

- **Navigation**

Communities relying on communication by navigation were very low. Only the motorboats used for catching fish and motor rafts used for carrying motorcycles plied across the river between the villages for instance boats were seen in Ban Tung Lung, Suwan Waree or Nok Hor. More navigation was visible downstream of the dam connecting with the Khong. Following the construction of the Pak Mun dam, the river channel is wider, deeper and there are also rapids, so the scope for navigation should be greater. The communities, however, still prefer land transportation.

The results from the field survey indicate that the benefit generated from the enhanced scope for navigation was low since the local people now have a way of life tied more to land in terms of communication. Moreover, the dam was designed as a bar across the river without considering the navigation factor. There were no opinions on economic loss for navigation of goods and passengers since the navigation for this purpose had ended since 1975.

- **Public Health**

Prior to the Construction of the Dam

From the literature review of Pak Mun Project studied by Team Consulting Engineers Co Ltd. and the Faculty of Tropical Medicine, Mahidol University (1984), it could be summarized as follows.

61.4 percent and 63.9 percent of the people in resettlement and reservoir were respectively infected with one or more kinds of parasites. *Opisthorchis viverrini* was 49.4 percent and the most common helminthic infection in the project area. The intensity of infection showed that 71.1 percent of cases were mildly infected and 2.4 percent were heavily infected. The more severe cases were found in the reservoir area. An examination of the ages of infected people indicated that the infection was predominant among members of the Labour force (15-64 years) although it was found in all age groups. Examination for metacercarise of *O. Viverrini* was done in fish caught by local people in the project. Pla Mae Sa Dang (Cyclocheilichthys spp.) had the highest infection rate (55.9%), Pla Kao Mon and Pla Ka Mung were an other two species that were infected with metaceria. These fish are common in the area and people are very fond of using them for making "Koi Pla", a popular uncooked fish dish. Bithynia snail, intermediate host of liver fluke/OV was found to inhabit the rice field, ponds small canals and the lake near the refugee camps. The most favorable time for breeding is early rainy season. It should also be noted that Bithynia snail does not inhabit in the Mun itself or its tributaries and Tricula operta does not live anywhere else except in the Mun River.

The nutrition status of preschool children in the project area consisting of reservoir and resettlement area during 1983 is shown by the anthropometric data revealing that about 31.5 to 51.7% of preschool children were under developed to some extent. Between 26.0% to 37.9% of the children suffered 1st degree malnutrition suffered while 5.5 to 13.8% suffered from 2nd degree malnutrition.

Post dam construction:

After Public Health Mitigation. Prevalence of human parasitic diseases of liver fluke, *(Opisthorchis viverrini)* and blood fluke *(Schistosomiasis mekongi)* was studied by reviewing the report of Surveillance and Prevention of Parasitic Diseases prepared in 1998 by the Office of Communicable Diseases Region 7, Ubonrachatani province. This monitoring program was aimed to study the existing status of parasitic diseases and extend surveillance of blood fluke disease of the high risk people in the area of Pak Mun dam site. The stool examination of 921 local people of 21 villages indicated presence of liver fluke in 23.1% of local people and no prevalence of blood fluke. The presence of liver fluke disease indicates the continued consumption of uncooked fish in the area.

Public Health Mitigation and Development Program

EGAT had provided the budget of 3.4 Million Baht for the public health mitigation and development program that included:

1. Project on improvement of health service infrastructure in the irrigation areas.
2. Project on surveillance and control of local communicable diseases.
3. Project on surveillance and control of mosquitoes in villages nearby the irrigation areas.
4. Primary health care project in the Pak Mun resettlement areas.
5. A study on nutrition, food sanitation and environmental sanitation.
6. Project on improvement of sanitation villages; main activity, health education and public relations.
7. Project on surveillance and control of Schistosoma mekongki and others in the Pak Mun Dam area.
8. A workshop for conclusion and finalisation of the plan.

Public health study indicates the decreasing of liver fluke disease. This is because of the parasite control program that has been implemented since 1984 before the dam construction. There are various intervention programs for parasitic control and prevention such as campaign for non-raw fish eating, giving the villagers education, monitoring and surveillance program, etc. The results of stool examination of 6 287 people in the Pak Mun Project in 1994, 27.7% was positive for the liver fluke infection. Then, all infected people were treated with antihelminthic drug, Proziguantel.(Ref.4) However, the liver fluke disease is still found 1.09% of 2 743 cases in stool examination of people (Ref. 4) in the project area. The villagers still hold their culture of raw fish eating, particularly for the group-eating behavior. The blood fluke (Schistosomiasis) have never been found in Ubonrachatani Province, which include the Pak Mun area. Similarly, the present nutrition status is much better than the previous time (pre dam construction) which is the result of prevention program implementation, such as nutrition education to the local people school milk and lunch program, etc.[91]

Conclusion

- **Riverbank Cultivation.** The pre-project assessment of affected area under cultivation, by the Survey subcommittee of Land and Assets indicated a loss of 912 hectares of land, out of which 84 hectares constituted riparian area. The estimated additional loss was nearly 57 hectares of riparian land affecting the practice of riverbank & riverbed cultivation and cultivation in the sand bar. The impact on the lives of the people, dependent on this land for livelihood and sustenance, has been significant. However, this loss was not assessed and compensated by the project authorities.

- **Forest and Wildlife.** A large proportion of the natural forest area being at a higher elevation was not affected by the water impoundment. However, forestland covering 20 hectares at the confluence of the Dome Noi and the Mun River was permanently submerged. The possible threat to several species of wildlife, marsh birds and amphibians due to the impact on their natural habitat was not assessed prior to the implementation of the project.

- **Natural Rapids.** The pre-project assessment did not record the permanent submergence of 51 natural rapids and the consequent impacts on fish habitat, Kaeng Tana National Park and tourism. The most significant impact is the loss of fish habitat, which has resulted in a decline in fish population and affected the livelihood and income base of local people dependent on fisheries. Mitigation measures were not considered for the loss of the 51 natural rapids.

- **Tourism.** The natural rapids on the Mun River are among the popular tourist areas in Ubon Ratchathani Province. After the completion of the project, and inundation of rapids, the number of tourists have decreased from the maximum of 248 516 in 1991 to 142 123 in 1998. The project was not able to compensate this loss through the creation of new tourism opportunities, although

KTNP was promoted for this purpose. Further the impact on the incomes of local people dependent on the tourism industry was not assessed or compensated prior to project completion. The affected people are estimated to have suffered losses in income ranging from 4 800-6000 Baht/year.[92]

Based on its own field studies, Egat draws the following conclusion: the impoundment of the Pak Mun Dam increased the depth of water, and sedimentation of suspended solids at the waterbed occurred. These situations caused the reduction of diatoms, the natural food of *N. aperta*, the snail intermediate host of *S. mekongi*. These were the major factors causing a decrease in *N. aperta* populations in the Pak Mun area.

5. Options Assessment and Decision making process

The Pak Mun project was identified in the early seventies when the first feasibility study was conducted by SOFRELEC. By May 1979 the project was transferred to EGAT for further study. The project went through a series of feasibility studies as listed in Table 41 below. Environmental Impact Studies conducted in 1982 indicated that approximately 4 000 households would be displaced if reservoir was impounded to a level of 113 MSL. After a new feasibility study an alternative design with a normal water level of 108 MSL was agreed upon in 1985. In April 1989 the project was presented by EGAT to the Cabinet. Nearly one year later the Pak Mun Hydropower Project was presented as part of a loan package to the Board of Governors of the World Bank. The comparison of the project as presented to the Cabinet and as presented by the World Bank to its Board is found in Table 42. Later, when it appeared that project costs would have to be increased, it was presented to NESDB for re-approval. In each of these occasions costs and benefits were presented. The original project design was further modified by relocating the dam 1.5 km upstream to avoid the submergence of Kaeng Tana rapids. EGAT also decided to lower the reservoir to 106 MSL during dry season from January to May and to adjust the dam's operating regime to uncover the upstream Kaeng Saphue rapids, another tourist destination.

Table 5.1: Decision Making Timeline

1970	The first Feasibility Study conducted on the possibility of building a dam was made by SOFRELEC in 1970. It concluded that hydroelectric developments on the Pak Mun River were not viable.
1978	In 1978 EGAT picks up the idea of building a dam near the Pak Mun and studies a dam on the Kaeng Tana falls. Only electricity benefits are included, no irrigation benefits are mentioned.
1980	In 1980 the Pak Mun power plant is planned as a base load plant. That year SOGREAH updates the feasibility study for EGAT of a multi-purpose Pak Mun Project that includes irrigation benefits. The study makes a clear distinction between the capacity (referred to as "MW" in the study) and the energy output (referred to as "GWh" in the study). The study also mentions EGAT development of "peak generation has moved ahead of basic energy generation". It adds "This explains why EGAT is at present concentrating efforts on the production of GWh and not MW"[93]. The total power benefit of the Pak Mun dam is calculated with the help of a linear programming model that allocates the cost of the alternative plant between oil-fired thermal plants and diesel-fuelled gas turbines. Because of the relative high price of diesel the model allocates all alternative least cost-generation to the oil-fired thermal plants. The end result of the calculation is that each MW of Dependable Capacity of the Pak Mun dam is worth Baht 1.89 million per MW and Baht 0.89 million per GWh. Both in 1980 constant prices and discounted at 12%. The yearly capacity benefit (per MW) is calculated as the sum of the yearly depreciation of the dam and the interest on the initial cost of the dam. The energy benefit is calculated based on fuel consumption per kWh and 1980 fuel prices. The Net Mean Peak Power Output for an installed capacity of 136 MW, location Kaeng Tana, a reservoir level of 112 meter, was 46.02 MW. The total power output was estimated at 406 GWh [94]. Although the report does not show the actual economic benefit calculation it includes sufficient data to allow the reader to reconstruct the calculation. From this it appears that SOGREAH seems to have assumed that the capacity benefit was assumed to be around 46 MW and the total energy output at about 406 GWh.
1985	In 1985 the Pak Mun power station becomes a peaking plant. In that year SOGREAH updates the feasibility study for EGAT of a multi-purpose Pak Mun Project. The benefits of the plant are clearly separated into energy and capacity benefits. The energy benefit of the plant is calculated assuming that the Pak Mun

	plant would replace energy produced in large thermal plants. It was assumed that these plants would on average use 80% coal and 20% heavy oil. The capacity benefit calculation assumes that the Pak Mun would replace capacity in coal-fired plants. The end result of the calculation is that each MW of Dependable Capacity of the Pak Mun dam is worth Baht 29.8 million per MW and Baht 6.15 million per GWh. Both in December 1984 constant prices and discounted at 12%. The Net Mean Peak Power Output for an installed capacity of 136 MW, a reservoir level of 108 meter, with tailrace channel excavation, was 81 MW. The total power output was estimated at 280 GWh [95].
1987	In 1987 the Pak Mun power plant is planned as a peak power plant with 4 turbines. In that year SOGREAH further completes the feasibility study of the multi-purpose Pak Mun Project. The choice between 3 and 4, 34 MW turbines is settled by the fact that using 4 turbines generates 10 GWh more than the solution using 3 turbines. SOGREAH calculates that if one assumes a tariff of Baht 1 per kWh, the additional Baht 15.7 million cost of the 4th turbine is paid of in less than 2 years[96]. The study still considers the Pak Mun dam to operate mainly as a peaking plant. The study shows how the runner setting is optimised to maximise the peak production. The report states that "the main impact of runner setting is not on total energy production but rather on distribution of energy between on-peak ad off-peak hours". The report adds: "…a deeper runner setting allows to turbine greater discharges during on-peak hours and thus for dry periods the remaining volume to be passed through the turbines off-peak hours may be reduced" [97]. The report concludes that in some cases a deeper setting may reduce the total energy produced may be lower because of the marginal efficiency for high discharges is significantly lower during on-peak than the marginal efficiency at medium discharges during off-peak hours. Given the figures of Baht 29.8 million per MW for capacity and Baht 6.15 million per GWh calculated in 1985, the optimum runner setting would be at 85 meter. This setting was calculated to produce 110.92 GWh (39%) of peak energy and 175.85 GWh (61%) off-peak energy. The reliable capacity of the plant was rated at 75.90 MW [98].
1988	The EGAT presentation to the Cabinet presented the Pak Mun dam as a peaking plant [99]. . The reliable capacity of the plant, calculated as Net Mean Peak Power Output, was 75 MW and total yearly energy production at 280.2 GWh [100].
1989	In 1989 SOGREAH further completes the definite study of the Pak Mun Project. The energy production of the dam is recalculated to be 107.80 GWh (36%) of peak energy and 193.14 GWh (64%) off-peak energy. The reliable capacity of the plant, calculated as Net Mean Peak Power Output, was 74.86 MW [101].
1991	The World Bank SAR mentions that "The Pak Mun Hydropower project forms part of EGAT's least cost development plan, essentially serving the peaking needs of the Northeast region of Thailand". The choice of an open cycle combustion turbine as alternate plant confirms that the World Bank assumed the Pak Mun dam would operate as a peaking plant [102].

The main benefit of the Pak Mun Hydropower Project is electricity generated by its turbines. Given that the Pak Mun Hydropower Project is a run-of-the-river dam, the amount of electricity generated depends on the relatively small amount of water stored behind the dam, the quantity of water flowing towards it from upstream and the operating rules of the dam. The availability of water is an uncertain event that can be predicted based on modelling of available hydrological records of the Mun River basin. Such modelling had been done and predictions of daily runoff at the Pak Mun Hydropower Project were available and used to calculate the peak and off-peak electricity generation potential. The results of this analysis were presented to decision-makers. However the final design and the operating rules to limit environmental impacts and to lessen the economic and social costs of Pak Mun Dam were not resolved when the underlying hydrological study was made by SOGREAH IN 1985[103/]. Consequently it is not clear as to how the dam's dependable capacity as predicted by the hydrological

study might have been affected in the final option decided by EGAT among the possible alternatives with regard to the dam's location, engineering design, and operating regime.

The dependable capacity of a hydropower plant is mainly a function of the available water discharge and reservoir water level. According to the general rule defined by EGAT, dependable capacity is understood to be the expected power output corresponding to 90% of the water level frequencies at dam site based on long-term hydrological records. For benefit-cost analysis the dependable capacity is also a measure of equivalence by which alternative power generation plants of different types with different installed capacities may be compared. EGAT's project document which was submitted to the Council of Ministers in May 1990 proposing the construction of the Pak Mun Dam rated its dependable capacity at 75 MW[104/]. In the original project document dated March 1988 that was submitted to the Council of Ministers, the proxy capacity of the alternative gas turbine plant against which Pak Mun was compared was rated at 136 MW. This estimate exceeded the claimed 75 MW dependable capacity of Pak Mun, and exactly matched the design capacity of the proposed hydropower plant[105/], comprising 4 horizontal bulb turbine generating units of 34 MW capacity each. The alternative gas turbine capacity was used in the project document to quantify the conceptual economic benefits of the project as avoided costs for power generation of the next best alternative.

In August 1991, when EGAT re-submitted the project to the National Economic and Social Development Board (NESDB) for endorsement of a 70% increase in the estimated investment costs, the capacity of the alternative gas turbine plant was revised to 150 MW. The dependable capacity of the hydropower plant remained unchanged at 75 MW and the expected annual energy output also remained unchanged at 280.2 GWh. Irrigation and fishery benefits continued to feature. In accordance with the valuation methodology using alternative power plant approach, the project's power benefits calculated on the basis of costs avoided by *not* investing in the equivalent alternative were thus raised. Firstly by the new capacity assumed for the equivalent gas turbine option and secondly by revising the unit cost of capital investment per MW of that capacity. The unit cost of the alternative gas turbine capacity had risen from the originally estimated 8.4 million Baht (US$0.34 million) per MW at 1987 prices[106/] to 12.5 million Baht (US$0.5 million) per MW at 1991 prices, when EGAT re-submitted the project to NESDB in 1991. The revisions economically justified the Pak Mun Dam as a multipurpose development project. With both the costs and the implied benefits adjusted, the project's expected economic internal rate of return (EIRR) changed only slightly from originally anticipated 18.71% in 1988[107/] to 17.35 % in 1991. NESDB accepted the project as proposed and endorsed EGAT's revisions[108/].

Table 5.2: Comparison of the project as presented to the Cabinet and as presented by the World Bank to its Board [109]

Description of electricity-related benefit of the Pak Mun Hydropower Project	In EGAT's presentation to the Cabinet [110]	In the Staff Appraisal Report of the World Bank
Type of power plant	Peaking plant [111]	Not mentioned explicitly
Average flow to dam	760 cumsec [112]	760 cumsec [113]
Average annual energy	280.2 GWh [114]	280 GWh [115]
Dependable capacity	75 MW [116]	Not mentioned
Peak energy production	Not mentioned	Not mentioned
Type of plant used in avoided cost calculation	Gas turbine [117]	Gas Turbine[118] [119]
Size of plant used in avoided cost calculation	136 MW [120]	150 MW (3 times 50 MW) [121]
Fuel type used in avoided cost calculation	Diesel [122]	Heavy fuel oil[123]
Heat rate used in avoided cost calculation	3,800 kcal/kWh [124]	Not mentioned
Heating value of diesel used in avoided cost calculation	8,959.6 kcal/Lt. [125]	Not mentioned
Fuel price used in avoided cost calculation	3.8850 Baht/Lt of diesel. (excluding taxes) [126]	Price of fuel oil based on a crude oil price of US$ 20 per barrel. [127]
Capital cost of the Pak Mun dam used in avoided cost calculation	8,424 Baht/kW, 1988 price, excluding transmission	
Operation & Maintenance cost used in avoided cost calculation	3% of turbine plant initial cost per annum [128]	3% of turbine plant initial cost per annum [129]

World Bank loan financing of the project was secured under the Thailand's Third Power System Development Project. In July 1991 the Bank's Industry and Energy Division, Country Department II of the Asia Regional Office, prepared the Project 's Staff Appraisal Report[130/ SAR). The SAR showed the Pak Mun Hydropower Project to be economically justified with EIRR of 15.7%, excluding irrigation benefits. As in EGAT's presentation to the Thai Cabinet and to NESDB, the Pak Mun Hydropower Project was submitted for approval by the World Bank's Board of Governors in December 1991 as a Table 1 least-cost peaking capacity power project. The project was to serve the needs of Thailand's Northeast region, where demand was twice the then existing production capacity. The region had to rely on power imported from Laos, and on supply carried over transmission lines from elsewhere in the country. The project's economic benefits were similarly estimated as the avoided costs of 150 MW internal combustion peaking turbines using heavy fuel oil[131/. Against the SAR's cited 12% opportunity cost of capital in Thailand[132/, the investment was therefore considered justified by the estimated EIRR, the discount rate at which the expected costs and benefits were equalised.

After loan closure in March 1995, the World Bank issued an Implementation Completion Report[133/ (ICR) on the project, conducted by the Infrastructure Operations Division, Country Department I, East Asia and Pacific Region, which was completed in June 1996. With 31% cost overruns, an actual total cost of US$232.65 million against the estimate of US$177.66 million at appraisal, the project's benefits were marginal if discounted to net present value at 12%, which was the opportunity cost of capital originally assumed by both EGAT and the Bank's SAR. But there was a change in assumption for the opportunity cost of funds. The equalising discount rate (EIRR) for the Pak Mun Hydropower project as re-evaluated by EGAT for the ICR was found to be 12%, "which is above the opportunity cost of 10% in Thailand, but much lower than the appraisal estimate of 15.7%"[134/.

5.1 Options and Decision making in Compensation Criteria and Provisions

Broadly three categories of affected people were compensated such as those directly affected by construction, those affected by inundation and those affected by loss of fisheries. Although compensation for inundation after the impoundment was anticipated, accurate baseline data on the number of affected people, identification of affected people and the distribution mechanism for compensation was not available.

A committee chaired by the Provincial Governor determined the compensation criteria and options. However, compensation for two categories was not foreseen by EGAT. Before compensation was given, the affected people had to register their complaints, negotiate and make their demands with a number of organizations at various levels of authorities.

5.1.1 Compensation for Affected People during Dam Construction

Eleven households inhabited the designated construction site at Ban Hua Heo. They were asked to relocate to a new settlement area by EGAT and offered 1500 Baht (US$ 60) per rai (US$ 375 per hectare) as compensation in 1989. The villagers felt the compensation too low and negotiated with EGAT over a period of three years between 1989-1991. In 1991 EGAT agreed to give each household up to 6 rai (0.96 hectares) of land equivalent to 35,000 Baht per rai as compensation. This equivalent value was set lower than the prevalent market price. Each household was also given 2 rai of residential land in a new settlement area and a house built by EGAT. They were further promised 8 rai of agricultural land, a 100-kg sack of rice per month during the initial period, six mango trees, ten banana trees, two tamarind trees, and ten chickens.

Villagers in Ban Hua Heo affected by the blasting of the rapids were offered three compensatory options. Temporary relocation during blasting from the village for which they would be compensated by a rent fee of 3500 Baht (US$ 140) per month. Permanent relocation to the new resettlement area developed by EGAT with land compensation and a house on 0.37 rai. Permanent relocation and building their own house with land compensation and an additional amount of 135,000 Baht (US$ 5400).

- **Compensation for Inundation and Resettlement**

Since 1989 committees and sub-committees were appointed to establish criteria and settle the compensation for the project-affected people. According to the NRSDB report, the Coordinating Committee for Resettlement of the project-affected people established the following different options for compensation for the loss of residential and agricultural land:

1. For partially submerged land, if the villager chose not to relocate the land as well residence would be raised above submergence level. If the villager chose to relocate, a plot of land would be given and a new house built in a nearby area. Existing infrastructure in the village would be improved so that the affected villagers did not move to other places.
2. Villagers living on lower elevation land would be relocated to a new settlement area and given a new house on a plot of land, including infrastructure and other facilities.
3. Villagers in the categories above who chose not to relocate to the resettlement area and instead wanting to move in with relatives or purchase their own land, could receive cash compensation.
4. Other measures to be determined later.

The above compensation categories were intended as guidelines for project-affected people to select the suitable compensation option. In practice however the criteria for selecting the appropriate categories were not entirely clear. Negotiations between the project affected people and the committee led to different types of compensation. Subsequently the villagers demanded that the

government should identify those who would be affected by the project and what the reservoir level would be in 1991. A committee was established in 1992 to survey degree of submergence of the residential and agricultural areas and the number of project-affected people. During 1992-1993, while the committee was giving compensation to those whose lands were inundated, a problem was raised about the situation of lands that were partially inundated or surrounded by water. It was only in 1993-94 that the committee developed criteria for giving compensation to those who lived between the 108-108.5 MSL and above the 108.5 level.

For villagers with land between 108-108.5m MSL, and whose residential land would likely be partially inundated or surrounded by water the committee offered the following options:

1. If they chose not to resettle their residential land would be raised above inundation level.
2. If they chose to resettle in another area, they would be given Baht 100,000 (US$ 4,000) as compensation and the land right would revert to EGAT.

For villagers with land higher than 108.5 m MSL, surrounded by water and located within 30 meters from the flooded areas, compensation for dismantling costs would be given to those who chose to resettle. In the case of inundated agricultural land, compensation of Baht 35,000 (US$ 1,400) per rai was given to the owner and a comparable amount of land would be identified and replaced, not exceeding an area of 10 rai. The villagers could also settle for cash compensation of Baht 35,000 per rai instead of land. For those whose land was partially inundated but not exceeding 3 rai, EGAT would give compensation for the inundated land and raise the rest above flood levels.

Several rounds of negotiations were required before the compensation terms were accepted by the committee and the people affected. In general, for those who lived below 108 m MSL, it was quite evident that their land was submerged, and they were given compensation. For those living between 108-108.5 m MSL or above 108.5 m MSL, the degree of inundation of the residential land varied from case to case. Some were partially inundated; some were inundated by backwater effects during rainy season, or surrounded by water on three sides. The effects of inundation also varied from the impacts of the loss of land to the inconvenience of decreased access and communication. Disagreement on who was eligible for what level of compensation often occurred. The other common problem encountered was the delay in giving compensation.

- **Compensation for the Loss of Income from Fishing**

Table 5.3: Loss of Fisheries livelihood: Evolution of Compensation criteria and award

Period	Process	Outcome	Provisions
May 15, 1990	EGAT establishes two committees, one on resettlement and one on compensation.		
June 1990	Resettlement begins		
Apr-Sept 1994	EGAT completes the dam, reservoir filled, generation units installed		
September 1994	Resettlement completed		
Till 1994, compensation committees did not start assessing the impact of the project on fisheries livelihood and income. The loss of income from fishing became a major concern of villagers during construction. As baseline data on fishing income was inadequate, the government established a succession of mechanisms and committees to determine the impact on fishermen.			
1993	400 fishermen gather at the dam site asking compensation for their lost income from fisheries		
April 1994	Just before impoundment, fishermen households and NGOs claim impact on		

	fish yield and income		
October 11, 1993**	The Sub Committee on the Impact of fishing occupation appointed by the Provincial Governor	Fishing area was categorised into 5 zones according to their distance from the dam site. Amount of compensation decreased as the zones moved further from the dam site.	Villagers from zone 1 were eligible for compensation close to 90,000 Baht, villagers from the furthest zone would receive a mere 15 Baht.
1994	Villagers staged 1 month protest in the Ubon Ratchatani provincial hall in response to the offered compensation	A flat rate of compensation was demanded for all affected people for the three years of construction	The demand was 35,000 Baht /year for the 3 years of construction
1994	The Sub Committee on the Impact of fishing occupation offers a flat rate in response	The villagers refuse the much lower flat rate offer	The offered rate was 6444 Baht /year
28th March - 27th April 1994	Committee makes announcement asking villagers to submit forms requesting compensation for fisheries at the offices of Amphoe Khong Chiam, Sirindhorn, Phibun Mungsaharn.	Criteria for assistance to the fishermen were formulated	
2 June May 1994	Sub committee declares eligibility for compensation for those matching the criteria	2140 fishermen households matched the criteria	
28th June 1994	300 fishermen gather in Khong Chiam and request for compensation.	Provincial governor receives a list of 2476 affected fishermen	
14th October 1994	1000 fishermen gather at the provincial office and then to the dam site	Provincial governor receives a list of 2390 affected fishing households	
January 1995	The Committee for providing Assistance and Developing Occupation for Fishermen in the areas affected by Pak Mun project, appointed. (CAODFF). The membership included affected people, NGOs, EGAT, and the government.	The CAODFF decides to compensate fishing households at a flat rate and fund co-operative activity to create a sustainable source of income.	The new flat rate of, 30,000Baht in cash and 60,000 Baht as assistance for developing new occupation (@ 20,000 Baht per household per year of fisheries lost for 3 years) was endorsed by the Cabinet in Jun 1995.
17 Feb, 1995	The new committee estimates a total of		

	3 237 affected people, (incl. 2 140 fulfilling earlier criteria +1 087 later requests)		
3 May, 1995	The committee identifies guidelines and examines the case of 2 140 + 2 390 affected fishermen		
19th June, 1995	The committee approves 571 households	571 fishing households get compensation for loss of livelihood.	
9th October, 1995	Committee gets reshuffled		
16th November 1995	The Committee approves additional 2 361 households	Eligible (571+2361) 2 932 households have to become Pak Mun Agricultural co-operative members by 29th Feb, 1996 to avail of the entire compensation	
1st April 1996	Committee acknowledges compensation payment for 2932 cases. Additional 247 cases are approved	722 cases don't want to be co-operative members and therefore fail eligibility criteria.	
By April 1996	CAODFF compensates 3 179 fishing households for loss in livelihood.	3179 fishing households get compensation.	30,000Baht in cash and 60,000 Baht as assistance for developing new occupation (@ 20,000 Baht per year of fisheries lost for 3 years)
27th March 1997	Committee reshuffled for the third time		
2nd July 1997	Committee examines the details of (3067cases+580 cases+65 cases =) 3712 households		
26th September, 1997	Committee agrees to set up new co-operative for 722 cases that had refused to join the old one.	CAODFF approves 695 households as eligible	
14th January 1998	Committee reshuffled for the fourth time		
27th April, 1998	The Committee approves 92 households as eligible		
Till June 1998	The CAODFF had on the whole, compensated 3966 households for the loss in fisheries income	A total of 356,940,000 Baht was disbursed compensation by the CAODFF	90,000 Baht /case. 30,000 Baht was paid in cash, 60,000 Baht was

April 19, 1999	Compensation for fisheries was given to 6202 households	Compensation disbursal would amount to 5581,80,000 Baht	Baht was deposited in the Agricultural Co-operative.
Compensation for permanent loss of fisheries			
January 25, 1997	Villagers from Pak Mun join the 99 day protest initiated by the Assembly of the poor, demanding compensation for permanent loss of fisheries. The FOP requested the government to provide land measuring 20 rai per household for 3301 households, who wanted to shift to agriculture from fisheries.	On 29th April, the government decided to compensate 3080 fishermen with 15 Rai of land as compensation for permanent loss of fisheries. Later unable to locate land, the government offered equivalent cash compensation.	525,000 Baht per household (@35,000 Baht per rai for 15 rai) was offered as compensation instead of land to affected households.
In the next two month 1997	The above Cabinet resolution was cancelled by the new government		
16th June 1997	56 sub -district and village heads submitted a list of 5109 affected people in 3 Amphoes.		
March 1999	5000 villagers begin a permanent occupation of the Pak Mun dam site demonstrating for compensation from government and the World Bank.		

The loss of income from fisheries became a major cause for concern for the villagers during the construction. The Subcommittee on the Impacts of Fishing Occupation was appointed by the Provincial Governor on October 11, 1993 to work on this problem. After the completion of the dam in 1994, the villagers decided to demand fair compensation from the government and were told that affected villagers would be able to apply for compensation for the loss of fishery during the three years of construction.

The Subcommittee set up a plan for compensation by dividing the fishing area into five zones according to the distance from the dam site. As such, Ban Hua Heo was considered as zone 1 and Kaeng Saphur as zone 5. Villagers from zone 1 were eligible for compensation of up to Baht 90 000 (US$ 3 600) while the amount of compensation gradually decreased the further the zone was from the dam site. In effect, villagers from the furthest zone would receive a mere Baht15 (US$ 0.6) as compensation for their losses during the construction period.

The villagers staged a one-month protest at the Ubon Ratchathani Provincial Hall in response to the proposed compensation scheme, demanding instead a flat rate of compensation for all affected villagers, at the amount of Baht 35 000/year for the three years of construction. A flat rate of Baht 6 444 was offered, but was not accepted by the villagers.

In disagreement with this number, however, the villagers staged a demonstration, which eventually led to the appointment of the Committee for Providing Assistance and Developing Occupation for Fishermen in the Areas affected by the Pak Mun Project. This committee then set up a set of criteria to determine the eligibility for compensation.

In 1995, after a complicated process of identification, compensation was finally granted to 3 179 households, given in three phases: June 19, 1995, November 16, 1995, and April 1, 1996. It was decided that each family would receive Baht 30 000 as compensation for the loss of fishery, over the three years of construction. In addition Baht 60 000 (Baht 20 000/ year, for three years) would be allocated for each affected household as assistance for developing new occupations. This part of the compensation was to be administered through the Pak Mun Agricultural Co-operative, which would be managed by villagers themselves.

It should be pointed out that the kamnan and headman group who also permanently lost income from fishing did not join the demonstration, and thus did not register for this identification process. Once compensation had been distributed to those who had qualified, this group submitted a petition to the government for receiving similar compensation. Their petition was strongly supported by the Ubon Ratchathani Provincial Governor, who argued that this group had been highly supportive of the government policy and should hence be accorded with compensation. Consequently, yet another committee was appointed, chaired by Mrs. Phanit Nitithanprapas, to consider the petition. It was decided that compensation would be given to 787 cases of this group. This compensation was given to the claimants on September 26, 1997 and April 27, 1998 through the Agricultural Development Cooperative, Ltd. In the end, the total number of villagers given compensation for the loss of income from fishing reached 6 202 households[135].

Table 5.4: Compensation paid to fishermen

Year	Cases	Baht
Jun 1995	571	51,390,000
Nov 1995	2,361	212,490,000
April1996	247	22,230,000
Sept.1997	695	62,550,000
Jan. 1998	92	8,280,000
Total	3,966	356,940,000 (US$ 14.2 million)

Chaowiang, 1988

Villagers who owned some land on slightly higher elevations cultivated some rice prior to the dam construction, and were thus able to adapt more easily to the new socio-economic conditions brought about by the dam. Villagers owning some paddy land near the riverbank, and who depended largely on fishing for cash income, however, have been unable to find viable means of living since the depletion of fish in the reservoir. In losing the riverine ecosystems, these villagers have further lost rich and diversified sources of natural products for sustaining their livelihoods. As such, the compensation of this permanent loss had not been addressed.

On April 10, 1996 an agreement was reached that there should be no more claims for villagers of Pak Mun dam. On January 25, 1997, the villagers from Pak Mun joined the 99-day protest initiated in Bangkok by the Assembly of the Poor. On this occasion, Pak Mun villagers demanded the government to pay fair compensation for the permanent loss of fisheries. In April 29, 1997, under General Chawalit Yongchaiyuth's government, it was first decided that 3 080 fishermen would be granted 15 rai of land as compensation for the permanent loss of fishery. The procedure was to be carried out by the Ministry of Finance. However, the government was unable to locate sufficient land for this compensation, and Baht 35 000 per rai was instead offered as cash compensation. The affected villagers were encouraged to buy their own land for the purpose of converting to farming. However, in April 21, 1998, Mr. Chuan Leekpai government decided to consider the villagers' problems on a case to case basis.

In March 1999, some 5 000 villagers began a permanent occupation of the Pak Mun dam site, demonstrating for compensation from the government and from the World Bank. They are still waiting for compensation to be issued for the permanent loss of income from fisheries.

5.2 Decision-making, Participation and Conflicts

The affected villagers have invested substantial amounts of time and effort in negotiating, making demands, and protesting, in order to make the government and EGAT understand and solve their problems which they themselves did not create. EGAT and the government took the decision on implementing the project, despite opposition by the villagers and environmentalists. This decision was made without any participation from the affected people. The project authorities also took the decisions on how the affected people should be compensated for losses incurred by the project. As pointed out in the OED report, EGAT was compelled to exceed the projected compensation costs. It seemed that despite the 'generous compensation', negative reactions still prevail. In order to understand the dissatisfaction among villagers with regards to compensation, one must examine the social and political processes and conflicts that steered the ways by which such compensation was negotiated and finally given. It then becomes apparent that the negative reactions are first and foremost reactions against the nature of the decision-making process around compensation where the affected villagers were marginalized.

- **The beginning of conflict: Formation of project opposition groups and dam supporter coalitions (1989-1990).**

The conflict between those in support and those in opposition to the project started to intensify at the beginning of 1989, as the Chatchai government was considering the approval of the Pak Mun dam project. Those in opposition to the dam formed a committee to campaign against the project, led by lawyers and urban people from Ubon Ratchathani. Meanwhile, those in support of the dam also formed a coalition comprised of local politicians, businessmen, and government officials. In March 1989, a rally was organized in front of the Provincial Hall to oppose the Pak Mun dam project. The main reasons for the opposition were the loss of land, the resettlement of the affected people, the negative impacts on the ecological system, and other social impacts that may be inflicted upon the people in the project area. Despite the local concerns expressed, Prime Minister Chatchai approved the dam project in principle, on April 8, 1989.

EGAT chose to provide information about the project to the villagers by sending letters to kamnan and village headmen, so that these could in turn inform the villagers. Moreover, EGAT tried to give more information to local government officials, who were in support of the project, and claimed that there would be no blasting of rapids, and the reservoir would not submerge the Kaeng Saphur rapids. It was quite clear at the time, that EGAT attempted to create support for the project by means of both local officials and the local media. Those in opposition to the dam submitted a letter to the government to encourage them to take a neutral position in this conflict.

At the beginning of 1990, the conflict over the Pak Mun dam project began to escalate at the provincial level. Although no violence was used in mediating the conflicts, familiar tactics were used to deter the demonstrators, such as the show of armed forces, and the organising of a counter-demonstration. As a result, mistrust between the parties involved was reinforced.

The demonstration ended when Minister of the Prime Minister's Office in charge of EGAT [136] agreed to establish a committee to investigate the impacts of the Pak Mun dam project. However, no committee was ever actually established. Furthermore, on April 17, 1990, Prime Minister Chatchai confirmed that the project would proceed, in consideration of the increasing demand for electricity and water for irrigation. On May 15, 1990, the Cabinet approved the budget of Baht 3 880 million for the Pak Mun dam project. In response to this, some 700 villagers protested against the decision and staged a rally for three days.

- **Conflict over broken promises by EGAT to not blast rapids. Village protests, supported by students and NGOs (1991-1994).**

On February 23, 1991, a military coup took place in Thailand. With the changing political climate, EGAT took the opportunity to advance its project, whereas the local politicians in support of the project ran for MP political offices at the national level. Environmentalists and NGOs began to join the villagers at the Pak Mun, to protest against the project. They were able to collect 12 000 signatures for a petition against the dam, which they sent to the Bangkok World Bank office, as well as to the Prime Minister, with the request to re-consider the project. On March 15, 1991, EGAT began to remove rocks and earth at the dam site, destroying a *saan piangta* [an altar for spiritual offerings] initially erected by the villagers. This triggered widespread protests and criticism.

In order to respond to the villagers' demands, two committees were set up. The first of these, chaired by Mr. Wathanyu Na Thalang, was responsible for identifying mitigation measures for the impacts by the project. The second committee was responsible for investigating the impacts induced at varying water levels. The two committees did not make much progress, however, as EGAT informed the Minister in charge of EGAT that less than 1 000 households would in fact be affected by inundation. Considering this information, the Minister insisted that the project be implemented. One of the villagers' demands was nevertheless met, namely that the Thai environmental impact study was disclosed to the public.

- **Conflicts at the international and local level. World Bank grants financial support, despite objections voiced by villagers.**

The conflict over the Pak Mun dam further escalated to the international level. Criticism by leading scholars on environment and public health was raised against the project, particularly with regards to the risk of occurrence of schistosomiasis in the project area and the impact of the project upon fish migration between the Mun River and the Mekong River.

5.2.1 EGAT promotional campaign and intensified tensions among villagers

At the local level, the conflict over the dam project was increasingly exacerbated, partly due to EGAT's provisions of benefits to the kamnan and headmen. On the other hand, those in opposition to the dam also received considerable support from university students and NGOs. These groups assisted the villagers in collecting information related to the dam project, analysing the impacts that would occur, and clearly defining and articulating the problems in their negotiations with government and officials. The local authorities discredited the students through the village broadcasting system, while also telling the villagers that no resettlement would take place for villagers from Ban Hua Heo. EGAT also organised a training camp for developing youth relations at the Khong Jiam district secondary school. Youth were told about the positive aspects of the dam construction and would, in turn, take a different stance than their parents vis-à-vis the project. EGAT further arranged a trip for the kamnan and headmen to visit the Sirnakrin dam in Kanchanaburi province, and the Ratchaprapha dam in Surathani Province. They were treated well during the trip, and shown the resettlement areas of these dams. However, they were prohibited to directly communicate with the resettled people.

- **Confrontational conflicts. Increased village resistance, and government use of violence as conflict resolution (1992-1993).**

At the beginning of 1992, a new issue of conflict arose, namely the blasting of the rapids in the Kaeng Ta Na National Park. EGAT's intention to blast these rapids had never been previously disclosed. In order to create a deep-water channel from the dam turbines to Kaeng Ta Na, measuring 60 meters in width and 1.4 km in length, rapids at different heights along this river stretch were blasted by EGAT. On September 28, 1993, Dr. Sawit agreed to appoint the Committee for Providing Assistance to

Villagers Affected by Pak Mun Hydroelectric Project. This committee was to be chaired by the Provincial Governor. Later, the governor appointed six sub-committees for resolving problems incurred by the Pak Mun project, for all of which the members were comprised of government officials.

- **New issues of conflict and the use of committees for conflict resolution**

The villagers demanded that, first, any land which is not inundated, but surrounded by water, must be considered as inundated land and hence requiring resettlement and fair compensation. Second, if the land area inundated upon completion of the dam construction was to exceed EGAT's predictions, the owner of the affected land must be compensated. However, the compensation committee rejected the first of these demands, on the basis that no village was completely surrounded by water like an island, and thus there would be no need for resettlement or for providing compensation.

At the beginning of November 1993, the government agreed to set up a committee to resolve the adverse affects of the project. The committee consisted of representatives from various ministries and departments as well as 6 villagers.

Before the committee had met to discuss the problems, however, Mr. Thongcharoen Srihatham and Ms. Wanida Tantiwithayapitak - leaders in the opposition group - were arrested by the police and charged for creating public disorder, trespassing public land at night, and for defaming others through dissemination of information.

On December 9, 1993, the committee concluded that:

- A tripartite committee for 13 villages, chaired by a District Officer, would be established to investigate the problems faced by the villagers for submission to the committee.
- EGAT would need to temporarily stop blasting the rapids until the issues under investigation were solved.
- The villagers who were arrested must be subject to a fair trial process.

Nonetheless, EGAT continued to blast the rapids on the other side of the river, bringing about yet another protest by the villagers. The villagers also submitted a letter to the Provincial Governor to reconsider the appointment of the tripartite committee since the appointed village representatives were exclusively EGAT supporters. On January 9, 1994, around 300 villagers, most of whom were women and elders, occupied the dam site so that EGAT was unable continue to blast off the rapids. Eventually, EGAT agreed to pay compensation costs for villagers of Ban Hua Heo for dismantling, relocating, and constructing houses in new resettlement areas.

- **Protests against unfulfilled government promises for compensation. Crises of institutional responsibility: Compensation schemes used as conflict resolution**

At the time near completion of the dam, villagers beyond Ban Hua Heo were troubled by the fact that the government had not met their demands yet. Indeed, promises of investigations to be conducted by various committees had not been fulfilled, while negotiations with regards to the 22 houses of Ban Hua Heo that had been affected by the blasting, were still unsettled. In April-May 1994, a two-week demonstration was held in front of the Government House in Bangkok, to yet again bring the villagers' demands for fair compensation to the government's attention, fearing that their demands would not be heard once the dam would be completed.

On this occasion, villagers specifically demanded:

- That compensation for the dismantling, relocation, and labour and resource costs for rebuilding their houses, for 352 households from 15 villages would be provided.

- That their previous request for compensation for the loss of fishery incomes be met.
- That those villagers whose land had been flooded, EGAT provide the previously promised 10 rai of land as compensation.
- That for the 22 villagers of Ban Hua Heo, who were earlier denied compensation for damage inflicted on their houses due to the blasting, a reinvestigation be conducted.
- That a tripartite committee be established, in which villagers would be able to participate.
- That the arrests of Mr. Thongcharoen Srihatham and Ms. Wanida Tantiwithayapitak be revoked.

The villagers demanded to see the Prime Minister but were deterred by policemen, some of whom physically harassed the villagers. Finally, Prime Minister Chuan, insisted that this problem would need to be solved by the provincial committee and he agreed to ask the governor of Ubon Ratchathani, as a chairperson, to call a committee meeting before April 6. At the meeting, the committee concluded that it could not take villagers' demands into account, as this would result in endless more demands, particularly with regards to compensation. The villagers were told by Dr. Sawit, Minister of the Prime Minister's Office in charge of EGAT, that their complaints would still need to be submitted through the provincial committee. Thus, the conflict between the government and villagers was not resolved due to the refusal by those with legitimate power to take responsibility, and the existing power relations between politicians and local bureaucrats.

In June, 1994, the Pak Mun dam was completed, and began to operate. However, the villagers' problems had not yet been resolved. The villagers decided to articulate their demands again with regards to the fairness of the compensation. The Committee chaired by then Governor Maitree Naiyakul announced that 2 230 fishermen from 36 villages, of three districts, would be able to apply for compensation for loss of fishery during the three years of construction. The committee divided the fishing area into five zones, starting from Ban Hua Heo as zone 1, and Kaeng Saphur as zone 5. Fishermen from zone 1 would be compensated for up to Baht 90 000, and the rate of compensation gradually decreased the further the zone was from the dam site. In effect, fishermen from the furthest zone would receive a mere Baht 15 as compensation for their losses during the construction period.

The villagers opposed this scheme for compensation, on the basis that the criteria based on the zoning system was unrealistic. Rather, they considered all of the lower Mun river area as their common fishing ground, where villagers from upstream and downstream could come to fish at Ban Hua Heo. In a one-month protest at the Ubon Ratchathani Provincial Hall, they demanded instead the same rate of compensation for all affected fishermen, at the amount of Baht 35 000/year for the three years of construction. The new governor at the time, Mr. Nittisak Ratchaphit, argued that there were discrepancies between EGAT, the Department of Fisheries, and the villagers, with regards to the number of households being affected. To resolve this problem, another committee was required to identify the real number of affected fishermen. Dr. Sawit insisted that the provincial committee had full authority to resolve this problem. As such, the committee decided that each household would receive a flat compensation rate of Baht 10 000, for the three years of construction, and the governor insisted that this was the final decision with regards to compensation.

1. Agreement on compensation scheme and testing of compensation eligibility

Finally, the villagers were able to meet the new Minister of the Prime Minister's Office in charge of EGAT, to make an appeal for a justifiable compensation scheme. In January 1995, Prime Minister Chuan Leekpai appointed a Committee for Providing Assistance and Developing Occupation for Fishermen in the Areas Affected by the Pak Mun Dam Project. It was chaired by Mr. Plodprasob Suraswadee, then General Director of the Fisheries Department, and consisted of state officials, representatives of the villagers, and NGO representatives.

In March, an agreement by the compensation committee was reached, and it was decided that each family would receive Baht 30 000 as compensation for the loss of fishery, over the three years of construction. In addition, Baht 60 000 (Baht 20 000/year, during three years) would be allocated for

each affected household as assistance for developing new occupations, and would be administered through the Pak Mun Agricultural Co-operative, which would be managed by villagers themselves. The villagers agreed to this compensation scheme, and finally ended their 5 month and 9 days long demonstration.

In order to qualify for the compensation, villagers were tested by the Mr. Plodprasob committee to show that they fulfilled a set of criteria, including the ability to row a fishing boat, ability to use various fishing tools, ability to name various fish species, and swimming ability. 2 932 households passed these criteria and were provided due compensation.

During this time, villagers that had earlier joined the kamnan and headmen group now also realized that they ought to have received compensation for their losses in fisheries. As such, they staged local demonstrations, asking for similar compensation. In response, a committee was set up, chaired by Mrs. Phanit Nitithanprapas, to investigate this problem, applying the same criteria as earlier to determine who would be eligible for compensation. Finally, this group of fishermen was compensated satisfactorily.

2. Problematic implementation of compensation scheme and resettlements

During the following couple of years, compensation payments were administered and resettlements implemented. It should be pointed out, however, that several villagers faced problems in receiving fair compensation from EGAT. This had partly to do with the lack of clearly defined criteria for compensation eligibility, such as how partially inundated land would be compensated for. Importantly, it also had to do with EGAT or government authorities frequently altering previous assurances to villagers about their rights to compensation. For example, in Ban Huay Hai, where the majority of the villagers had to be relocated, the former headman was persuaded by EGAT personnel to set the precedence to move out, with the promise of receiving due compensation at a later date. Together with 6 other villagers, he took the lead to resettle in an area east of the original village. However, EGAT later refused to provide the headmen and the 6 villagers with the full compensation as promised, on the basis that the resettlement had occurred prior to the establishment of compensation criteria.

3. Sustained conflict over the permanent loss of fisheries, and consolidation of the protest movement. Indifference displayed by the government.

On January 25, 1997, the villagers from Pak Mun joined the 99-day protest initiated in Bangkok by the Assembly of the Poor. Pak Mun villagers demanded the government to pay fair compensation for the permanent loss of fisheries. In April, under General Chawalit Yongchaiyuth's governance, it was decided that 3 080 fishermen would be granted 15 rai of land. However, the government then could not find enough land for compensation. Then, it was decide that Baht 35 000 per rai was offered as compensation for the permanent fish loss. However, in April 21, 1998, Mr. Chuan Leekpai the then Prime Minister withdrew this compensation scheme, on the basis that compensation would not be issued for any projects already completed. In March 1999, some 5,000 villagers began a permanent occupation of the Pak Mun dam site, demonstrating for compensation from the government and from the World Bank.

6. Criteria and Guidelines, Policy Evolution and Compliance

6.1 Hydropower Aspect

Within the framework of this study and considering that the study did not have access to some of the EGAT and World Bank files, it is not possible to give a definitive answer to questions related to the evolution of Government policy during the preparation and implementation of the project.

The following remarks can however be made. At the time the project was presented by EGAT to the Cabinet of Ministers it did not use the type of overall system planning tools that can calculate the system-wide benefit of a power generation investment. The project level Equalising Discount Rate methodology used by EGAT was according to best practise at the time.

However the size of the alternative plant used in the Equalising Discount Rate calculations may not have complied with the best practice at the time. There existed at the time a method of calculating Dependable Capacity of a hydropower project that relies on an analysis of the hydrological record of the river to be dammed. EGAT and SOGREAH, its consultant during project preparation used this record. The method of calculating Dependable Capacity had changed from an average of available capacity to the available capacity that is available 90% of the time or 11 months out of the year. However the alternative plant was entered as a benefit of the Pak Mun project using the installed capacity instead of the Dependable Capacity by EGAT. The World Bank analysis used an installed capacity that was rounded up to be able to compare the output of the plant to a multiple of a 50 MW gas turbine. Why this was done when at the time many sizes of gas turbine were available on the market that could have been combined to equal either installed or dependable capacity is not clear.

6.2 Environment Policies on Dam and Reservoir Construction

According to the National Environment Policy framework on building dams and reservoirs, approved by the Cabinet on April 18, 1978, the following policy guidelines and measures must be undertaken by the project-implementing agency:

a) The project must integrate all related activities that aim to conserve and protect forest resources and aquatic life, reduce health and sanitation problems, conserve and develop fisheries in the reservoir, excavate inundated archaeological sites and geological resources, resettle the affected people and promote tourism in the project area in order to maximise benefits and to reduce the environmental impacts of a dam and reservoir construction project;

b) Proposals for foreign loans needed by a construction project must include proposals for other related activities;

c) The project-implementing agency must conduct studies and prepare reports on the environmental impacts of the project, as well as on its engineering and economic aspects. The agency must carry out environment impact studies (EIS) and regularly submit them to the National Environment Board;

d) Reports on the environmental impacts must be adequately disseminated in the government and private sectors.

e) Project-implementing agency personnel will be given legal authority to make arrests in order to prevent sn influx to the areas in the reservoir for the purpose of fishing, earning income, encroaching on and deforesting forest areas;
f) All related government agencies must coordinate their plans and implementation activities. If necessary, a coordinating committee can be appointed to be directly responsible for the task.

EGAT, as the implementing agency of the Pak Mun project, carried out the Environmental and Ecological Investigation (EEI) and the Resettlement Plan (RP) Investigation in 1981 based on the water level of 112 metres MSL. Both the investigations were comprehensive and covered the aspects required by the national environment policies mentioned above. However, the EEI lacked detailed understanding of the dynamic relationship between the villagers and their environment. The "technocentric" attitude reflected in the report seemed to minimise the negative impacts of the project. When the location of the dam site was changed in order to reduce the degree of submergence, new environment and resettlement impact studies were not carried out. Therefore, the two reports were not entirely useful for the project-planning and implementation purposes.

During the construction of the dam and after the completion, at least three major project impact studies were conducted[137]. However, they were not adequately disseminated to the public and particularly to the affected villagers, as required by the National Environment Policy. Villagers who lived along the Mun River did not know whether their land would be flooded until the project was almost completed. They were not informed about the blasting of the rapids until the blasting took place.

Before and during the project construction, EGAT used at least 25.50 million Baht on public relation activities to disseminate information about the benefits and impacts of the project among various groups of people[138]. The 2ndArmy and private companies undertook campaign activities regarding the project-benefits. In the project area, EGAT worked through the kamnan (sub-district head) and village headmen, who in turn used village radio broadcasting systems and group meetings to inform the villagers[139]. However, the villagers who opposed the dam most often refused to attend such meetings[140].

During the period when the Cabinet was considering the feasibility of the project, local people, local politicians, NGOs and academics concerned about its potential environmental impacts organized peaceful protests. Despite the protests, the project was eventually approved in principle by the Cabinet in March 1989, and was given budget approval in February 1990. No public hearing took place prior to the approval of the project. Nor were the EEI and RP reports released to the would-be affected people or the public. Only the Police Captain, a minister from the Prime Minister Office in charge of EGAT, came to Ubon Ratchathani to explain the project to the public.

It is obvious that the Thai government, which is officially the project holder, and the World Bank, which gave loans to build the Pak Mun dam, violated the Bank's guidelines. According to the World Bank's Operational Directive 4.00, the borrower is expected to take the views of the affected groups and local non-governmental organisations fully into account in project design and implementation, and in particular in the preparation of EIAs. As described above, the affected people in the Pak Mun project and local and national NGOs were not consulted nor their views were taken in to account in the design and implementation of the project (which began after the Operational Directive 4.00 was adopted). It will become clearer below of how EGAT and the government exclude the affected people from the project implementation.

6.2.1 Other Laws and Procedures

In the construction of a large dam, land and other natural resources at the dam site are extensively used, including the river's banks that get inundated upon dam completion. In the case of the proposed Pak Mun dam project, land and natural resources that were affected by the project can be divided into three categories: public land, common land customarily used by villagers[141], and privately owned land. Prior to beginning the actual construction of the project, EGAT, as the implementing agency, was obliged to follow legal measures to acquire the right to use each of the three categories of land. The means by which EGAT acquired access to using the project land area, however, have circumvented the legal requirements on several accounts.

The EGAT Act 1988 (article 9:4) grants EGAT the right to build dams on both public and private property, as long as such an undertaking does not violate other existing laws[142]. A government agency wanting to use public land must, according to the Land Act 1954, article 8, must first identify a comparable land area to replace the land to be affected, before the public land can be transferred to the agency's ownership. EGAT did not abide by this requirement, and land that could replace the land to be used for the dam construction was not identified. No responsible agency monitored or raised any objection to EGAT's lack of legal compliance.

According to the National Park Act 1961, no resource in a national park may be possessed, destroyed, altered or bought. Permission to temporarily use land within a National Park area may be given upon the review by the Royal Forestry Department and the approval by the National Commission of National Parks. For the permanent use of land within a National Park, a so-called royal decree must be issued so that ownership of the land area in question is transferred to the user. EGAT asked permission from the Royal Forestry Department for using 698 rai[143] of land, located within the Kaeng Ta Na National Park, for dam construction. Of this land area, 573 rai would be temporarily used during the dam construction, while the remaining 125 rai of land was required for the permanent use by EGAT for the Pak Mun Project[144]. While a Cabinet resolution was made on February 12, 1991, stating that the 125 rai of land would be permitted for EGAT to use, this resolution did not grant EGAT ownership of the land. Indeed, only the issuing of a royal decree would legalize the transferring of ownership – and thus the permanent use – of the land in question. While no royal decree was granted, EGAT proceeded to use this land, within Kaeng Ta Na National Park, for the construction of the project construction.

During the construction of the dam foundation and expansion of the channel below the dam, EGAT needed to blast the rapids in Kaeng Ta Na National Park. The blasting of the rapids at and above Kaeng Ta Na was in direct violation of the National Park Act 1961. In order to "legalize" the blasting of the rapids, the Minister of Agriculture and Cooperative appointed EGAT personnel as park officials, equipping them with legal status. According to the National Park Act, such officials have the right to conduct activities within the park area, which would otherwise be considered illegal. Activities that, for example, cause soil degradation, change the course of water, or involve the use of explosives, would normally be illegal within a National Park area. If carried out by park officials, however, these activities may be interpreted by the same law as being for the protection or management of the park, for facilitating tourism, or for research and public education, all of which are legally justified causes.

Consequently, EGAT claimed that they were blasting rocks in the water, not rapids *per se*, and that this would not destroy the Kaeng Ta Na rapids. The Kaeng Ta Na National Park Unit also supported this stance, by claiming that EGAT were legally blasting rocks on behalf of Royal Forestry Department, and in accordance with the National Park Act. EGAT and the National Park Unit have also attempted to develop the area surrounding the rapids as a tourist recreation area. For example, a suspension bridge was built connecting the Ta Na National Park headquarter to the Don Ta Na island in the middle of the Mun river, and another bridge connecting the island to the left bank of the river.

In the case of privately-owned land, a royal decree has to be passed prior to the project's implementation in order for the state to reclaim such land for its purposes. In such an event, fair compensation must be given to those whose land is reclaimed. The government passed a Royal Decree in 1991 reclaiming the land belonging to the villagers in the project area as government owned, so that it could be used for the Pak Mun project. EGAT agreed to give compensation to all villagers whose land, at an elevation below 108m MSL, would be affected by the project. Various kinds of compensation offers were also provided for villagers with residential land between 108 m MSL and 108.5 m MSL, as well as for those whose agricultural land would be inundated.

As for the common land customarily used by the local people, no specific law exists for how the government may reclaim ownership. However, in the case of the Pak Mun project, the government

passed a royal decree that granted ownership to individual villagers, so that they could receive compensation for the loss of the land they had customarily used.

The Pak Mun project reflects Thailand's policies in definition of project-affected people. That is, laws and policies were designed and interpreted to allow the state to control and use natural resources without giving adequate concern toward environmental impacts and affected people. Before the Constitution 1997, community rights were not recognized by the state. In fact, the rights of individuals, community, and local government to participate in decision-making around the conservation and management of cultural and natural resources have only recently been instituted in Thailand's new constitution[145]. As a result, for the Pak Mun project, EGAT and other government agencies involved were legitimate in using natural resources for the benefit of national development and also in defining who would be the affected people. By contrast, the local communities along the lower Mun River had neither the right to participate in the conservation and utilisation of natural resources nor in defining who was affected by the project.

7. Summary Findings

7.1 What were the predicted versus actual benefits, costs, and impacts?

- **Cost of the project**[146]

In May 1989 the Cabinet approved the 17m high, 136 MW Pak Mun project with a budget of 3.88 billion Baht (US$ 155.2 million). In 1991 NESDB approved the modified project cost of 6.6 billion Baht (US$ 264 million). The final cost tally by EGAT in 1999 was 6.507 billion Baht (US$ 260 million). In nominal terms the project costs increased by 68% from the original estimates between 1989-99. Not including taxes and interests during construction the cost overruns in nominal terms are 91% over original estimates in 1988. However in real terms (calculated at constant 1998 prices) the actual total project cost did not differ significantly from the original estimates in 1988.

Compensation and Resettlement costs increased from 231.55 million Baht (US$ 9.26 million) in EGAT's 1988 estimates to an actual expenditure of 1 113.1 million Baht (US$ 44.24 million) till 1999. In real terms resettlement costs increased by 182%. Compensation for loss in fisheries, which was unanticipated in the original estimate, accounted for 395.6 million Baht by April 1999 (US$ 15.8 million).

- **Benefits - Hydropower**

Pak Mun dam is located at the end of a large watershed where rainfall and runoff vary considerably between dry and wet seasons. During wet months Pak Mun can turbine the daily inflow to serve the 4 hour peak demand and in addition can generate power in off-peak hours with surplus water available. However during the dry months the plant cannot produce its full rated capacity for the 4 hour peak demand due to insufficient water.The output of the plant depends on the water level in the reservoir and the tailwater level. The Pak Mun Dam's power production peaks in the wet season when it is least needed in the power system and is lowest in the dry season when it is most needed. When the water levels in the Mekong river are very high, the power plant will be shutdown for lack of generating head.

The operation records from the commissioning of the plant in 1994 indicate that Pak Mun's average annual output has been 290 GWh. This compares with the estimated average of 280 GWh. Pak Mun dam featured as a 136 MW, run-of-the-river project, to serve peaking needs in EGAT's presentation to the Cabinet as well as World Bank documents. However following the rules based on the daily power output data betweeen 1995-99, Pak Mun plant can use only 15% of its capacity as reliable 4 hour peak capacity.

The actual dependable capacity of Pak Mun project calculated from daily power output between 1995-98 assuming that all available power gets assigned to a 4 hour peak demand period is only 20.81 MW. This 21 MW is what the Pak Mun project offsets in gas turbine capacity. However the value adopted by EGAT and sanctioned by the World Bank is much higher at 150 MW.

The actual operation of Pak Mun is often different from what was assumed in the planning studies. This type of operation may be beneficial from an ancillary services point of view (such as frequency and voltage regulation, Var control etc.), but the energy benefits will be less than planned.

Recalculating the project's equalising discount rate assuming that one would need one 21 MW gas turbines to provide the dependable capacity of a 20.8 MW hydro plant the current report reaches a value of 7.88% which is below the shadow cost of capital in Thailand. When the benefits of the ancillary electricity net support of the dam and the green house gasses reduction benefit of the dam

were included in the evaluation of the dam, these benefits were not sufficient to make the project economically justifiable.

EGAT and the World Bank have suggested that they looked at the overall power system at the planning stage. In the context of the whole system, it is possible that there would be enough (hydro) storage energy in the system to be able to cope with a dry year dry season output of Pak Mun. Pak Mun on the other end is in the dry season always able to produce 136 MW over a number of hours, and that is enough to increase the output or start a thermal plant. It may not do that over an extended period, but that may not necessary. In that case the full 136 MW could be used for the capacity benefit[2].

- **Benefits - Irrigation**

The Pak Mun project was presented for review to the NESDB in 1988 and to the Cabinet of Ministers in 1989 as a multi-purpose development project. In the 1991 World Bank SAR for the Third Power Project, besides hydropower and irrigation, fisheries appeared as a major benefit from the Pak Mun project. Irrigation benefits were not included in the economic analysis of the project by the World Bank in its 1991 Staff Appraisal Report. The irrigation benefits of a run of river project were doubtful and this was known at the time the irrigation benefits were quantified in EGAT's project document.

- **Benefits - Fishery**

About 7% of the project benefits were attributed to Fisheries in EGAT's 1988 Project documents.

The 1981 EIA predicted that fish production from the reservoir would increase considerably, though some fish species may be affected by the blockage of river flows by the dam. The fish yield expected from the 60 square km Pak Mun reservoir was 100 kg/ha/year without fish stocking and 220 kg/ha/year with the fish-stocking programme. However run-of-the-river reservoirs cannot sustain such high yields, as they do not provide the appropriate habitat for pelagic fish species. In Thailand even storage reservoirs that perform better under fish stocking programmes have a fish yield of about 19 to 38 kg/ha/year. The predicted fish yield from Pak Mun head pond was too high. A more realistic estimate would have been around 10 kg/ha/year. There has been no evidence to indicate that the fish productivity of Pak Mun reservoir has reached anywhere near the anticipated 100 kilogram per year.

The 1981 EIA valued the total annual predicted fish catch in the head pond at US$ 320 000 at the rate of 20 Baht per kg, without stocking. With stocking program the predicted catch would be worth US$ 693 000 at the rate of 20 Baht per kg. The 1981 EIA underestimated the total value of fishing yields that could be obtained from the free flowing river. After the completion of Pak Mun dam, the lower Mun River experienced decline in fishing yields at 20 Baht/kg with an estimated value of US$ 1.4 million per annum. In addition to this decline in fish species upstream led to the closure of 70 Tum Pla Yon traps. At the price of 18 Baht/kg at the end of 1980s, the value of annual catch from these traps is calculated at US$ 212 000 per annum. (1 US$ = 38 Baht) EGAT and the World Bank have different opinion on this finding. A detailed basis for the conclusion is presented in p132 in response to EGAT's comments.

[2] (i) The study team could not find system planning outputs, nor seen documents referring to system studies.

(ii) Pak Mun is situated in the NE region. According to many reports this region needed peaking capacity and for this reason Pak Mun was justified. This is not in line with WB and EGAT now treating Pak Mun as a component of the whole system. Better alternatives to Pak Mun at a cheaper rate were available in Thailand (see endnote 63). We find no reason to alter the conclusions arrived in this study.

- **Impacts**

The 1982-83 Environmental Planning Survey predicted 241 households as displaced people. The actual number of households displaced by Pak Mun dam was 1 700. Unpredicted by the EIA, a large number of households were adversely affected due to declining fishing yields. Until March 2000, 6 202 households were compensated for loss in fisheries during the 3 year construction period. Compensation for the permanent loss of fisheries has not been given.

7.2 What were the unexpected impacts, if any?

- **Impact on Fish Migration & Fish diversity**

Of the 265 fish species recorded in the Mun-Chi watershed before 1994, 77 species are migratory and 35 species are dependent on rapid habitat.[147] Available evidence does not indicate disappearance of any species before 1990, and nearly all species are very common ones to the region. Out of 265 species, about 10 were introduced species.

The decline has been higher in the upstream region. The latest survey recorded 96 species in the upstream region. Out of 169 species not found in the present catch, 51 species have been caught less significantly since the completion of the project. At least another 50 species of rapid dependent fish have disappeared, and many species declined radically. Migratory and rapid-dependent species were affected seriously as their migration route is blocked in the beginning of the rainy season, the head pond has inundated their spawning ground and the fish pass is not performing. Long-term studies are required to arrive at firmer conclusion on exact number of species disappeared from Chi - Mun river basin after the construction of Pak Mun dam. Fish catch directly upstream of the dam has declined by 60-80% after the completion of the project.

EGAT and the World Bank have indicated that a number of species have disappeared prior to Pak Mun. Thus, it is argued that impact on the fish species might be less than indicated here.

The Pak Mun case study concludes that the difference in number of species in fish surveys before and after dam construction may well be exacerbated by the cumulative impact of many different developments in the watershed. These include: water resources and hydropower development in chi-mun river watershed, deforestation, domestic waste water discharge, agriculture intensification and development, fisheries, industrial waste water discharge, saline soils and enforcement of water quality standards and classification. All these developments have contributed to a decline in fish species in the Mun/Chi watershed as a whole. The Pak Mun Dam cannot be blamed for the apparent disappearance of all these fish species. Cumulative impacts of all developments including the Pak Mun Dam have led to disappearance of fish species. Downstream of Pak Mun project, one or two species of fish have completely disappeared from the catch after the dam construction.

Location of the dam on the Mun river 5.5km upstream from its confluence with the Mekong has affected several migrating and rapid-dependent fish species. Thus, decline in and disappearance of several migrating and rapid-dependent fish species are directly attributable to the Pak Mun dam.

- **Performance of Fish Pass**

The project provided several mitigation measures, including a fish ladder to facilitate fish migration. Provision of a fish ladder was based on very little knowledge and experience. This mitigation plan came out at the time the dam construction was almost completed, even this important plan was not well prepared.

The 1981 EIA did not consider the construction of a fish ladder necessary for the Pak Mun dam but recommended the feasibility study of a fish way. The plan for fish pass came at a time when dam

construction was almost completed. In effect, the fish pass was constructed after the completion of the dam at the cost of 2 million Baht (US$ 0.08 million). The fish pass has not been performing and is not allowing upstream fish migration. The project authorities have discontinued monitoring of fish pass.

A vertical slot fish pass or a Denil fish pass instead of a pool and weir fish pass may have been more effective.

- **Reservoir Stocking as Mitigation**

Reservoir fishery was developed by EGAT in response to claims of declining fish catch. Total cost of stocking the head pond with fresh water Prawn (*Macrobrachium rosenbergi*) ranged between US$ 31 920 and US$ 44 240 annually between 1995-98. The department of Fisheries estimates that the total annual revenue of fishing yield ranges between 1.2 to 3.2 million Baht. However the estimated annual catch and revenue for fishermen are too high. The Department of Fisheries in their revenue estimate included the naturally occurring Macrobrachium species that can breed in fresh water. The M. rosenbergi spawns in salt water and migrates to fresh water and therefore cannot establish a population under reservoir conditions. For this reason it may well turn out that the stocking of M. Rosenbergi in Pak Mun head pond is not generating any income for the fishermen. The project has discontinued fish and prawn stocking.

7.3 Impact on Livelihood

In the post-dam period fishing communities located upstream and downstream of the dam reported 50-100% decline in fish catch and the disappearance of many fish species. The number households dependent on fisheries in the upstream region declined from 95.6% to 66.7%. Villagers who were dependent on fisheries for cash income have found no viable means of livelihood since the dam was built, despite efforts to provide training opportunities. As their food security and incomes became threatened they sought various ways to cope including migration to urban areas in search of wage labour.

Some households had to settle in forest reserve areas or on other common property as the compensation money was insufficient to buy alternative land. The Thai economic crisis affected households that did not use the compensation money to buy productive assets. Cropping incomes have declined and there has been a reduction in livestock as people are selling both due to a shift from farm based occupations as well as reduced grazing land.

Next to fisheries, loss of access to common property such as forest and grazing land has been among the other adverse impacts. Forests and riverbank dry season gardens were not compensated.

Since the completion of the project several committees were set up to assess the number and extent of households affected by loss of fisheries income. In all, over 6 202 fishermen demonstrated to the committee that they were engaged in fishing and their income affected following construction and operation of Pak Mun dam.

Based on the committee's findings, EGAT paid 90 000 Baht to each of the 3 955 fishermen in 1995, and it approved payment of 60 000 Baht each to another 2 200 fishermen in March 2000. Still, a large number of households located upstream of the dam are still waiting to be recognised for compensation. Unexpected costs of the project included the compensation for fisheries (488.5 million Baht had been paid up to March 2000) and investment on fish and prawn-stocking programme. Till March 2000, 488.5 million Baht (US$ 19.5 million) had been paid as compensation for loss of fisheries livelihood.

While the government acknowledged the impact on fisheries and agreed to compensate eligible households at the rate of 90 000 Baht as compensation for loss of income during the three-year

construction period, mitigation for the long-term loss of fisheries livelihood is under negotiation. On January 25, 1997, the villagers from Pak Mun joined the 99-day protest in Bangkok demanding fair compensations for the permanent loss of their fishing livelihood. Land and cash compensation promised by the government in April 1997 was retracted under a new political regime in 1998. From March 1999 villagers began demonstration for compensation from the government and the World Bank for permanent loss of income from fisheries.

- **Decision making and Conflict**

Assessment of project impact, like the assessment practices in past dam projects, remained focused on inundated areas and resettlement issues. Pak Mun project happened to be the first run-of-the-river type dam, with no reservoir and thus impacts due to flood and resettlement were not assumed to be as serious as of other big dam projects in the region. Thus fisheries impacts were not assessed and therefore overlooked. No study ever predicted that fisheries issues would become problematic, during construction or implementation though people raised this issue with the World Bank as early as October 1991 and prior to that with EGAT.

It has been realised by almost all of the stakeholders that planning, decision-making, implementation and mitigation were done with inadequate base-line information, especially on fisheries, the serious and most controversial of the issues. The project authorities viewed that it was not possible to determine the number of fishermen actually affected or the extent of loss suffered and hence the perception of exaggerated and ever-increasing claims for compensation. The absence of a proper baseline meant that claims for compensation by a large number of families would not be considered legitimate which meant that the only possible recourse for the affected villagers was prolonged protest.

Thus, the Pak Mun project got mired in a protracted process of conflict between the adversely-affected villagers and the project developers and the government. Exclusion of affected people from the decision making process and protracted protests, demonstration and confrontation for recognition and settlement of compensation and rehabilitation entitlements resulted in very strong negative perception within the community for the project.

- **Impact on Rapids**

The height of the dam was reduced and its location changed to drastically reduce resettlement of persons and to preserve the Kaeng Tana and Kaeng Saphue rapids which are tourist attractions. This was done at a substantial sacrifice in power benefits. Still, more than 50 natural rapids were permanently submerged by the project. These rapids served as the habitat of a number of species of fish. Several rapid-dependent fish species seem to have disappeared due to their submergence The implication of the loss of rapids for fisheries was not assessed in the project's environmental impact study.

- **Other Environmental impacts**

The project has resulted in the loss of riverbank vegetation, natural forest and community forest. In the pre-project period, the women in the community harvested 40 edible plants, 10 bamboo species and 45 mushroom species for household subsistence and small income. A number of medicinal plants were also found near the Mun riverbank. Loss of these plants and vegetation through inundation has implications for biodiversity and household food security. These aspects were overlooked in the environment assessment study in 1982 and absence of fresh EIA for the redesigned project.

7.4 What was the distribution of costs and benefits: who gained and who lost?

Pak Mun project was a part of EGAT's least cost development plan to serve the peaking needs of Northeast Thailand. However as the project cannot function as a reliable peaking plant of 136 MW due to a number of constraints, the nature and extent of gain to Thailand's Northeast region from the power contribution of the Pak Mun project remains a matter of speculation. From the distribution by power producing types in overall generation since 1988, it is apparent that hydropower is gradually playing a less important role in power provision. From the data on contribution of different power generation to the seasonal peak load, it can be seen that hydropower contributes significantly during the hottest and driest months in Thailand. These are also the months when the Pak Mun hydropower plant is least likely to have the water resources to contribute because it has no reservoir.

Communities dependent on the fisheries for livelihood in the upstream and downstream of the Mun River experienced an ongoing decline in fish catch. The Royal Thai Government had to recognise and pay compensation to 6 202 fishermen for the unanticipated loss in fisheries income. While compensation settlement has been reached with over 6 202 households regarding loss in income during the three years of construction, compensation for permanent losses in livelihood is under negotiation.

Despite the cash and credit compensation, permanent loss of fisheries cannot be replaced by an one-off cash compensation. As a result of the project and in the absence of baseline information, the Thai Government is left vulnerable to ever-increasing claims for compensation for the loss of fisheries livelihood. Regarding the issue of fisheries, all stakeholders stand to lose, not only from a disrupted ecosystem but also from increased expenditure at mitigation efforts that is unlikely to mitigate the losses.

Villagers who owned some land on slightly higher elevations were able to grow more rice compared to before the dam construction. Villagers who were dependent largely on fisheries for cash income, however, have found no viable means of living since the depletion of fish in the reservoir. The changes were particularly acute in paddy production. Along the Mun River, swamps and wetland forests, are parts of the riverine ecosystem. During the rainy seasons, these are flooding areas and places for fish to spawn. In the past, villagers used the area along the river to find bamboo shoots, mushrooms, native plants and vegetables that they depend on for their subsistence. During the dry seasons, they also developed narrow patches of land along the riverbanks for growing vegetables. In the upper part of the lower Mun, where banks were not steep, land along the river was developed as paddy fields. These have brought drastic changes in the way that villagers use natural resources. As their food and income security has been destabilized, villagers have sought different ways to cope with the changing conditions. Some of them and their children began to leave their villages to look for alternative employment opportunities, such as working in construction or in factories. Compensation was not invested in productive assets. Many affected people who were given compensation used the money to build their new house or change their roof. Many villagers sold their cattle in order to have cash in hand. Many also have debts, borrowing from their cooperative as well as local moneylenders. Short term wage opportunities and one-off cash compensation cannot replace the loss of a productive resource base by the community.

After resettlement, villagers have witnessed many social and cultural problems. The new social arrangements have disrupted former social relations and changed patterns of interaction among the villagers. Before the Mun river serve as the stage for their social life. Villagers met, interacted, developed social network of exchange, and helped each other. The traditional communal ceremony usually organized on the riverbank could not be held due to the submergence of the ceremonial site and, in part, due to the social disintegration of the communities. Since the beginning of the Pak Mun project conflicts of ideas and interest arose between those who opposed the dam and the kamnan and headmen group. The conflict was intensified during protests and demonstrations for compensation.

Those who were opposing the dam were often discriminated against. The conflict over the dam project at the local level created mistrust and deep social rifts.

The local community and adversely-affected villagers have expended considerable time and effort over nearly ten years in protests, demonstrations and negotiations with the government and project authorities. What became an issue of lost livelihood and a wrangle over compensation was initially a demand for a say in the decision-making processes which involves the development, utilisation or transformation of natural resources which form the livelihood base of the community. The process has created tremendous bitterness and negative perception among the community at being excluded from critical stages in the decision-making process.

The World Bank and EGAT have suggested that the income level of the families in the region improved significantly since the completion of the Pak Mun project. The NRDC data is presented as evidence. The NRDC data was analysed and inferences drawn (see Annex 3 for details). However, the NRDC data was not used in drawing conclusions. See page 164-165, 167, 176-77 for an understanding on the NRDC data.

WCD finally based its conclusions on the primary data generated by the study as well as other studies conducted specifically in relation to the Pak Mun project. Thus, the 1996-97 OED study was also used as a benchmark.

7.5 How were the decisions made?

The National Energy Authority (NEA) initiated development of the water resources of the Chi-Mun watershed. The preliminary feasibility study completed in 1970 selected the Kaeng Tana rapids as the possible dam site. By May 1979 the project was transferred to EGAT for further feasibility studies.

Environmental Impact Studies conducted in 1982 indicated that approximately 4 000 households would be displaced if reservoir was impounded to a level of 113 MSL. In order to reduce the project's environmental and social impacts, after a new feasibility study an alternative design with a normal water level of 108 MSL was agreed upon in 1985. The relocation of the dam site significantly minimised the extent of displacement from the project to an estimated 248 households. The original project design was further modified by relocating the dam 1.5km upstream to avoid the submergence of Kaeng Tana rapids, an important environmental and tourist site. EGAT also decided to lower the reservoir to 106 MSL during dry season from January to May and to adjust the dam's operating regime to uncover the upstream Kaeng Saphue rapids, a popular tourist destination. It should be acknowledged that EGAT and the Thai government made substantial sacrifice in power benefits in order to minimise social and environmental impacts.

However a new EIA was not conducted at this stage which may have identified and anticipated some of the new environmental impacts arising from the new location of the Pak Mun project.

In April 1989 the project was presented by EGAT to the Council of Ministers of the Thai Government (the Cabinet). Nearly one year later the Pak Mun Hydropower Project was presented as part of a loan package to the Board of Governors of the World Bank. In 1991 when it appeared that project costs would have to be increased, it was presented to NESDB for re-approval. In each of these occasions costs and benefits were presented.

The Pak Mun dam was described as a multipurpose development project by EGAT in the project document dated March 1988. Claims of associated and attributable benefits from the project, which were modest relative to the value assigned to electricity generation, included irrigation, fishery, navigation improvement and recreation enhancement. Only the benefits of power, irrigation, and fishery were quantified in EGAT's project document. The project later qualified for World Bank loan financing as part of Thailand's Third Power System Development Project. The World Bank's Staff

Appraisal Report (SAR) was completed in July 1991 the Bank's Board of Directors approved the project in December 1991.

In August 1991 when EGAT resubmitted the project to the NESDB for the endorsement of a 70% increase in estimated investment costs, along with the expected annual energy output, the irrigation and fishery benefits remained unchanged. The revisions showed that the Pak Mun dam as a multipurpose development project including resultant irrigation and fishery potentials was still worthwhile. NESDB accepted the project as proposed and endorsed EGAT's revisions. The project's EIRR changed from 18.71% in 1988 to 17.35% in 1991- irrigation benefits were quantified. Neither the SAR nor the revised NESDB application in 1991 identified how the irrigation components were going to be financed but benefits were included in both and quantified in the latter's presentation.

In recent communication with the Pak Mun study team EGAT has indicated that the power benefit of the Pak Mun Dam is the core benefit of the project. Other benefits such as fishery, irrigation, etc. are secondary, and are not necessary for project justification.

The conceptual economic benefits as avoided costs for power generation of the next best alternative, were used in the project's (the power only component) economic evaluation. The actual hydropower benefits of the dam were not used by EGAT or the World Bank in the economic justification of the project. Both institutions limited their analysis to a switching value analysis, also called Equalising Discount Rate analysis. Such an analysis is used to rank projects by priority once they have been estimated to be economically viable. The lack of proper ex-ante economic analysis means that it is not possible to conduct a comparison of Projected and Actual Economic Value of the project.

The Cabinet mandated the EGAT to establish eligibility criteria and finalise the process of compensation to the affected people. The Governor of the Province of Ubon Ratchathani, the Director-General of the Department of Fisheries, and the Permanent secretary of the Prime Minister's Office were put in charge of the compensation process. The focus of the process shifted from lost assets like land and other properties to decline in fisheries affecting livelihood.

Affected villagers were not consulted at the early stages of the decision-making process and there were no attempts to include them in the decision making on the project or the mitigation measures. The issues around inadequate assessment of impacts and compensation were not addressed at the outset. Negotiation on compensation began only after long protests by the affected community and NGOs. Participation of affected villagers and NGOs in the compensation process was first elicited through the Committee for Assistance and Occupational Development of Fish Farmers (CAODFF), formed by order of the Prime Minister in January 1995, eight months after completion of the dam. The Director-General of the Department of Fisheries headed the committee. EGAT remained solely responsible for all costs relating to the works of the various committees and working groups and for the compensations paid out.

7.6 Did the project comply with the criteria and guidelines of the day?

The Pak Mun project complied with the standards of the Cabinet at the time and was thus approved in May 1990.

Under the 1992 Promotion and Conservation of National Environment Act, reservoirs with capacities larger than 100 MCM or surface areas greater than 15 square km require an Environment Impact Assessment Study. The EIA studies have to be submitted to the Office of Environmental Policy and Planning for consideration prior to being submitted to the Cabinet or appropriate authorities for endorsement for permission to proceed. Pak Mun dam with a reservoir storage capacity of 225 MCM and surface area of 60 square km would require an environmental impact study under the 1992 law.

Since the Cabinet endorsed the project in May 1990, the provisions under this act did not impinge on Pak Mun dam.

The 1981 EIA produced inadequate baseline information. Baseline studies of aquatic resources need to cover the different seasons and a timeframe of at least 2 years. Assessment of natural fluctuations in abundance of fish populations as well as the cumulative impacts on aquatic resources from other development projects in the watershed was necessary. An appropriate socio-economic survey was required to identify the extent of dependency of the local population on fisheries. Further, the project that was approved by the Cabinet was different from the one for which EIA was conducted in 1981.

By the time the project reached implementation stage, the nature, extent and site of the project had changed and this warranted a new EIA. By 1990, the Pollution Control Department and the Office of Environmental Policy and Planning of the Ministry of Science, Technology and the Environment had also evolved an extensive set of guidelines, standards, classifications and procedures in place to carry out appropriate EIA. The World Bank too had an extensive set of procedures and guidelines in place for the Terms of Reference, implementation and review of EIA. The Pak Mun dam did not comply with the existing World Bank guidelines that required a new EIA and appropriate impact mitigation prior to the implementation of the redesigned project. If the Pak Mun project complied with the World Bank's standards at the time of appraisal in 1990, many of the serious unexpected impacts could have been avoided. By the time mitigation measures related to fisheries were put in place in response to peoples protests, the dam construction work was completed.

Compensatory measures apart from inundated houses and land were formulated and implemented at a later stage of the process. The monitoring of fish species and fisheries activities after the completion of the dam has been haphazard and not systematic. The performance of the fish ladder has not been adequately evaluated, and monitoring withdrawn. Adaptive management such as relocation and improvement of the fish ladder might have helped, but was not considered.

The process of compensation of affected fisheries households has been a long and tedious process as a result of inadequate baseline studies that should have defined the number and location of households depending on fisheries and also the value of their fish catch.

7.7 How would this project be viewed in today's context?

The economic premise on which the project was justified can be questioned. The planners confused a switching value analysis, also called Equalising Discount Rate analysis, with a traditional economic benefit analysis. The former analysis should be performed to choose the best of two project implementation solutions that have already proven to be both economically viable. When applied to power projects the switching value analysis should be done on projects that have the same dependable capacity and this was not done in case of Pak Mun project.

Since the Pak Mun project was in reality conceived and operated as part of EGAT's power development plan to respond to long-term national load forecasts, its claim as a multipurpose project is misleading.

In the present context, the absence of assessment and lack of consideration of the project impact on fish and fisheries in Mun River in the initial planning and decision-making stages would be considered a critical lapse. This is more so given the fact that this World Bank funded project was approved and implemented in the early 1990s. The absence of comprehensive assessment of the households whose fishing occupation, fishing income, and subsistence was affected by the dam at appraisal meant considerable unplanned cost escalation in terms of compensation. The participation of affected communities and civil society was elicited late in the process of compensation, mitigation. Confusion resulted from lack of clear division of institutional responsibility and this was compounded

by lack of clarity in eligibility criteria as a result of which affected people spent nearly ten years in negotiating compensation claims with the government.

With hindsight, as demanded by the World Bank guidelines, a fresh EIA for the redesigned project would have been called for whose terms of reference should have included nature and extent of impact of the project on livelihoods based on fisheries. Such a study would have been useful in making available relevant baseline for comprehensive identification of fishing villages, the extent of population affected, the level of dependency on fisheries by season, the prevailing income, and the resettlement location options allowing continued access to the riverine resources and alternatives.

If plans and policies were adequately implemented with respect to social impacts and resolution of conflicts, villagers would not have had to waste time and effort in negotiating and protesting against the dam. Nor would the country as a whole have lost an important ecosystem. One of the key lessons emerging from the study is that if all the benefits and costs were adequately assessed, it is unlikely that the project would have been built in the current context.

8. Lessons Learned

- *Power Benefits*: Power benefits of run-of-the-river hydropower plants may be much lower than could be expected from their installed capacity. Although such plants may have less environmental impacts than reservoir dams or certain thermal power stations, being highly dependent on the variable & uncertain run-off, in many cases they may not be economically feasible due to the insufficiency and unpredictability of their power output.

- *Economic Premises*: Underlying assumptions of project benefits and costs should be rigorously monitored and subjected to necessary revaluation. The switching value analysis or the Equalising Discount Rate analysis should be performed to choose the best of two project options that have each already proven to be economically viable. Records[148] of actual peaking power output by Pak Mun generators should have been kept since the commissioning date, to enable the post-facto monitoring and performance assessment for the validation of generated economic benefits of the project.

- *Multipurpose Benefits*: Multipurpose benefits of dam projects should be examined and projected after taking into account the terms of the restraints imposed by hydrological regime, topography, storage, reservoir operating rules and environmental mitigation etc. A continuous process of monitoring of aspects such as hydrology, water quality, upstream water use etc would help to make informed decisions and enable accurate forecasting.

- *Policy and Implementation*: Pak Mun project was implemented with financial support from the World Bank at a period when substantial procedures, guidelines and policy support existed for a comprehensive EIA process. That despite the favourable policy environment, the highly adverse impact of the project on fish migration was overlooked and later mitigation measures inadequate, resulting in significant social and economic consequences is a reflection of the lack of priority accorded to environmental issues at the stage of planning and implementation.

- *Cumulative Environment Impacts*: A systematic long-term study of the state of aquatic biodiversity, water quality, habitat modification of the Mun-Chi watershed is required to assess the cumulative impact of ongoing development activities in the upstream region. A continuous monitoring program is necessary to record the natural fluctuations in biodiversity especially the 265 interacting fish species and impacts of development interventions in order to create a reliable baseline line and set a level for sustainable use of aquatic resources.

- *Comprehensive Baseline*: The controversies over Pak Mun dam can be attributed to the lack of comprehensive environment impact assessment and socio-economic baseline information that failed to anticipate the adverse impact of the dam on fish diversity and the consequent implications for community livelihood & income dependent on fisheries. This assessment error or underestimation of losses not only led to the subsequent escalation in expenditures on compensation and mitigation measures beyond the original resettlement plan, but also created prolonged confusions around identification of affected people, eligibility criteria, nature & amount of compensation etc.

- *Absence of Consultation*: Villagers affected by Pak Mun dam had predicted impacts on fisheries at the early stages. However they were not consulted and there were no attempts to include them in the decision-making on the project or the mitigation measures. Consultation with local people at the early stages is essential to incorporate local knowledge and wisdom about the ecosystem and livelihood.

- *Decision-making & Conflict*: The compensation to Pak Mun Dam affected people did not come from a comprehensive initial assessment followed by appropriate settlement against losses. Compensation claims against lost fisheries income were addressed by the government and project

agencies after a lengthy process of protest, demonstrations, confrontation and negotiations. The uncertainty of the situation compounded by inappropriate mitigation measures, implementation delays and lack of continuity in government decisions created a situation of general unrest through escalated protests and high negative perception about the project. The Pak Mun dam is a legacy with significant level of conflicts over very fundamental issues, and some drastic rethinking on the dam's future can only be arrived at through constructive dialogue among all the stakeholders.

9. EGAT'S Comments on June 2000 version of Pak Mum Report

[Response to the comments are underlined]

9.1 General Comments

Knowledge of Authors:

Researchers and Commissioners misunderstand and/or lack basic grounding in the study's technological area especially in regard to economic aspects and financial analysis. For example, it is clear that they do not understand what the dependable capacity of the hydropower plant is which causes inaccuracies in their economic analysis. The authors have used EGAT's formula to calculate the dependable capacity of the Pak Mun project?[149]

In terms of fisheries, it is also clear that the researchers do not comprehend how to make use of information from biologically-investigated data. To determine the difference of fish species before and after Pak Mun dam construction, they compare the result of field survey in many sampling stations to observed data at the fish ladder. This assertion is not correct. Please see Annex 6-fisheries, or table 4 in fisheries component report - the fish species recorded before construction is compared with three existing studies conducted between 1995-99 looking at fish species passing through the fish ladder as well as the 1999 study on upstream, downstream of Mun River, Songkram River and Rasi Salai dam. The study of fish species passing through the fish ladder does not imply that the data was obtained through observation only at the fish ladder. In fact the majority of sampling points of the fish surveys carried out after construction of the dam are located in downstream areas -P.37

Dr. Chavalit consolidated data from all fish surveys, after construction of the dam, including data from his own surveys. Not only the fishladder surveys are included, but all fish species found at sampling points in the Mun/Chi watershed up- and downstream of Pak Mun dam.

This creates a significant error in impact conclusion. The most serious drawback is lacking judgment in using the data from interviewing people who are involved in the dam protesting campaign and drawing conclusions from there. These shortcomings make the outcome of the study totally biased and lacking in credibility. Data for the current study was based on field survey involving all categories of the affected people - those who are agitating as well as those not involved in agitation, and observation data collected at various points upstream and downstream of the dam. In addition, other studies conducted after completion of the Pak Mun dam have also been used in the current study

9.1.1 Standard of Documentation Format:

The format of WCD's report writing is substandard comparing to general technical documentation. For detailed technical documentation kindly refer to detailed reports of each of the components. For example, report of the power component of the project is presented in elaborate details. There is no appropriate citing system in the documentation and it creates difficulties for the readers to judge the correctness of the paper. Please mention specific areas where information has been used without citation. At this stage, the document has clear citation of all documents used, which are mostly from EGAT or the World Bank. The authors make the reader confused by drawing conclusions that cannot be supported and glossing over the project's positive aspects. Kindly indicate the positive aspects that have been 'glossed over'? This shows the lack of authors' sincerity and elementary courtesy and respect for the readers and stakeholders.

9.1.2 Use of Incredible Data

The commissioners and researchers do not declare the limitation of data collection in the study. They just state that the base line data to determine the required answers is not available but they do not try to solve the problems systematically. They decided to ask the necessary information from interviewing the local persons involved in thedam protesting. It should be clear that the outcome of such interviewing would be negative to the project but they prefer or relish in making the project look bad. This factor is the major cause that makes the paper unconvincing. Furthermore, the authors avoid use of creditable data but prefer to use doubtful data that can serve their pre-planned results. For example, instead of using five published biological surveys that reveal the list of fish species found in the Mun River, they decided to use private records of Chavalit Vidthayanon (1999), which have not been officially published, to demonstrate the number of fish species found before dam construction. Kindly indicate these five published biological survey reports to help us look at them? Probably the 5 publications mentioned at page 7. We went over those and included the fish species in our table. Some scientific names of fish species mentioned in the 5 reports have been changed by Dr. Chavalit., because those names are not valid anymore due to new classification.

This example shows that the data used is unconvincing and consequently makes the report fruitless. We cite below only a few examples and the reader may refer to our detailed comments to draw his own conclusions.

9.1.3 Misleading Conclusion:

It is clear that the conclusion of the report is misleading. A good example is that the authors try to demonstrate that there were 265 fish species found before dam construction by using the results of biological surveys during 1969 to 1993 and accompany to Chavalit's private record. In conclusion, WCD never clarify that the number of fish species is accumulated record during the 27 years before the dam construction but conclude that 265 fish species found before dam construction. And to point out the violent impact of the project, 96 fish species found at the fish ladder is used to compare with the accumulative record. This style of conclusion is conducted in many aspects and makes the paper absolutely incredible.

The WCD draft final version of the Pak Mun Case Study places the Pak Mun Dam in the context of other developments in the Mun/Chi watershed: development of water resources, hydropower development, deforestation, domestic waste water discharge, agriculture intensification and development, fisheries, industrial waste water discharge, saline soils and enforcement of water quality standards and classification. All these developments have contributed to a decline in fish species in the Mun/Chi watershed as a whole. The Pak Mun Dam can not be blamed for the apparent disappearance of all these fish species. Cumulative impacts of all developments including the Pak Mun Dam have led to disappearance of fish species.

The fisheries report has consolidated data of all fish surveys in the Mun/Chi watershed, including Dr. Chavalit's own surveys. Comparisons were made between number of fish species found at sampling points downstream of the location of the dam and number of fish species found at sampling points upstream of the location of the dam. Further comparisons have been made in before time of construction and after time of construction of the dam.

The apparent impact on 169 fish species is not blamed on Pak Mun Dam alone, but on cumulative impacts. Further not all 169 identified species are necessarily extinct, but the populations have declined: "The calculated loss of 169 fish species is exacerbated by the difference in efforts and number of sampling points of the fish surveys before and after dam construction." (page 45)

9.1.4 Unfair Conclusion:

The unfair conclusion is demonstrated clearly in fish yield prediction. To discredit the accuracy of fish yield prediction, 60 tonnage of fish catch is stated as reasonable by the author. But to calculate the value of fisheries revenue, 1 900 tonnage of fish catch was referred to. Where was 1900 tonnes mentioned? It is certain that the authors have no unity to conclude the study. They may use any source of data to meet their pre-planned answers without consideration whether the data is reasonable or not. The accuracy of fish yield prediction from Pak Mun head pond has been examined against the annual fishing yields from storage reservoirs of Ubolrathana, Chulaphon and Sirinthon, where with regular stocking annual fishing yield range from 19 to 38 kg per ha. The EIA predicted an annual fishing yield in Pak Mun reservoir of 100 kg/ha without stocking and of 219 kg/ha with stocking, therefore appear too optimistic compared with the actually obtained fishing yields in Ubolrathana, Chulaphon and Sirinthon reservoirs. All three are storage reservoirs where pelagic fish as *Clupeichthys aesarnensis* can make up to 70 % of the total fishing yield (MRC 1997). The report therefore concludes tentatively that: A more realistic, but still speculative prediction of the total annual fishing yield in Pak Mun headpond would have been 60 tonnes, based on 10 kg/ha…..

9.2 Benefits from Hydro Power

The power benefit of the Pak Mun Dam is the core benefit of the project. Other benefits such as fishery, irrigation, etc. are secondary, and are not necessary for project justification. The WCD report must correct the wrong impression it gives that the project has been justified using the secondary benefits. The WCD report merely states that irrigation benefit was quantified in EGAT's project document and did form the justification of the Pak Mun multi- purpose project as presented to NESDB and the Cabinet of ministers for approval in 1988.

9.2.1 Economic Justification

The key issue that seems to have been of undue concern is the dependable capacity of Pak Mun. Different numbers have been calculated by the reviewers. Earlier, 75 MW was computed and now 21 MW appears in the draft. As EGAT's representatives have clearly pointed out in the Stakeholder Meeting on 23rd February 2000, dependable capacity is not the most important parameter as the reviewers persistently try to emphasize. The estimation of the Dependable Capacity of the Pak Mun Hydropower plant is important because it allows a comparison with the Dependable Capacity of the alternate source of peak power.

It is only used for the least-cost study and varies from month to month. Here again, we would like to stress that the concept of dependable capacity is defined as " the capacity corresponding to the 90% level of confidence based on the long-term reservoir simulation" is still applied in the power system planning. As mentioned in the Power component report - The power systems planning model used by EGAT has severe limitations. While demand and supply of power vary on a daily basis the model is only able to optimise allocation of generating capacity on a monthly basis. Further the Pak Mun Hydropower project is entered as a fixed plant. In effect EGAT is treating the Pak Mun Hydropower plant as a base-load plant. In the case of Pak Mun the non-firm (not dependable) portion of the plant output is entered as base load. Table 1.1 and Table 1.2 show the dependable capacity used in the planning study and the actual operation records of the Pak Mun over the 5-year period of 1995-1999. Table 1.2 does not mention whether the MW calculated accounts for peak hours?

It can be seen from the two tables that the dependable capacity as well as the corresponding energy generation of Pak Mun used in the planning study very well match the actual operation records. This proves that the planning of the Pak Mun dam has been based on solid analysis performed with sophisticated planning techniques. The mean net peak power output- calculation method which is used by EGAT - is the straight average of mean net power output for every year in that period - masks the large variations in daily and monthly power production. While in storage dams this variation can

be managed by releasing water all year round to generate power during peak period, the same cannot be done for a run-of-the-river-project.

The peak generation of 126-136 MW has been achieved in 1995-1999 - as can be confirmed by the actual data already presented here - indicating that Pak Mun can serve more than the dependable capacity of the peak month used in the planning criteria which was already conservative. The report does not say that Pak Mun cannot attain generation capacity of 136 MW. The issue that is examined in detail is whether and to what extent, 136 MW can be sustained over the 4 hour or peak demand period. The WCD report demonstrates that Pak Mun is actually operated below its theoretical capacity due to the unreliability of water runoff and operational constraints and therefore cannot function as a reliable peaking plant.[150]

In this regard, the use of 150 MW (installed capacity) gas turbine which has dependable capacity equivalent to the hydro capacity in the range of 120-130 MW in the economic analysis by EGAT is rational and in line with the criterion for determining the peaking capacity of the gas turbine. The planning criteria of EGAT has been proven to work well as the system could serve the demand during the high growth period between 1990-1995 for which the growth for both the peak and energy demand was over 10%. P.36 of the WCD report illustrates why it is not justified to assume that Pak Mun substitutes a 150 MW gas turbine plant. It clearly draws from the fact that Pak Mun cannot function as a reliable 136 MW peaking plant. Pak Mun replaces 21 MW or lower in gas turbine capacity.

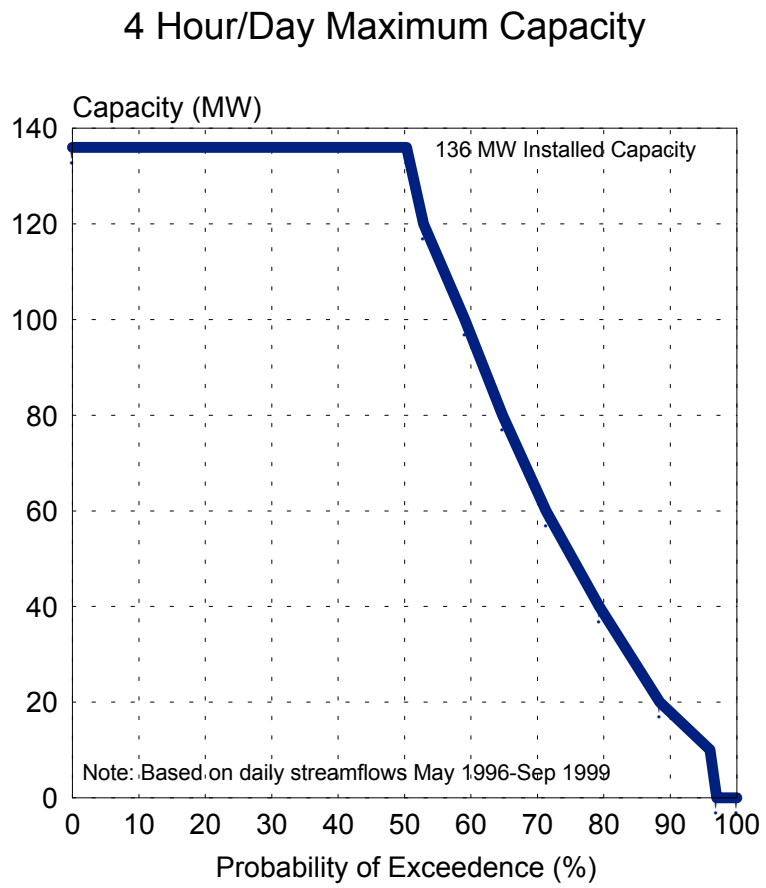
Furthermore, the full commissioning of the Pak Mun in 1995 coincided with the time when the power system of Thailand grew at a very high rate (14.56% for peak demand and 13.25% for energy demand). The operation of the Pak Mun has contributed a great deal to the power system in the time of need. Pak Mun contributed to which demand- peak or energy - and what was the proportion of contribution?

The reviewers for the WCD on this subject do not have adequate knowledge of system planning, system operation or even basic understanding of the power utility. They only relied on their common sense and consequently completed the study without rigorous technical analysis. It is clearly seen that they do not seem to know what the dependable capacity for the hydro power plant means.

9.2.2 Economic Justification

The duration of the daily peak in the NE region of Thailand at the time the latest planning studies were done was about 4 hours. Table 2 of EGAT's comments provides the monthly generation totals for a period of 5 years, or 60 months. At a 90% level of exceedence the monthly generation is 3600 MWh. If the peak duration is 4 hours, then the maximum 4-hour peak output is 3600/30/4=30 MW.

This value is based on monthly data. On a daily basis, this value is less, as shown in the following graph:



At the 90% level of exceedence the 4-hour peak output is about 18 MW. Adjusted for the differences in forced outage, this would replace about 20 MW of gas turbine capacity.

The WCD finds the estimate of 21 MW offset gas turbine capacity, as derived by the independent power consultant credible, and cannot accept the EGAT/WB value of 150 MW.

An aspect which was not adressed in the case study is that of energy benefits, where EGAT‘s values are based on replacing gas turbine generation only. In fact during the non-peak hours, and even some of the peaking period, the marginal generator is oil-fired steam plant, with cheaper fuel and lower incremental heat rate than gas turbines. The internal rate of return would have dropped to a much lower value than 8% if this fact would have been taken into account by the power consultant.

The WCD agrees with EGAT that the actual benefits of Pak Mun can be better estimated by means of power system simulation software, deducting system casflows with and without Pak Mun. However neither EGAT nor the WB has provided copies of such studies to the WCD. If such studies have been done and were replacing Pak Mun by a 150MW gas turbine, then that would have been the wrong approach. In the case without Pak Mun the number of gas turbines should have been the result of optimization results, constrained by the LOLE values of the with Pak Mun case. For Pak Mun itself no average monthly energy outputs, but all years of the hydrological period should have been analyzed.

The WCD is aware of the fact that Pak Mun‘s capacity is small compared to the total system demand, and that by deducting two large numbers (for the system cashflows with and without Pak Mun) certain inaccuracies may manifest themselves.

The WCD also understands that system demand growth in the period of decision-making about Pak Mun was very rapid, and that Pak Mun was perhaps the only project with a sufficiently advanced

design for rapid implementation, although of course gas turbines can be ordered and installed within about a year, and is thus much quicker.

The WCD is quite aware of the important role of Pak Mun for the electricity supply to the NE Region, but only finds that from a supply point of view, it was for a 10% or 12% discount rate not the most economic solution. The ancillary services of Pak Mun to the NE Region are also recognized, but do not change the WCD's overall conclusions.

9.2.3 Financial Analysis

The power development plan selected by EGAT is based on a least-cost solution. This means that the plan minimizes all the costs needed for the power development over the study horizon of 10 to 15 years. The Pak Mun was one of the power plants in the least-cost solution under the prevailing conditions at the time of the study (PDP87-02). In the economic analysis, taxes and IDC as well as escalation were not considered. These cost items are part of the financial analysis that is performed to validate the profitability of the project itself. However, the use of an average tariff as the financial benefit of the project is not at all relevant to the financial study of EGAT. Operation of the power system requires generation from three types of power plants, ie base load plant, intermediate plant and peaking plant. The production cost of the base load plant is the lowest while that of the peaking plant is the highest. It is *not* possible in any way, *for a power utility like EGAT,* to evaluate the benefit of an individual power plant in the system against the average sale tariff. This is because the sale tariff is the quantity that reflects the combined generation expenses of all the power plants in the system, not an individual power plant. In addition, the structure of the tariff is controlled by the Government and at the same time has to comply with the covenants set by the lending institutions such as the World Bank, IBRD, etc.

This approach might be applicable if EGAT were an IPP who wanted to sale its power to a power pool, not as a power utility as EGAT is at present. *If the reviewers persist on using this approach, we will have to conclude that they have distorted the facts and tried to intentionally mislead the readers to believe that the Pak Mun was not financially sound which is absolutely untrue*.

Based on the clarification at the Stakeholder Meeting on the EGAT's planning practices and other related matters, the reviewers still do not show any sign of understanding on the subject. This ignorance can be clearly seen in the contents of the draft final report. In this respect, EGAT has no choice but to reject the WCD study. Financial analysis has been dropped from the current version of the report

9.3 Fisheries Aspects

9.3.1 Methodologies and Data Used

WCD refers to a lot of data in the case study but some of them lack credibility. Following are some examples of the data that should not be used in the case study.

Number of Fish Species Found before and after Dam Construction

The report refers to many sources of data to reveal the number of fish species found before date that the Pak Mun dam was completed.

(1) Thaenthong, A. and N. Siripan (1969), General Survey of Fishes and Fishing Gear in the Mun River, Ubon Ratchathani Province. Annual Report of Ubon Ratchathani Freshwater Fisheries Station, Department of Fisheries.
(2) Duangswasdi, S. and T. Chookajorn (1991), Fisheries Characteristics and Species Distribution of Fishes in the Mun River, Technical Paper No.125. National Inland Fisheries Institute.

(3) Dunangswasdi, M. and S. Duangswasdi (1992), Fisheries Resources and Fisheries Activities in the Mun River, Technical Paper No.136. National Inland Fisheries Institute, Bangkok.
(4) Duangsawasdi, S. et al. (1993), Fish Species and Abundance in the Proposed Pak Mun Reservoir Area, Ubol Ratchathani Province. Technical Paper No. 152 National Inland Fisheries Institute, Bangkok.
(5) DOF and EGAT, 1995, Report of Research Project on Fundamental Data of Fisheries Resources and Migratory Behaviours of Fishes in Pak Mun Project Area, Phase I and Phase II.

EGAT and DOF are not willing to release the raw data. All in all, this report, that should have been the main background information to the fisheries component of the Pak Mun Case Study, fails completely in systematic approach and presentation. It also fails completely in reliable identification of fish species. The only field guide of Thailand dates from 1945 (Smith). After 1945 many fish species have obtained a new name, many new fish species have been discovered, and many species have been moved to other subfamilies. Dr. Chavalit is a renowned taxonomist in Thailand. He builds on the work by Kottelat, Rainboth and Roberts.

In table1 in the Annex of WCD report Chavalit has checked all the scientific names of fish species and has changed or deleted old names where appropriate

These five technical reports are creditable because they were published by the official organisations. These technical reports reveal that 158 fish species were recorded during the year 1969 to 1993. It was also found that 19 fish species have not been found since the year 1981. It is more reasonable to state that there were 139 fish species in the Mun River before the construction of the Pak Mun Dam but the WCD's report on the Pak Mun case study refers to the data of Chavalit Vidthayanon, an official of Royal Thai Government Fisheries Department, which does not appear in the reference list.

Dr. Chavalit is named in Table 1 Annex 3, but not in the references
It is doubtful that his report is qualified enough to be published by any creditable organization. If this is the first time that his report is published in term of technical report, it is necessary to state the method of data collection to declare the creditability of the report. Combining the five conceivable data reported by five published technical report and of unqualified data belonging to Chavalit's report, it provides the number of 265 fish species found in the Mun River. Using some of unqualified data make the WCD's report questionable.

For the number of fish species found after dam construction, four technical reports were used referred i.e.

(1) Nicholson, A.(1995), Assessment of Combined Overflow Weir and Submerged Orifice Fishway on the Mun River, Thailand. B.Sc. Thesis, School of Geography, University of New South Wales.
(2) Pholprasit et al. (1997), Fish Passing through the Pak Mun Fish Ladder and some Factors Affecting their Migration, Thai Fisheries Gazette Vol. 50 No. 4
(3) Pholprasit et al. (1997), Fish Passing through the Pak Mun Fish Ladder and some Factors Affecting their Migration, Thai Fisheries Gazette Vol. 50 No. 5
(4) Sripataraprasite, Pradit (1999), Effect of Fish Ladder on Migratory Fish Species and Fisheries in Pak Mun Dam, A dissertation proposal.

It is noticed that the number of fish species reported in the papers is the fish species found at the fish ladder. It is incorrect to conclude that all sampling done to study the performance of the fish ladder took place at the ladder itself. Clearly upstream and downstream areas were looked at under these studies. Whereas the number of fish species found before the dam construction is referred by the technical report presenting the fish found in many sampling stations along the Mun River. The usage of two different sources of data from different methods should be avoided especially to compare the different situation of environment.

Decline of Fisheries Yield From the Mun River

It is stated in WCD's report that after construction of Pak Mun Dam the catch of fish declined compared to that before dam construction. That statement follows from interviews with folk fishermen in October 1999. This data is not at all credible because at the time the fishermen were interviewed, a campaign to claim the loss of fisheries was underway at the dam site by a group of Pak Mun dam protesters. It is understandable that the answers of the fishermen in the site have to be biased because they want to proclaim that the construction of the dam decimated fisheries resources. So the data from the mentioned method is not admissible for a fair study. It is fair and logical to interview affected fishermen in the local context to determine impacts on their daily livelihood means. The fact that they are protesting does not take away their prerogative to be the primary respondents regarding issues affecting their lives and livelihood.

Rapids as Spawning Ground of Fish

The case study firmly states that there are a lot of rapids impacted from impoundment of Pak Mun Dam reservoir. It is claimed by the report that these rapids serve as the spawning ground of 17 fish species belonging to Pangasidae, Sisoridae, and Cyprinidae. But the report does not reveal the sources of technical data to corroborate that statement. It is generally known that until now no technical report deals with the life history of fish found in the Mun River. There are some technical reports i.e. Pholprasit, 1997 which states that the 17 fish species generally found in the habitat of rapids but that report does not state that the rapids are the spawning ground of those fishes. If WCD would like to claim that the rapid is significant spawning area of any fish species, creditable technical reports should be cited for public inspection. *A creditable technical report "for public inspection" is Smith, 1945. This book is outdated and many scientific names given to fish names are not valid anymore, and many new fish species have been discovered in the Mekong Basin after 1945. Dr. Chavalit is now working with Rainboth for the Mekong River Commission to write a new fieldguide for fishes in the Mekong. We need to have patience till this fieldguide is published. Spawning areas of fish are not published in scientific reports but in field guides. We have to wait for an updated fieldguide of fishes in the Mekong Basin.*

If a particular bird species is nesting on the ground instead of in trees, not immediately a scientific report will be published. Researchers obtain this type of information from so called traditional knowledge systems. Interviewing local fishermen and asking local fishermen the right questions brings much information to researchers as for instance that specific fish species are spawning in rapids. Dr. Chavalit has confirmed the scientific names of fish species that spawn in rapids

Calculation of Fish Productivity in Run-of-the-river dams

WCD rejects the calculation and prediction of fish yield from Pak Mun reservoir that assumes 100 kg/ha/year and 219 kg/ha/year and a pick up rate of 10 kg/ha/year.
It is very clearly mentioned in the WCD report, fisheries & aquatic bio diversity section: that 10 kg/ha/year is an assumed rate based on the experience of fishery productivity of storage in Thailand where yields are between 19-38 kg/ha/year and the fact that pelagic fish species that form the majority of fish population in storage reservoirs cannot be sustained in the head pond of a run-of-the-river project such as the Pak Mun dam. See P.42 and Table 4.18 in P.43 - where established fisheries yield of three storage reservoirs are cited and that is used as a basis for drawing the conclusion that the EIA predictions were over estimates - there is no question of 'cooking anything'.

The WCD researchers do not disclose the sources of the picked up rate and do not describe any assumption showing that the WCD's rate is more reasonable than that assumed by the EIA. WCD's report only states that "*In the head pond of the Theun-Hinboun run-of-the-river dam (located in the Mekong Basin in Lao PDR), fishing yields are also notoriously low. Annual fishing yields at the Theun-Hinboun have not yet been reliably estimated, but fishing yield in the head pond area is less*

than before dam construction." This cited statement of WCD's report does not reveal any sign of the rate 10 kg/ha/year and the statement confirmed that the fishing yield at Theun-Hinboun run-of-the-river has been not been systematically assessed, so that the rate of fishing yield at 10 kg/ha/year is only "the result of cooking the figure" to be used in this paper.

Conclusions

WCD's report draws conclusions about many aspects of fisheries to concur with the objectives of the study but some of them are "unfair" and "misleading" inferences.

Unfair Conclusions

(1) Fish Yield Calculation

"*Benefit-Fishery: About 7% of the project benefits were attributed in EGAT's 1988 project documents.*

The 1981 EAI predicted that fish production from the reservoir would increase considerably, though some fish species may be affected by the blockage of the river flows by the dam. The fishing yield that expected from the 60 square km Pak Mun reservoir was 100 kg/ha/year without fish stocking and 220 kg/ha/year with the fish-stocking program. However run-of-the-river reservoir cannot sustain such high yields, as they do not provide the appropriate habitat for pelagic fish species. In Thailand even storage reservoirs that perform better under fish stocking programs have a fish yield of about 19 to 38 kg/ha/year. The predicted fish yield from Pak Mun head pond was too high. A more realistic estimate would have been around 10 kg/ha/year. There has been no evidence to indicate that the fish productivity of Pak Mun reservoir has reached anywhere near the anticipated 100 kilogram per year."[Executive Summary].

The conclusion is absolutely unfair to EGAT because WCD has no evidence to support technical data to show the reasonability of using the rate 10 kg/ha/year for fish yield prediction. As mentioned before 10 kg/ha/year is an assumption based on established yields in storage reservoirs. One can similarly question the evidence or analyses used by the EIA to predict 100-219 kg/ha/year fishery yield from the Pak Mun head pond, which is clearly very high. Monitoring of fish catch upstream of the Pak Mun Dam by Mr. Pradit Sripapatrprasite has confirmed 10 kg./ha/year as a ball-park estimate. Furthermore fishing yields of 100-219 kg/ha/year have never been reached up till present in any reservoir in the Lower Mekong Countries on a sustainable basis.

The other point that shows the biased conclusion of WCD researcher is the data investigated by WCD and reported in page 47 that "*...the current catch by the remaining fishermen of affected 5 000 households is roughly estimated at 38.1 million Baht = 1.0 million US$. The annual fishing yields by the affected households before completion of the dam is estimated at 90.9 Million Baht = 2.4 Million US$. Fishing yield declined from 929 kg/year per houshold before dam (1982) to 507 kg/year per household after dam (1999). If the total number of affected households is 5 000 and average price per kg of fish is set at 20 Baht per kg, the total value of the 1982 annual fish catch is conservatively estimated at 90.9 Million Baht, equivalent at 2.4 million US$. Since the construction of the dam the number of fisheries household declined 24%. In 1999 the total value of the annual fishing yield can be estimated as: 3760 household X 507 X 20 = 38.1 million Baht, equivalent with 1.0 million US$. The value of the decline in fish catch after construction of Pak Mun dam is therefore roughly estimated at 2.4-1.0 = 1.4 million US$ per year."* [Page 47]

Based on WCD's data, it is clear that the WCD's data and WCD's conclusion are in contradiction. To conclude the decrease of fishing yield, WCD refers to the rate of 10 kg/ha/year, which would provide only 6000 ha X 10 kg/ha/year = 60,000 kg of fish catch or 60 tonnage of fish catch. There is a serious misunderstanding and misinterpretation of the report here. 10 kg/ha/year is merely cited as an assumed or likely yield from the head pond of the Pak Mun dam. This figure is meaningless in calculating decline because fishing yield and fishery revenue is accrued from the entire river,

upstream and downstream and is not restricted to the head pond site. The 507 kg/year /household is an average annual figure not limited to the head pond area. The basic conclusion of the WCD report is that the free-flowing river has higher annual fishing yield, which means higher revenue for fishing households and which is now clearly declining.[151] The fish yield and revenue from free-flowing river was neither correctly understood or estimated by the 1982 EIA. And bullet point 1 in Conclusion P.52 states this clearly.

But to compute the loss of fishermen's revenue, WCD refers the rate of 507 kg/year/household, which would provide 3 760 household X 507 kg/household/year = 1 906 320 kg/year or 1 906 tonnage of fish catch which is higher than the value estimated by 1982 EIA. The conclusion of WCD's report make the reader absolutely confused and suspect on WCD's objective to conclude such data.

Let's take a look again to the latest WCD report version:

Table 4.22 says that before dam construction, average annual catch upstream and downstream of the dam was 1 170 kg and 688 kg respectively. An average of both up and downstream dam fish catch at 929 kg based on a rough estimate of the percentage households fishing upstream and downstream at that time, 50 % of households fishing upstream, and 50 % of households fishing downstream. (1170+688)/2 = 929.

5,000 X 929 X 20 = 92.9 million Baht = estimated value of fisheries before dam

Table 4.22 in the current report mentions 421 kg/household upstream of the dam in 1997. Downstream of the dam households catch more fish and there is less decline in fish catch. Also the proportion of fishermen who changed occupation (Table 4.25) differed upstream 31.2 %, dam site 15.4 %, and downstream 16.7 %. The original number in Dr. Sansanee's paper was 23 % for both upstream and downstream)

Thus 31.2 % of 2500 fishing households stopped fishing upstream of the dam. That left 1,720 households X 421 kg/year = 724,120 kg/year.

Downstream (including damsite) 16 % of 2500 changed occupation (Table 4.25). 2,100 households X 507 kg/year (this number disappeared in the final report, but was in Sansanee's paper, it is realistic) = 1 064 700 kg/year.

724,120 + 1,064,700 = 1,788,820 kg/year

1,788,820 * 20 Baht = 35,776,400 Baht (= estimated value of fish catch after dam construction)92.9 million Baht - 35,8 million Baht = 57.1 million Baht annual loss in fish catch = 1. 5 million US$ annual loss.

Performance of Fish Pass

"*...The fish pass has not been performing and is not allowing upstream fish migration. A vertical slot fish pass or a Denil fish pass instead of a pool and weir fish pass may have been more effective.*"

This conclusion is unfair because the list of reference on page 109 appears two technical articles concerning the performance of fish pass at Pak Mun Dam. Both two articles were authored by Sanay Pholprasit, a Fisheries Expert of the Royal Thai Government Fisheries Department. It abstract is included here:

"*The study on fishes passing through the Pak Mun Fish Ladder and some factors affecting their migration was conducted after the Pal Mun Dam completed, between June 1994 to April 1996. The passing fishes were collected by trap at the uppermost passing chamber once a week, eight times during 2-hour period. Some physical water quality parameters were also measured.*

The results found that 63 fish species can pass through the ladder, and another 8 fishes species were found at the fish-entrance area. The average number of fish passing was 984 individuals per day. The highest average occurred in the early rainy season with 3 314 individual passing per day, and the lowest average occurred in the dry season with 30 individuals per day.

But the WCD's report did not mention even a bit of this report.

Please see P50 of the WCD report. Paragraph 4 clearly mentions that earlier monitoring studies recorded a greater number of species being able to ascend the fish pass than later monitoring studies. *It* goes on to state that despite different fish species found to be able to ascend the fish ladder, in the early years after dam completion highest quantity of fish found at the ladder was 200 kg/day in peak migrating season and in a later study in 1999, this was only 12 kg per day..

Misleading Conclusions

(1) Impact on Fish Migration and Fish Diversity
"*Of the 265 fish species recorded in the Mun-Chi watershed before 1994, 77 species are migratory and 35 species are dependent on rapid habitat. The latest survey after the construction of the dam recorded only 96 fish species in the upstream region.*" [Executive Summary]

"*Table 6.2 in Annex 6 shows that before dam completion 265 fish species have been recorded in the Pak Mun River, the latest survey after dam construction record only 96 species upstream of the dam. The calculated loss of 169 fish species is exacerbated by the difference in efforts and number of sampling points of the fish surveys before and after dam construction. Upstream, midstream and downstream of large tributaries of the Mekong River as the Mun and the Chi rivers the composition of species is changing.*"

This conclusion intend to convince the reader that Pak Mun dam construction caused a sudden reduction in fish diversity in the Mun river. The fact is that there are five creditable technical reports, which reveal the list of fish species found during the year 1969 to the year 1993 and the data of those reports indicated that only 158 fish species were found in the area. There are 19 fish species that has not been found after the year 1990, they are; - *Macrochirinchthys machrochirus,* (Pla Phukpla), *Parachela crygastroides* (Pla Pap), *Opnasus kotatensis* (Pla Nummuk), *Rasbora mysersi* (Pla Siew-kwai), *Rasbora retodorsalis* (Pla Siew-Kwai), *Cyclocheilichthys mekongensis* (Pla Numlung), *Mystacoleucus chilopterus* (Pla Kiyok), *Systomus aurotaniatus* (Pla tapiensai), *Systomus spiropterus* (Pla Tapiensai), *Catlocarpio siamensis* (Pla Takok), *Garra fasciacauda* (Pla Leahin), *Botia lecornti* (Pla Moo-sak), *Macronema macromnema*(Pla Sa-ngua), *Pangasianodon gigas* (Pla buk), *Clanus macrocephalus* (Pla Duk-oui), *Xenentodon canciloides* (Pla Kratunghew), *Parambasis siamensis* (Pla Pankeaw), *Tridentiger ocellatus* (Pla Boo-hangdok), and *Euryglassa harmandi* (Pla Baimai). So it may be stated that before construction of the Pak Mun dam, 139 fish species were found in the Mun River. WCD refers to the list of fish species recorded by Chavalit Vidtayanon, 1999, which his report has not been published on any creditable journal or magazine. It is very doubtful that while 5 groups of researchers found only 158 fish species, Chavalit found 265 fish species in the Mun River. His report could be an excellent technical article but it is questioned why international or domestic institute has not published his work. It is possible that his technical work does not meet an acceptable standard. WCD should not use his results for the conclusion because it makes the WCD's report incredible.

Number of Impacted Person
"*c) Villagers who permanently lost income from fisheries. The number of households affected in this manner was finally determined to be 6 202. The increase in the number (originally estimated to 2 140 households) was due, in part to the re-investigation undertaken by the committee for Assisting and Developing Fishing Occupation in the Pak Mun Project Affected Area, which came up with 3 179 households who lost their income from fishing during the dam construction. In addition, the kamnan and headman group, who did not joint the demonstration but submitted their petition for the*

compensation later, which was also taken into consideration"[4.7 Resettlement: project and actual impacts, Page 63]

"*Conclusion:*
The EIA for the project did not accurately predict the number of affected people, and the wide array of impacts experienced by the Pak Mun communities. Around 6 202 households who permanently lost income from fisheries initially were not considered affected by EGAT. The lack of accurate data on the effects of submergence in each village became problematic in determining who would be resettled and to what extent compensation would be given."[4.7 Resettlement: project and actual impacts, Page 64]

Both two paragraphs concluded in WCD's report shows that the WCD's researchers do not understand the facts in the case of Pak Mun compensation scheme. Traditionally, development project in Thailand would consider the impacted persons to be compensated only if they are directly affected by the project. The compensation measure has to be affirmed by the law. Those affected indirectly will be helped by the project in term of "subsidization". In case of Pak Mun project, it is the first time that fisheries loss is picked up as the issue to be considered and there is no law to practice the compensation. A lot of people residing nearby the Mun River claimed that they are fishermen and their fisheries income decreased as a consequence of dam construction. The agencies concerned had no evidence to identify whether they are fishermen or not. So all persons who have basic performance of fishing activities were accounted in the list of persons to be subsidized by the project.

Furthermore, to state those 6 202 households who permanently lost income from fisheries is not correct and contradicts the WCD's conclusion in page 47, which states that 3 760 households gain 507 kg of fish catch per year after dam construction. The fact that there was no legislation in place to identify, assess and compensate livelihood losses does not mean that these losses have not occurred. As far as the actual number of fisher people suffering losses due to disrupted fish migration and declining catches upstream and downstream, there is an absence of full assessment of both fisheries impacts as well livelihood impact beyond the actual project site. That the current study attempts to use both existing literature as well field interviews to analyse these aspects does not mean that losses have not taken place. The figure of 6 202 is based on the number of households compensated for fisheries losses till April 1999. The actual losses if it means permanent loss of fisheries are far higher, likely to be irreversible and have implications for a large number of households which are yet to be identified - and this is irrespective of whether they are considered eligible under current compensation criteria.

9.4 Social Aspect

It appears that the information for analysis of social impacts was solicited from an interviewing a small number of people who were protestors and who are currently demanding additional cash compensation. Such information was absolutely insufficient and biased. Please specify which information you mean here?

For the analysis, inferences were made on feeling not on established facts and were therefore rather subjective. No appropriate analytical tool was used. What is meant by a proper analytical tool?

The simple fact is that this study cannot be technically accepted as it was looking only at the negative impact and public issues and without due knowledge, which led to biased conclusions. What is due knowledge?

9.5 Resettlement Aspect

The 1982-1983 Environmental Planning Survey predicted 241 households as displace people. The actual number of families whose houses displaced by Pak Mun Dam is still 241. These houses

comprise 11 houses situated in the dam's construction site, 136 houses situated lower than the reservoir flood level of +108.00m MSL and 94 houses situated slightly above the flood level (+108.00m to + 108.50m MSL) The estimated number of resettlement households which EGAT submitted for Cabinet approval in May 1990 was 400. Therefore, to state that the actual number of households directly displaced by Pak Mun Dam was 1,700 as mentioned by WCD is not correct. The assertion here is incorrect. The figure of 1700 households is also given in the WB OED, 1998, see P.2, which says, "altogether 1700 households lost their house, land or both".

The WCD summary figure of 1,700 may be the number of households of all categories of affected people without carefully considering the different categories. The main body of the report mentions and describes the various categories of affected people. In fact, the other number of households affected by Pak Mun Dam can be divided into 4 groups as follows:

1. Directly-affected households, whose only agricultural lands inundated, was 490 families.
2. Directly-affected households, whose only lands were situated in the dam's construction site (at Ban Hua Heo), was 26 families.
3. Indirectly-affected households, whose houses were situated even above +108.50 m MSL but still worry about their safety because their houses are anyhow close to the river banks, or some of which are nearly surround with water, was 445 families (all of them had received the house – removal expenses.)
4. Indirectly-affected households, whose houses were situated near the dam site and probably affected by splinters and noise from rock blasting, was 194 families which 26 families is the same as families in 2. (they moved out for they were contented with compensation money)

In EGAT's normal practice, we have our resettlement Policy. This policy is to make the affected people better off. The recent evaluation by the World Bank indicated that resettlement operation at Pak Mun was successful and EGAT is one of the better agencies at resettlement throughout the world. (Reference: Report No.17541 Recent Experience with Involuntary Resettlement Thailand –Pak Mun, June 2, 1998 P.21-22)

To accommodate wishes of the affected people at Pak Mun, the enormous compensation packages were provided as follows:

- The land compensation rate is 35,000 Bath per rai (0.16 hectares). This rate was about 7 times the prevailing market rate, when project implementation started in 1991. At present, land prices in the project area are still about 75% of the compensation rate.
- In addition to the compensation paid for land and property, EGAT provides to those: (I) settling in resettlement are : a house plot of 800 sq m, a two-storey house of 4 x 8 m and a farm plot (up to 10 rai) ; (ii) settling in nearby village area: a house plot of 600 sq m, a two-storey house of 4 x 8 m. and a farm plot (up to 10 rai) ; (iii) relocating entirely from the area: 135 000 Bath; and (iV) affected by blasting and renting another house temporarily; 3 500 Baht/month.
- The generous compensation package has caused discontent among the non-affected villagers and has led them to seek inclusion in the list of affected people.
- Special considerations were made for villagers who do not wish to accept any of the resettlement options offered.
- A massive land titling exercise has been completed on time.
- Villagers have been given options to settle in the resettlement areas near the Sirindhorn dam, in their own villages on higher ground, or to move out of the project site.
- The full range of resettlement options have been offered even to those villagers living in Hua Heo who would not be affected by the flooding but who say they are affected by construction activities.
- Resettlement options (with 100 000 Baht for removal expense from normal) have been offered to people living between +108.00m and +108.50 m MSL. elevation, in addition to the earlier option of raising the house plot by back-filling.

- Vocational training was provided to affected families.

Compensation paying and provision of assistance for affected residences and farm land were completed in 1993. All affected villagers were satisfied without any complaint. The constant conflicts substantiates the finding that 'all affected' were not satisfied. Further all affected were not even considered eligible for compensation in the beginning as their losses were not assessed and had to go through a protracted negotiation process. P.80, Table 5.3, under decision-making, illustrates this long process. Further there is no conclusive evidence that the 'enormous' compensation as stated by EGAT has made the affected and resettled people better off. And finally, it is well established that a one-off cash compensation cannot substitute a permanent and sustainable source of livelihood, which in this case is the fisheries.

CONCLUSIONS ON ECONOMIC SITUATION

(We have looked at all available information, including the 1997 OED original questionnaries. Our consultant dealing with social aspects traced a sample of the OED study families to collect information on the current economic status. Further, we analysed NRDC village census data for the following years: 1990, 1992, 1994 and 1996. For the benefit of readers, we have presented the census data in Annex 3 of the report. The NRDC village census was not available for 1998 and thus we could not see what has happened to the economic condition of the families following 1997 economic impact. Besides, the methodology of the NRDC Census and significant variance shown over the period from 1990 to 1996 created problems in interpreting the data.

The OED study and village census stops at 1996. Living standards have probably risen significantly since the initial 1982-83 baseline, but that there has been a shift from a farm system mode of production (including fishing and livestock along with crops) to a more diversified production system in which non-farm labour (including labour migration to Bangkok) has become more important than production from the farming system.

The diversified economic situation enabled the families to have enhanced income even though most of the affected families did not replace the lost lands and livelihoods with the compensation money they received. The national economic downturn affected the economic situation of the affected families whose living standards prior to 1996 had become increasingly dependent on wage labour and especially on jobs in Bangkok. The OED sample pointed to a static level of income, but there was rising indebtedness among the affected families.

The sustainability of the living standards of those who lost access to land and communal resources (especially grazing with the result that many sold their large animals) is also related to the emphasis placed on cash compensation (some 66% of total resettlement costs). Few people used that to buy replacement land (those losing 4.5-8 ha on average bought only half a hectare of replacement land) but rather used it for housing, savings, assistance to children, and consumer goods. Because of the shift toward non-farm employment, the emphasis was on cash compensation which is now proving to be unsustainable.

While it may be possible that the shift toward non-farm employment began before the project, certainly the project (due to loss of land and grazing resources, and large amounts of cash compensation), significantly sped up the process.

Thus, the WCD revisited some of the 50 land losing households interviewed by the Bank-funded team in 1996. The social and fisheries teams - for reasons of comparing findings did field work independently - concluded that project affected people did suffer from reduced fishery productivity. The reservoir fishery (due to stocking of fish and shrimp) productivity was much lower than predicted to replace loss of fish upstream of the dam.

Inability to replace lost lands and common property resources coupled with significant drop in fish availability at the reservoir and upstream affected livelihoods of the affected people. The Thai economic downturn made the situation worse for the affected families.

9.6 Ecological and Environmental Aspects

On methodology and data gathering, literature reviewing was based mainly on very few previous studies and reports. There was hardly any new data and information collected except some observations based on very few site visits. Most of the data was collected from interviewing with the protestors. Such information was definitely biased.

Data analysis and assessment was made mainly negative information obtained from interviewing the protestors. The study should have included both positive and negative aspects of the project in order to produce an unbiased and inclusive result.

This study is at risk for technical integrity as it was produced with biased information and data. There were quite often that wrong data were being used and made inappropriate references (see example in the Public Health Aspect). As such, the lesson learnt presented in the report only reflects no justification. What kind of information can be considered unbiased?

> Between Pak Mun Dam and Kaeng Saphue, the study reported that 51 rapids were flooded when the fact is that there are only 8 sites which can be classified as rapid. These are; Kaeng Saphue, Kaeng Kai Khia, Kaeng Khan Rai, Kaeng Kham Phuang, Kaeng Tat Hai, Kaeng Khot Liew, Kaeng Khan Luen and Kaeng Tung Lung. Beside these 8 rapids, other places are merely submerged rocks. By reporting that 51 rapids were flooded, it was an intention of the writer to mislead the reader that the loss and negative impact from the construction of the dam was immense. What is the difference between rocks and rapids - rocks under water cause rapid formation? Question for the authors: are these rocks or rapids - if rapids do they have names?
>
> Generally, the natural vegetation mostly found on the riverbanks in some parts of the Mun river is Fresh Water Swamp Forest. During the dry season, these areas become barren with rocks and laterite soil that are not suitable for cultivation. These types of vegetation found mostly in the area nearby the city of Ubon Ratchathani and in the area of Si Saket Province. There is definitely evidence of dry season riverbank cultivation and communal grazing areas being affected by the project.
>
> For tourism study, the study should have the country data on social and economic condition, population income from 1995 until present. The economic crisis prevailed over the country has led to high unemployment and closing of several factories. People are facing with decreasing of income and purchasing power. During our monthly visits at Kaeng Sa Phue rapid over the years during 1994-1999, sales has been much lower at shops and restaurants in the area. Tourist visiting the rapid brought their own food as it is much cheaper than buying from the shop. The social aspect should also be incorporated this kind of data into the analysis as well.

9.7 Public Health Aspect

A number of official reports showed that the public health of the local people and communities have been significantly improved as a result of direct and indirect benefit from the Pak Mun Dam such as;

(1.) With an increase of income, people would have a better quality of life. Considerable improvement of public facilities and infrastructure is apparent such as, water work system, sanitation and road upgrading.
(2.) Fish restocking program have significantly increased amount of fish in the river, which has been the main source of protein supply in the local people's diet.
(3.) Local people have also benefited from the mobile medical unit serving the project area and its vicinity. Health problems and epidemic diseases are significantly lower than the previous record before the construction of the dam.
(4.) The snail intermediate host of blood fluke river disease *(Neotricular aperta)* has decreased since the implementation of the project.

Reference was made of only one document and data was old which could not represent the current condition of public health in the area. The data and information cited in the report was inaccurate and many errors were found. It is clear that the writer of this aspect does not have adequate knowledge and expertise in the field of public health. The report of Regional Office for Communicable Disease Control 7, at Ubon Ratchathani has not been used in the study.
Only negative impact of disease transmitted from the snail intermediate host was looked at. The fact that Pak Mun dam also led to the reduction of the host snails was not at all considered in this report.

The study was done by the person who has no adequate knowledge of public health. Erroneous data was used and miscalculated. Thus made this report of no technical integrity and value. Details of some of the mistakes and inconsistencies is attached.

Some Mistakes and Incompleteness Found in The Report

Topics and Contents in WCD Final Draft Report	Comments
4.8 Impact of Pak Mun Project **Page** 67, row 12, 13. The beta race Neotricula aperta B race, (changed as desired)	It should written as *Neotricula aperta*, beta race,
Page 67, row 16, 17. There is no information on the survival and reproduction of this snail in any large reservoir in Thailand. (deleted from page 67)	According to Temcharoen et al, (2000).(Ref. 3). The life span of one generation of *N. aperta*, beta race, in the Mun River was about 1½ years and snail began to lay eggs from late June to July. They laid eggs for a period of ten months. The eggs began to hatch from July. During July to October or November, the juvenile snails could not survive and died.
Page 67, row 19, 20, 21 However, recent cases have been reported from the known endemic area of *Schistosomiasis mekongki* in southern Laos not far from the site.	The endemic area of *Schistosomiasis mekongi* was in Khong Island, southern Laos. It is located at more than 150km from the project area and downstream of the Mun

Topics and Contents in WCD Final Draft Report	Comments
(not far is changed to 150kms)	River or dam site.
Page 67, row 24, 25, 26, 27, 28, 29, 30 Fish and snail intermediate hosts of the disease have been prevalent in the Mun River and could have become more abundant with the Pak Mun project implementation. In the Pak Mun reservoir, certain fish intermediate hosts of this disease are expected to thrive and could be a cause of transmission of the disease among those eating raw fishes and snails caught from the reservoir. It was anticipated that incidence of liver fluke might increase as previously demonstrated for the Nam Pong project in Khon Kaen. (deleted)	According to Ref. 1-2, *Bithynia sp.*, first intermediate host of liver fluke was found only in the rice field, ponds, small canal and the lake near the refugee camps. No *Bithynia sp*. was found in the Mun River. The cyprinoid fish bought from the market of three Amphoes in the project area were found habouring metacercariae of *O. viverrini*. However, none of cyprinoid fish collected from the Mun River was infected with *O. viverrini*. Thus, the infection in cyprinoid fish was only in the rice field, ponds, small canal and the lake near the refugee camps. In the Nam Pong Project, *Bithynia sp.* (snail first intermediate host), Cyprinoid fish (second intermediate host), villagers infected with *O. viverrini* and a habit of consuming uncooked fish of the people were found in the project area. Thus, these factors caused the increasing of prevalence of liver fluke in the Nam Pong Project. However, in the Pak Mun Project, no *Bithynai sp.*, snail first intermediate host of liver fluke and cyprinoid fish haboured with metacercaria of *O. viverrini* in the Mun River. Thus, the people in the Project area got the liver fluke infection by eating uncooked fishes caught from out side the Mun River in the Pak Mun Project area. According to two previous results, the Nam Pong Project caused the increasing of liver fluke infection in the villagers in the area but the Pak Mun Project was not the cause of increasing of liver fluke infection in the villagers in the area.
Public Health • **Prior to the Construction of the Dam** **Page** 71, row 17 From the literature review of Pak Mun Project studied by Team Consulting Engineers Co. Ltd. and the Faculty of Tropical Medicine, Mahidol University (1984), it could be summarized as follows. **61.4** percent and **63.3** percent of the people in resettlement and reservoir were respectively infected with one or more kinds of parasites.	According to Ref.2 (same reference as mentioned in the draft final report) the correct percents are **61.4** percent and **63.9** percent of the people in resettlement and reservoir area were infected with one or more kinds of parasites. (% changed as indicated)

Topics and Contents in WCD Final Draft Report	Comments
Page 71, row 31, 32, 33, 34, 35 A common finding in physical examination was Contact Dermatitis (10/1,000 rate in resettlement area, and (9.9/1,000 rate in reservoir area). It is note worthy that Cercarial Dematitis was well known to the people in both areas. This irritation of the skin caused by the penetration of cercaria of non-human schistosome is from the contact with swimmer itch (44.6 - 50.5% of the interviewees) and knowing to local people as "Hoi Cun" or Itching snail (74.7-75.6% of the interviewee). (this para has been replaced with the suggested text)	Contact Dermatitis is a kind of the skin diseases. However, in its summary the Commission conflated it with *Cercarial Dermatitis* which is a kind of the snail borne diseases. The irritation of the skin, *Cercarial Dermatitis*, is caused by the penetration of cercaria of non-human Schistosome which sheds from the snail, *Indoplanorbis exustus*. It is not from the contact with swimmer itch as mentioned in the report. "Swimmer Itch" is the other name of "*Cercarial Dermatitis*". The snail, *Indoplanorbis exustus*, is well known to the farmer as "Hoi Cun" or "Itching snail" and its habitat is the ponds, canals and rice fields. This snail was found only outside of the Mun River. According to comment 1 and 2, it shows that the commission has no knowledge on the snail borne diseases. This condition caused the commission to summarise the report incorrectly.
Page 71, row 37, 38, 39 The nutrition status of preschool children in the project area consisting of reservoir and resettlement area during 1983 is shown by the anthropometric data revealing that about **37.2 to 49.9%** of preschool children were under developed to some extent. Between **26.9% to 34.5%** of the children suffered 1st degree malnutrition suffered while **7.9 to 12.9%** suffered from 2nd malnutrition.	According to Ref.2 (same reference as mentioned in the draft final report) the correct percents are **31.5 to 51.7%** of preschool children were under developed to some extent. Between **26.0%** to **37.9%** of the children suffered 1st degree malnutrition suffered while **5.47** to **13.79%** suffered from 2nd malnutrition. (figures have been changed as indicated)
Page 72, row 1, 2 The stool examination of 921 local people of 21 villages indicated presence of liver fluke in 36.2% of local people and no prevalence of blood fluke.	According to the report of Surveillance and Prevention of Parasitic Diseases 1998, the prevalence of liver fluke was only 23.1% of the local people. 36.2%, as showed in the report, was the prevalence of infected people with parasitic diseases. (figures changed as indicated)

Topics and Contents in WCD Final Draft Report	Comments
Page 72, row 20, 21 However, the liver fluke disease is still found in the project area.	The results of stool examination of 6 287 people in the Pak Mun Project in 1994, 27.7% was positive for the liver fluke infection. Then, all infected people were treated with antihelminthic drug, Proziguantel.(Ref.4) However, the liver fluke disease is still found 1.09% of 2 743 cases in stool examination of people (Ref. 4) in the project area. (Incorporated this para in the report)
Page 72, 73	The Additional Comments on Public Health Issue: However, according to TEAM & Mahidol University (1984) and our field studies in the project area in 1994 to 1999, *Bithynia sp.*, snail first intermediate host of the liver fluke was found to inhibit in the rice field, ponds etc. but not in the Mun River itself or its tributaries. The villagers in the project area ate the uncooked cyprinoid fish collected from the Mun River. This fish would not be infected with the liver fluke as the epideiniology or life cycle of *O. viverrini* in the Mun River was not completed. Thus, the villagers got the liver fluke infection from eating the uncooked fish collected from the rice field or ponds. The copious population of *Neotricula* (=*Tricula*) *aperta*, beta race, snail intermediate host of *Schistosoma mekongi*, are in the Mun River or the project area. But the endemic area of the blood fluke, *Schistosomiasis mekongi*, is in Khong Island, southern Lao PDR. It is located more than 150km from the project area and downstream of the Mun River or dam site. Also, our field studies in the Mun River, the project area, began in May 1994 and continued monthly until April 1999. The population of *N.aperta*, beta race, were found decreasing than prior to the construction of the Pak Mun Dam. (Incorporated these paras in the report)
Page 73 Conclusion	**Conclusion** on page 73 should be added the following paragraph: The results of our field studies: the impoundment of the Pak Mun Dam increased in the depth of water, sedimentation of suspended solids at the waterbed. These

Topics and Contents in WCD Final Draft Report	Comments
	situations caused the reduction of diatoms, the natural food of *N. aperta*, the snail intermediate host of *S.mekongi*. These were the major factors causing a decrease in *N. aperta* populations in the Pak Mun area. (Added this conclusion to the report)

Reference

1. TEAM Consulting Engineers Co., Ltd. (1982). Environmental and Ecological Investigation of Pak Mun Project. Vol II. Main Report Page; VI 118-VI 171.

2. TEAM Consulting Engineers Co., Ltd. (1984). Final Report, Selected Environment and Ecological Investigation of Pak Mun Project. Vol II Main Report. Page ; II 1 – II 91.

3. Temcharoen et al, (2000). Field studies on Neotricula aperta, beta race, in the Mun River at Phibun Mangsahan, Ubon Ratchathani Province, Thailand : II. The life cycle. (in press)

4. Medical and Health Office EGAT's, (1995). Report on Surveillance Control of Parasitic Diseases in Pak Mun Area.

10. World Bank Comments on June 2000 Version of the Pak Mun Report

[Response to the comments are underlined. Response to the general comments in p147-151 not given as the executive summary has been revised answering the comments]

10.1 General Comments by the World Bank

1. The World Bank appreciates the opportunity to comment on the Pak Mun Dam Case Study, commissioned by the World Commission on Dams (WCD). We note that the Report is still a working paper prepared for the WCD, and that "the views, conclusions, and recommendations contained in the working paper are not to be taken to represent the views of the Commission." We understand that the series of case studies would be used to contribute to the larger body of knowledge on dams in preparation of the Commission's final report. In that spirit, we request that the Commission take into consideration the following comments.
2. We have grouped our comments under the following headings:
A. Bank's Views on Key Aspects of the Pak Mun Project.
B. Bank's Views on the Presentation and Conclusions of the WCD Report
Annexes:
Annex I Projected and Actual benefits of Hydropower
Annex II Aquatic Biodiversity and Fisheries
Annex III Social Aspects

10.2 Bank's Views on Key Aspects of the Pak Mun Project

Did the project comply with the criteria and guidelines of the day?

3. It is our view that the Pak Mun project (which was funded with $23 million from a World Bank loan and $157 million of EGAT's own funds and local borrowings), complied with the World Bank standards in effect at the time of appraisal in 1990.
4. The project was supported by: (a) an Environmental Impact Assessment (EIA) which was approved by the Office of Environmental Policy and Planning and the project was endorsed by the Cabinet; (b) an Environmental Impact mitigation Plan; and (c) a Resettlement Plan.
5. The environmental and social impact analyses, mitigation, management and monitoring plans conformed to the norms pertaining at the time of appraisal. Those norms have become more rigorous, however, over the last several years.
6. The height of the dam was reduced and its location changed to drastically reduce resettlement of persons and to preserve the Kaeng Tana and Kaeng Saphue rapids which are tourist attractions. This was done at a substantial sacrifice in power benefits. It is true that a new EIA was not prepared following these design changes, but this was not considered necessary as the environmental and social impacts earlier assessed were substantially reduced.
7. The project provided several measures for mitigating potential adverse impacts on fisheries including: (a) the construction of Fisheries Development and Conservation Centers; (b) provision of a fish ladder to facilitate upstream migration of fish; and (c) conduct of fisheries migration studies.
8. The project provided for the strengthening of health facilities, vigilance on potential diseases and studies related to health.
9. An economic analysis following the methodology laid down in the Bank guidelines was performed to justify the project based on its power benefits.

What were the weak points in project preparation?

10. In our view the following were the weak points in project preparation:

11. We agree with the WCD Report that the EIA had inadequate base-line information on fisheries in regard to: (a) the extent of dependency of the local population on fisheries; and (b) assessment of natural fluctuations in abundance of fish populations as well as the cumulative impact on aquatic resources from other development projects in the watershed.

12. The Resettlement Plan at the time of appraisal was not prepared in sufficient detail as to qualify for what the Bank now terms as a Resettlement Action Plan (RAP), a requirement mandated by later Bank guidelines.

13. There was lack of consultation with affected persons in the formulation of the Resettlement Plan and in the development of fisheries.

How were the social and environmental aspects handled during project implementation?

14. While it is acknowledged that the resettlement program got off to a slow start, significant improvements took place during implementation to make it one of the "good practice" examples of resettlement associated with dams (refer **Annex 3**). Substantial improvements were made in the physical infrastructure, such as roads, health centers, schools etc., in the project area. Effective mechanisms were put into place to resolve problems and complaints. It is noteworthy that people affected by other projects in Thailand demanded that their resettlement be carried out along the lines of Pak Mun. Follow-up surveys showed that the affected people were able to use their cash compensation for productive purposes, and incomes among re-settlers showed rising trends until the financial crisis of 1997. In respect of consultation in the resettlement planning process, a feature that was absent during project preparation, attempts were made to make up for this during implementation, but with little success. Health aspects of the project were well handled.

15. Before project implementation, in August 1990 EGAT prepared an Environmental Impact Mitigation Plan for the project which covered resettlement, forest conservation (primarily related to the newly created Kaeng Tana National Park), tourist attraction conservation, fisheries development, health aspects, land transportation improvement and archaeological salvage, public relations and environmental monitoring. With respect to each aspect, the scope of work was defined, responsible parties identified, budgets prepared and funds were allocated. This plan was carried out in its entirety.

What are the Bank's views on the fisheries aspects?

16. The lack of detailed baseline studies on fisheries has created serious problems that have remained unresolved to this day. When the issue arose for compensating persons who had lost income from fisheries due to project construction activities, it was not possible to determine the number of fishermen that were actually affected or the loss of income they had suffered. This resulted in exaggerated and ever-increasing claims for compensation. This lacuna has also resulted in current (in our view unsubstantiated) claims that the Pak Mun project has been directly responsible for a permanent and substantial loss of fish species and fish catches.

17. While acknowledging that more could have been done in project preparation to establish baseline data on fisheries, the Bank considers that it is important to differentiate between the impact on fisheries on the project per se and the adverse impacts caused by many other factors, including fishing mal-practices, population pressures, pollution and other environmental factors, as well as the impact of poverty which afflicts the region. It is necessary to undertake a more thorough analysis of the entire fisheries issue before coming to definite conclusions (refer **Annex 2**).

18. At the time of project completion, the Government and EGAT had complied with the agreements reached with the Bank in putting into place the Fisheries Development and Conservation Centers, in stocking fish in the reservoir, in constructing and monitoring the performance of the fish ladder and in conducting fish migration studies. Of late the Fisheries Conservation and Development Centers are inactive, the fish ladder monitoring abandoned, and stocking of fish in the reservoir discontinued. This state of affairs needs to be rectified.

19. Finally, the Bank is of the view that the solution to the fisheries problem is to strengthen the management of fisheries, in close consultation between the Government, the local fishermen and fisheries experts, and the Bank stands ready to assist in this area.

10.3 Bank's Views on the Presentation and Conclusions of the WCD Report

Report Presentation

20. While the main body of the Report faithfully reproduces the material collected by the various teams, the Executive Summary and the Summary Findings (Section 7), overemphasize the negative impacts, in many cases with insufficient analysis or without regard to differing views (the latter have been by and large relegated to Annexes 3 and 9).

21. The Report does not include references to two Bank evaluations of the Pak Mun Dam. The Bank's Operations Evaluations Department (OED), which reports directly to the Executive Directors of the Bank and has a reputation for unbiased retrospective evaluations, reviewed the Pak Mun Dam project and found its resettlement actions to be "best practice". The Bank's Implementation Completion Report (ICR) for the Third Power System Development Project rated Borrower Performance during project preparation as Satisfactory and during implementation as Highly Satisfactory.

Study's Limitations

22. The Report acknowledges the study's time constraints, however, the summaries do not fully address: (a) the limitations under which the study had to be undertaken and how this could affect the conclusions; (b) the adversarial environment under which data had to be gathered from brief interviews which could result in a heavy anti-dam bias; and (c) the possible influence on the data of the 1997-onward economic crisis affecting the entire country and more predominantly the rural areas, and the broader issue of poverty in the northeast of Thailand.

Hydropower Planning, Economic and Financial Analysis

23. The Report contains a number of factual errors in the technical areas of hydropower planning and analysis, where the Report draws heavily on simplistic analyses by its researchers and has relegated the responses of specialists to annexes, with little reference to those responses in the body of the report or the executive summary.

24. The Report questions the analyses of the Bank in several areas and concludes that the benefits of the project were overestimated during the planning stages and that in operation actual benefits were less. The Bank disagrees with these conclusions. These issues are briefly dealt with in the following paragraphs, and a more detailed elaboration is provided in **Annex 1**. The Bank has found the project economically viable and the economic benefits gained from the dam fully justify its construction.

25. The Report says that "no proper economic analysis was conducted of the project". It finds as "*strange that the World Bank in its 1988 analysis did not use conventional IRR calculation.*" As explained in detail in **Annex 1**, the method the Bank used to evaluate the economic viability of the project was the appropriate one for a power project which was being constructed as a component of an integrated system. And this methodology complied with the Bank's guidelines.

26. The Report relies on a "thermal equivalent methodology" to conclude that EGAT and the Bank were incorrect in their assessment that Pak Mun would be more economical than a thermal power plant in delivering similar quantities of power to the EGAT system. The thermal equivalent analysis, although widely used in the hydropower industry, is approximate at best. Based on the assumptions pertaining at the time of appraisal, the Bank maintains that the appraisal least-cost planning study, which compared alternative expansion plans, provides the best estimate of the relative economic merits of Pak Mun and of alternative thermal expansion.

27. The main area where the Report's analysis is considered to be the most debatable is in its assessment of the capacity benefits of a run-of-river project to a large power system. It is normal to operate storage and run-of-river plants in a complementary fashion, with run-of-river projects

operating in the wet season on base load and storage plants minimizing their energy output by operating on peak. In the dry months the storage plants compensate for the shortfalls of the run-of-river plants. EGAT's system meets this criterion in that it is large, diverse and has a substantial proportion of storage based hydropower plants. The rigorous analyses conducted by EGAT and the Bank at appraisal were designed to take into account these effects.

28. The Report makes an error in attempting to carry out a financial analysis of the Pak Mun project, using EGAT's average tariff as its revenue. The appropriate procedure would be to apply the average tariff as a revenue to the overall expansion program or a "time slice" of it. However, the appropriate rate of return is not the opportunity cost of capital as stated in the Report (a real rate of 12 %) but rather the average costs of capital, which in EGAT's case is about 6% in nominal terms.

Aquatic Bio-diversity and Fisheries

29. On aquatic bio-diversity and fisheries, the Report's conclusions are seemingly in contradiction with the data provided in the body of the report, its annexes, and other supporting documents that were prepared as part of the assessment of the impact of the project. The report emphasizes perceived adverse environmental impacts on aquatic biodiversity and fisheries by the Dam while not giving due attention to indications of benefits derived from the available data (refer Annex 2).

30. The Report (page 45) indicates that before dam construction there were 265 fish species in the Mun River and after construction the number fell to 96 species in the upstream area. The supporting analysis ignores actual historical data on fisheries and adverse influence on fisheries of factors other than the Pak Mun Dam; the conclusion about the drastic reduction of almost 169 species due to the Pak Mun dam is erroneous.

31. The Report has made conclusions on the number of fishermen affected, the reduction in fish catches and in income from fisheries based on interviews with the affected people, without addressing inconsistencies in data. The catches from the Mun River and head-pond are difficult assessments to make, for often only the commercial catch (sales) is reported and not the subsistence catch. This difficulty is further compounded by the fact that fisher folk are being compensated by the Government for losses in fish catch. This can lead to underreporting. Moreover, fish production can be affected by a wide range of events, some of which are anthropogenic (e.g., fishing intensity, enforcement of regulations, deforestation, pollution discharges, etc.) and others that are natural phenomena such as the timing and quantities of precipitation. Therefore, there is a complexity of factors that can affect records of fish yields that often require many years of baseline data collection and analysis to determine not only what all the impacts are but also what weight should be applied to each in making an assessment of changes in fish production.

32. The data from the Project Area, as taken from Annex 1C of the Report, compares the annual catch per household at the beginning of the construction period and the year after construction. This is the only data available that includes the number of households engaged in fishing with the number rising from 302 in 1992 to 613 in 1995. The annual catch per household increased as well from 118 kg to 778 kg or a gross overall increase in fish yields from about 35.6 t to 476.9 t. This production increase was most likely due to the expansion of aquatic habitat (60 square km) that also benefited from the relatively large catchment area (117 000 square km) from which considerable nutrient runoff. These nutrients would enter the head-pond, be retained, and is the base for primary productivity as a key driving force in the food chain. The stocking program of indigenous freshwater prawns and fish took further advantage of this increase in natural feed availability.

33. In summary, it is clear that a more rigorous analysis is necessary to verify the consistency in data collection methods and to resolve the inconsistencies in available data to the degree possible, before arriving at potentially misleading conclusions on loss of aquatic bio-diversity and depletion of fish catches and income from fisheries.

Social Aspects

34 The Report also does not address in its summaries the views expressed by EGAT and the Department of Fisheries (DoF) on various aspects. These include: (i) exaggerated loss of income from fisheries; (ii) exaggerated number of affected fishermen; (iii) uncertainties regarding overestimation of fish yields by the EIA; (iv) non-recognition of the measure of success in the operation of the fish ladder; (v) uncertainties on the exaggerated loss of fish species; (vi) uncertainties on rapids as spawning grounds; (viii) uncertainties on the exaggerated loss of income from fishing using Pla Yon traps; and (ix) doubts on the success of shrimp stocking in the reservoir. While the views of EGAT and the DoF have been published in Annex 7, they have not been given due prominence nor analysis while arriving at the conclusions in the report summaries.

35. The Report does not present a balanced view of resettlement and compensation issues, and fails to take note of the significant achievements of the Pak Mun resettlement program (refer **Annex 3** and para. 14).

36. The WCD report prior to the Stake-holder Meeting, gave due recognition to the National Rural Development Committee (NRDC) census and presented conclusions based on the data. We have reproduced this in **Annex 3** (of World Bank comments). However, in the current version of the Report, NRDC census data has been relegated to Annex 3 of the WCD report. What is striking is that this analysis and conclusions based on this data get substituted, without explanation, by a fresh Section 4.6.2 Actual Impacts: Fresh assessment and affected people's views.

Environmental Aspects

37. The main conclusions of the report and our comments, in brackets, are: (a) loss of 56 hectares of riverbed area and 7.52 hectares of land near the sand bar area, resulting in a loss of income from cultivation of vegetables etc. during the dry season (proper assessment of such income is, in our view, difficult and the income is in any case a very small percentage (about 4%) of the total income); (b) loss of 51 natural rapids between the mouth of the river and Kaeng Saphue, resulting in a negative impact on fisheries and cultural practices (the number 51 is, in our view, not an established number and the impacts are conjectural); (c) partial loss of natural beauty of the Kaeng Tana rapid due to increase in water level caused by the dam (the Kaeng Tana Rapids are supposed to have been enhanced by the project, which allowed for flow even in the dry season); (d) inundation of the Kaeng Saphu Rapids for about 7 months of the year (the project does not contribute to any increase in the inundation period of the Kaeng Saphue rapids); and (e) decline in tourism near the rapids (a view not supported by proper data).

10.4 Annex I Projected and Actual Costs and Benefits of Hydropower

[WCD's response for each of the points is given and underlined]

Cost of the Project

1. The Executive Summary makes an appropriate comparison for the economic analysis, i.e., costs are compared in constant terms before duties and taxes, concluding that the actual total project cost did not differ significantly from the original estimates in 1988 (despite large increases in compensation costs). However, the statement in the body of the report presents a somewhat different conclusion: "real cost has not changed much since 1980 irrespective of the fact that the final project is considerably smaller". Modifying the project (between 1980 and 1988) to reduce the reservoir area by one half (and thereby lessening the resettlement needs) did, according to the calculations made in the Report, reduce costs in constant terms by 20 percent which is significant. The fact that this was a lesser percentage than the 33 percent reduction in energy is a measure of the trade-off made of economic benefits in return for a reduction in the social impacts.
Response: At constant 1998 prices, total project costs in 1999 not including taxes and interests is 11% over estimated costs in 1988. However, the cost of the final project is not too different from the cost of the original project in 1980 to reflect 33% reduction in energy.

Hydropower Benefits

2. The report correctly notes that energy output of Pak Mun over its first five years of records exceeds the projections of the feasibility studies and the Bank's appraisal.

Response: The projection was 283 GWh/year, actual generation was 289 GWh on average, which is basically the same.

However, it questions the analyses of the Bank in several areas and concludes that the benefits of the project were overestimated during the planning stages and that in operation actual benefits were less. The Bank disagrees with these conclusions. The analysis could have benefited from a greater understanding of the way the Bank appraises projects and more accurate interpretations of certain aspects of the complex fields of power system planning and hydropower economics. These issues are briefly dealt within the following paragraphs.

Economic Analysis

3. The Bank considers the project economically viable and the economic benefits gained from the dam fully justify its construction.
4. The Report says that "*no proper economic analysis was conducted of the project*". It finds as "*strange that the World Bank in its 1988 analysis did not use conventional IRR calculation.*" As explained in detail in the following paragraphs, the method the Bank used to evaluate the economic viability of the project was the appropriate one for a power project which was being constructed as a component of an integrated system. According to the Bank's operating procedures, the project itself should be demonstrated to be part of the least-cost expansion plan, and the Economic Internal Rate of Return (EIRR) should be calculated for a "time slice" of the overall expansion plan using average tariff (or the demonstrated "willingness to pay") as a minimum proxy for economic benefit. This was the process used by the Bank during appraisal.
Response: Bank seems to ignore the next paragraph that mentions that traditional IRR analysis as well as equalizing discount rate analysis was performed on two projects in Thailand in 1979. Was this done against Bank rules?

Applying the average tariff to a particular generation project, as suggested by the Report, would give misleading results.

Response: Report suggests this point.

Financial Analysis

5. The Report makes a similar error in attempting to carry out a financial analysis of the Pak Mun project, using EGAT's average tariff as its revenue. The appropriate procedure would be to apply the average tariff as a revenue to the overall expansion program or a "time slice" of it. However, the appropriate rate of return is not the opportunity cost of capital as stated in the Report (a real rate of 12 %) but rather the average costs of capital, which in EGAT's case is about 6% in nominal terms.

Response: 6% was not mentioned as a benchmark return on the Economic evaluation

The Bank's appraisal of the project included financial projections of EGAT which were appropriate for an integrated power utility.

Response:
(1) Does this means that if a public utility can survive unproductive investments financed by the WB such investment are acceptable?.
(2) Financial analysis has been dropped from the report

Least-Cost Analyses

6. The Report relies on a "thermal equivalent methodology" to conclude that EGAT and the Bank were incorrect in their assessment that Pak Mun would be more economical than a thermal power plant in delivering similar quantities of power to the EGAT system. The thermal equivalent analysis, although widely used in the hydropower industry, is approximate at best. Unless a thermal alternative could be clearly identified, it is not accepted by the Bank as a basis for appraisal, although it may be accepted as demonstrating an initial case of economic viability. This assessment appears to be shared by the WCD Secretariat in the thematic paper on "Financial, Economic and Distributional Analysis." In that paper, it is noted: "sophisticated best practices for the evaluation of power benefits are often employed in dam appraisal, and these methods appear to be relatively reliable in predicting performance, however exceptions do occur, particularly where a simple alternative power plant method is employed." Based on the assumptions pertaining at the time of appraisal, the Bank maintains that the appraisal least-cost planning study, which compared alternative expansion plans, still provides the best estimate of the relative economic merits of Pak Mun and of alternative thermal expansion.

Response: The WCD agrees with this point. However neither EGAT nor the WB was in the position to show WCD the outputs with and without Pak Mun system studies done as part of the planning work. Nowhere in the historic documents given to WCD there is mention of these system studies. Instead in all documents the approach is to compare Pak Mun to oil-fired gas turbine.

7. Thermal alternative analyses are prone to error, but based on the review carried out in later paragraphs, assessments carried out in the planning phase appear to have formed reasonable, if conservative assessments of Pak Mun's economic viability in comparison with a thermal alternative.

Response: The assessments are not conservative. Practically in all cases the Pak Mun project is compared with a gas turbine for both capacity and energy. More than half of Pak Mun's production is in the wet season during off-peak hours. During these hours the marginal generation is oil-fired steam plant, and during the night even lignite fired steam plant, with much lower incremental heat rates, and for lignite much lower cost per GJoule, than gas turbines.

In contrast, the analyses presented in the Report include some basic errors.

8. The area where the Report's analysis is considered to be the most debatable is in its assessment of the capacity benefits of a run-of-river project to a power system. It correctly notes that run-of-river projects are less valuable to the system than storage projects[152] because of the intermittent nature of flows and, therefore, of energy output and of capacity availability. Unfortunately, storage projects, which require a larger land area for the reservoir, invariably have greater environmental and social impacts which led EGAT to try to develop a run-of-river project. The intermittent nature of the flows was fully appreciated in the planning and preparation of the project. Regrettably it also applies to other types of renewable energy such as those produced by wind and photo-voltaic solar cells However, while this is a serious problem in a small systems served solely by an intermittent source of energy, the disadvantages of this kind of a project are offset when the project forms part of a large diverse system, particularly when that system has substantial hydroelectric storage plants. It is normal to operate storage and run-of-river plants in a complementary fashion, with run-of-river projects operating in the wet season on base load and storage plants minimizing their energy output by operating on peak. In the dry months, the storage plants take over. EGAT's system meets this criterion in that it is large, diverse and has a substantial proportion (in 1999 11% of peak, 15% of installed, and only 4% of kWh) of storage based hydropower plants. The rigorous analyses conducted by EGAT and the Bank at appraisal were designed to take into account these effects.

Please find also below a rather intriguing table

	Water released for power generation	Installed MW	Produced GWh	CUM/MW	MCM/GWh
Total Hydro 1999 (1)	21,137 (3)	2,874	3,433.46	7.36	6.16
Pak Mun (May 1996-August 1999, annualized)	14,501	136	287.70	106.62	50.40
%		5%	8%		

Sources: (1) EGAT 1999 Yearbook; (2) calculated from data supplied by EGAT; (3) it is likely that water used by Pak Mun is not included in this figure

Response: The figure above shows that Pak Mun could indeed save up to a maximum of 8% of storage dam water. However, since according to WB Pak mun is operated at a peak plant only in the dry season, this savings should be much less.
The table above also indicates the inefficient way Pak Mun uses water. This comes from the low head.
These general remarks are not disputed by the WCD. But there is no evidence of such planning work in any of the documents submitted by WB or EGAT. EGAT should show when any storage dam water has been saved up with the help of Pak Mun generation? Which dam turbine is shut down when Pak Mun operates?

One has to put into doubt that EGAT can really plan the use of Pak Mun in the countrywide system properly. It has told TDRI in an official letter that it does not keep records of on and off-peak generation of Pak Mun. It has also told us they have no record of other system wide support activities of Pak Mun such as Var support.

However, why don't we turn the question around and ask WB/EGAT to present the data of how much water and power from storage dams was saved during Pak Mun operations by reducing storage dam output by the amount equivalent to Pak Mun at the time.

Irrigation and Fisheries Benefits

9. The Report gives the impression that irrigation and fisheries benefits were taken into consideration to justify the project. The Pak Mun project was justified and accepted solely on the basis of its hydropower benefits. Irrigation and fisheries benefits were not considered by the Bank to justify the Pak Mun Dam Project.

Response: As far as the Bank is concerned, this is true. The last planning document of EGAT calculates the EIRR with and without fisheries and irrigation benefits.

World Bank Appraisal Process

10 The Report examines the methodology used by the Bank in estimating the economic benefits of Pak Mun. In this regard we would like to affirm that the methodology used for appraising Pak Mun followed the Bank's standard guidelines as set out in the attached extract from OMS 3.72 dated September 1978. According to this, appraisal consists of three steps: (i) rigorously estimate demand; (ii) investigate whether the project is the least costly means of meeting the anticipated level of demand; and (iii) determine whether the project per se is worth executing, by establishing that the benefits of the project as a whole exceed its economic costs. Dealing with each step in turn:

- No questions have been raised with respect to EGAT or Bank estimates of demand;

Response: Agreed.

- With respect to the second step, the OMS states " The determination of the least cost alternative usually involves the comparison of different time streams of capital and operating costs by an appropriate discounting technique". At the time of appraisal, EGAT had already demonstrated this, since its Power Development Plan (PDP) including Pak Mun had actually been developed using a sophisticated least cost planning computer program. However, since the PDP was an overall system planning exercise, a more project oriented analysis was needed to justify the specific Pak Mun investment decision. Therefore, the Bank requested EGAT to carry out additional computer runs comparing the "next" best expansion plan without Pak Mun, with the already developed least cost plan including Pak Mun. This exercise confirmed that the plan with Pak Mun remained the least cost solution with discount rates up to 15.7%. Sensitivity analyses carried out confirmed the robustness of its economic viability to changing circumstances. [153]

Response: If a proper systems analysis had been done it would have been easy to extract the net benefits attributable to Pak Mun by subtracting the cashflows of the best system development with Pak Mun (at zero investment) from the cashflow of the system without Pak Mun. Nowhere was this done.

The WCD would have liked to get a copy of the detailed outputs of EGAT's runs with and without Pak Mun as done during the WB project appraisal. In the run without Pak Mun, what choice did the program have with respect to additional thermal generation. Did it include the free choice of any number of 50 MW gas turbines? Was the year to year fluctuation of Pak Mun's production part of the LOLP calculations, and if yes, how was this done? Was this a run for the NE region of Thailand, or a run for the whole EGAT system? If the run was for the whole system, where was the gas turbine addition located, and why was the unit capacity only 50 MW? Why do all planning reports discuss the 'dependable' capacity as a planning consideration for NE Thailand when in fact a 'whole' system run was done? We really wanted to examine all questions listed above.

Further, we had other important questions:
why, if system studies were done, was a 'more project oriented' approach necessary?

Why was the turbine chosen to be 50 MW?. At the time of the appraisal many companies were able to deliver turbines of almost any capacity up to about 80 MW.

WB argues that the inclusion of the Pak Mun project was based on the results of runs of a Power Development Plan (PDP) including Pak Mun had actually been developed using a sophisticated least cost planning computer program. How come that still now Pak Mun is included in the PDP analysis as a fixed plant. Please see pages 64 and 65 of Griffon Report. Is EGAT using less sophisticated analyses now than 12 years ago?

- Regarding the third step, the OMS states that "In most cases it will not be possible to quantify the economic benefits by consumers in excess of the amounts they actually pay and therefore the estimate of the social value is precluded. It is normally possible to calculate an incremental financial return based on revenues from additional sales attributable to the project …this usually represents at least a minimum estimate of the economic rate of return". The OMS also notes: "A second difficulty arises from the fact that where the project consists of selected parts of an expansion program, it may not be possible to attribute the benefits deriving from these separate parts." The solution offered is to "…ignore the project and use the whole investment or a "time slice" as the basis for calculating the incremental financial return". The economic analysis carried out in the Staff Appraisal Report (SAR) also followed this methodology. As reported in the SAR, "To confirm the viability of EGAT's PDP, the Economic Rate of Return (ERR) is calculated on the basis of the incremental cost and benefit streams associated with the 1990-99 time-slice of EGAT's overall investment program.", and "The projected levels of EGAT tariffs producing the minimum covenanted 25% self-financing ratio are used as a proxy for benefits, ignoring consumer surplus." "The ERR on this expansion program is 16 percent.".

Response: It was presumably assumed here that EGAT would raise its tariffs in such a way that the financial targets would be satisfied. It is therefore not surprising that a 16% return is obtained. How did the projected tariff increase compare with actual tariff increases?

11. Based on the above, the Bank considers that the economic justification methodology used in the appraisal of the Pak Mun project was rigorous and in conformity with its operational procedures.
Response: The analysis may have been rigorous, however it was not presented to the Board of Directors of the Bank, nor has this sophisticated analysis ever been presented to anyone else so far.

Thermal Alternative Analyses

General

12. At various stages of the preparation of the project "thermal alternative" analyses were carried out in relation to Pak Mun by consultants and by EGAT. The Report criticizes the earlier analyses and presents its own to demonstrate that the equalizing discount rate of the Pak Mun project was greatly overestimated. The thermal Equivalent analysis, although widely used in the hydropower industry, is approximate at best and unless the thermal alternative can be clearly identified [154,] it is not accepted by the Bank as a basis for appraisal, although it may be accepted as demonstrating a "prima facie" case of economic viability.

Response: Agreed. (this point needs correction)

However, given the extensive reliance placed on thermal alternative analysis by the Report a review of the thermal alternative approach and the potential sources of error in it are presented below.

13. The objective of thermal alternative analysis is to predict the results of a rigorous least cost planning analysis of the type carried out by the Bank and EGAT at Pak Mun appraisal. That is, if the rigorous analysis were to be carried out, what combination of thermal plant and fuel would replace the

hydropower plant in the "without hydro" alternative expansion plan. Based on this selection an equalizing discount rate is calculated.[155] In formulating the thermal alternative there are two basic choices, the type and amount of thermal capacity and the type and amount of thermal fuels.

Response: We have not seen "a rigorous least cost planning analysis", thus it was assumed that the thermal alternative analysis was the only one applicable.

Capacity

14. It is necessary to predict both the type of plant and quantum of capacity that will be displaced. The type of plant is the analyst's best estimate of the plant that would be displaced or deferred because of the hydropower plant. Even this decision is not straightforward. If it is decided that a hydropower plant would displace a new coal fired steam turbine capacity, it would be wrong to assume a 134 MW hydropower plant would displace a 134 MW coal plant when the current size of coal plant being built in the system is 600 MW (with associated economies of scale reducing unit capital cost and increasing efficiency). One would have to look more closely at how the alternative investment program would be affected. There are also complications determining the quantum of capacity to be displaced. In selecting the appropriate capacity, the analyst needs to take into account the following differences between hydropower and thermal plant:

- Hydropower plant has a higher mechanical availability (after planned and forced outages) than steam turbine or gas turbine plant. None of the planning reports quotes complete data in use at the time[156]. However, Sogreah uses an overall availability for hydropower of 95 %[157]. For thermal power typical values in use at the time[158] were 78 % for 600 MW coal fired units and 82.5% for gas turbines. These values are consistent with the partial data quoted by Sogreah. .

Response: Availability considers planned and forced outage. The availability of a gas turbine does not only depend on mechanical availability but also on the availability of gas. That is why gas contracts contain non-delivery penalties. The availability of a dam depends mainly on the availability of water.

Hydropower plant may also need to be de-rated if hydraulic head [159] is regularly below the "rated" head, the head at which a turbine can deliver its full rated output. EGAT for its overall system planning exercises assumed a "dependable capacity" for hydropower of "the unit output at reservoir water level corresponding to 90% of the water level frequency based on long term reservoir simulation, using past hydrological records". It is clear from this definition that its pre-occupation is with its large storage reservoirs and multi-purpose reservoirs which draw down substantially during dry seasons.[160] The definition has no relation to possible energy limitations which are discussed in the next paragraph.

Response: There may have been confusion here. In the classical sense 'dependable' capacity is also related to the duration it can be supplied. The capacity which Pak Mun can reliably provide power over 4 hours, which was the peaking period in NE Thailand at the time Pak Mun was conceived, is 20 to 40 MW, depending on whether one looks at daily or monthly energy outputs.

- For hydropower plant, capacity might be limited by the amount of flow (and thus the amount of energy) available. The amount of energy required will depend on how it is required to operate in the system. In a mixed hydro-thermal system a "run-of-river" hydro plant like Pak Mun will normally be dispatched first in periods of very high flow (full base load operation) and last in periods of very low flow (to serve the extreme peak). For flows in between these extremes, other duties might be assigned. In general, dispatch in peak periods will be maximized because in these periods fuel replacement will be more valuable. However, dispatchers might partially vary from this approach if it is considered that load following and system ancillary services (standing and spinning reserve, frequency regulation) are more valuable to the system, particularly if the system

is amply served with peaking capacity on a particular day. The amount of energy actually required will thus depend on many factors including the predicted maximum demand, the shape of the load curve, the overall capacity of the system and the current availability of this capacity, the composition of plant in the system including storage capability of the various hydropower plants, system requirements for ancillary services etc. The dispatcher considers all such factors in determining the optimum dispatch to meet system requirements. The use of computerized generation planning techniques has greatly simplified the job of the system planner, since the programs simulate the operation of the entire system on a monthly basis, attempting to emulate the actual decisions that would be made by the system dispatcher. Therefore, if one is carrying out a computerized generation planning analysis as EGAT carries out for its PDP and as EGAT and the Bank carried out at appraisal, it is not necessary to manually allow for de-rating of hydropower plant because of energy limitations. The program does this automatically. If in a particular month[161], hydropower energy limitations result in the full hydropower capacity not being dispatchable, and this results in load shedding, then it will be taken into account in the calculation of Loss of Load Probability. However, if one is attempting to define a "thermal alternative", then it is necessary to estimate to what extent, if any, energy limitations will limit the usable capacity of the hydropower plant.

Response: This is all logical. The sentence before last is important. If the LOLP *with* the hydro in very dry months increases to impermissible levels, then the hydro capacity must be complemented with other forms of generation.

In EGAT practice Pak Mun entered the model as a fixed plant according to a schedule of output.. Since Pak Mun is so small and so unpredictable power is taken whenever it is available and fits in with needs.

- Power plants of the same capacity, but with different sizes of generating units, will have different effects on overall system reliability. This is because an outage of a large sized unit (whether forced or planned) will reduce system load carrying capability more than for a small unit.

Response: It is also the case that energy limitations of the hydro plant affect the whole station, irrespective of the number of turbines. Besides that, other hydros may in the same period also suffer from the same feat. This is not detected when working with average year hydro capacities.

Energy

15. The type of thermal generation displaced is only partly related to the type of power plant assumed as the alternative. Introduction of a new plant into an existing mixed system generally results in a complex re-arrangement of energies generated by existing power plants. Again, this is handled readily by the computerized generation planning program, but in defining a "thermal equivalent" the analyst needs to make his best estimate of this re-arrangement. The only numerical adjustment required to determine overall thermal energy in the equivalent plant is for possible difference in transmission losses depending on relative locations of the alternative power plants with respect to the load.
Response: Agreed

16. What can be concluded from the above review is that in a complex mixed system, definition of a thermal alternative, which will adequately reflect capital costs and fuel displaced by a new hydropower plant being introduced into the system, is very difficult and different analysts are likely to come to very different conclusions. For project appraisal a rigorous system planning analysis as carried out by the Bank and EGAT is indispensable.

Response: Documents related to "rigorous system planning analysis" have not ben available and thus there is no way to verify it.

17. Based on this background, the various thermal alternatives assumed over the years are briefly reviewed.

Sogreah

18. It is important to review the Sogreah analysis since one of its assumptions has been adopted by the WCD Report and has strongly influenced its conclusions. The analysis is presented in the Sogreah report dated October, 1985 although the planning criteria were agreed with EGAT in December, 1983[162]. It is clear from the discussion in this report, that EGAT and Sogreah realized that the definition of "dependable capacity" used for overall system planning purposes was not adequate to define the value of a run-of-river hydropower plant to the system in the context of a specific investment decision As a tool for project optimization studies, Sogreah in consultation with EGAT came up with what was considered to be a conservative derivation of the "thermal equivalent". For capacity "…it was decided to calculate the peak capacity of the Pak Mun project as the average capacity generated during peak hours (4 hours a day), using day to day simulation over the whole period of records." Since EGAT had no gas turbine or oil-fired steam capacity in their expansion program it was decided to use coal-fired steam turbines as the alternative. With regard to fuel, in view of the unknown mixture of oil and coal, a conservative approach involving 80 % coal and 20 % oil was adopted.

Response: That was in our opinion a correct 'dependable capacity' definition.

19. The analysis seems to have been conservative in other respects. For example, no adjustment was made to the alternative capacity to take into account: differences in mechanical availability of hydropower and thermal; de-rating of thermal plants; differing effects on system reliability (the capital cost used for coal fired power plants applied to a 600 MW size). Based on figures presented earlier an adjustment in equivalent thermal capacity up to about 25%[163] might have been justified. Also since the North East Region was a net importer of energy, the alternative thermal plant which would be located in Bangkok may have had some transmission costs.[164]

Response: The mechanical availability of hydro is not the problem. As stated before energy limitations of hydro plants are to a large extent occurring at the same time. They are not like forced outages randomly occurring events of unconditonal probability, but tend to be clustered. Just like a breakdown in the gas supply system would cluster around a gas turbine breakdown.

20. However, the main assumption needing reexamination is that relating to "dependable capacity" since the WCD Report has adopted the definition used by Sogreah. When considering the load duration curves applicable at the time (Figure 4.1), the four-hour assumption is questionable. The curve does indeed indicate a peak from 6 pm to 10 pm. However, the energy in that peak is equivalent to about 2.5 hours generation on average. Moreover, if the effect of weekend days is taken into account, over a full week an average of only 1.8 hours per day of generation would be required to meet the four hour peak. This is an average for all plants meeting the peak (about 500 MW). If the 136 MW of Pak Mun were allocated to the extreme peak, as it would be in times of energy shortage, it would need to generate about 1.5 hours on weekdays or an average of about one hour per day over the full week[165].

Response: In the absence of Fig 1, is this a remark for the whole EGAT system, or just for NE region? How about the other hydros in the system? Do (can) they all serve the extreme peak in very dry months?

21 On the basis of energy constraint, the "dependable capacity" for the hydropower plant would not have to be reduced from 136 MW to 81 MW as assumed by Sogreah. On the other hand, they do not appear to have considered the effect of reduced hydraulic head in reducing the capacity of Pak

Mun. While reservoir draw-down was not an issue[166], the high tail-water levels during some months, resulting from high levels in the Mekong, should have been considered. If a criterion analogous to EGAT's 90% resevoir level criterion is taken[167], the tail water level that is exceeded 10% of the time is about 99.5m[168]. With a reservoir level of 108.0m, gross head is 8.5m which is below the rated head of 11.0m. This would reduce "dependable" capacity to about 68%[169] of installed or 92.5 MW (the actual output of Pak Mun at 8.5m gross head is in fact 92.5 MW). However as shown above the capacity of the equivalent thermal plant should have been at least 1.25 higher[170] i.e. 116 MW.

Response:

This is incorrect:

- Hydro non-availabilty due to droughts occurs for most hydros at the same time, irrespective of number of units. The 'equivalent' thermal plant is not 1.25 times higher.
- If weekly pondage is the operation mode (EGAT only uses daily pondage), then average pool level ca. 1m to 1.5m lower. Added to this is the effect of lowering FSL by 2m during the dry season. During the most critical months level of April and May the net head at full turbine release is more likely in the order of 6m, with correspondingly lower capacity.

22. The above illustrates the complexity associated with the thermal equivalent approach, and the possibility of obtaining very different answers depending on the assumptions made. Nevertheless, it might be concluded that, on the whole, the Sogreah analysis was conservative.

EGAT 1988 Analysis

23. The EGAT analysis was carried out in March 1988[171] effectively updating the Sogreah Feasibility study to take account of developments in the intervening three years, primarily completion of more detailed studies on the downstream channel, the definite design of the project and the decision to lower operating level of the reservoir during the months of January to May so as to retain the benefits of Kaeng Sapphue rapids as a tourist attraction.

24. In selecting the thermal alternative, EGAT took cognizance of developments in the power system in the five years since the Sogreah planning methodology was developed. By 1988, the surplus of gas turbine capacity noted by Sogreah had already been absorbed and EGAT were including both open and combined cycle combustion turbine power plants in their system expansion plans[172]. Moreover, it was clear by this time that Pak Mun would primarily serve the load in the North East Region. Logically, EGAT selected gas turbine as the alternative capacity considering that the capacity factor of Pak Mun based on average energy output was only 23.5%.[173]. In the EGAT PDP gas turbines were assumed to be fueled with natural gas; however, because supplies were limited, such gas needed to be diverted from existing steam turbine plants. Nevertheless, EGAT considered that the alternative plant to Pak Mun would probably be located in the North East region where gas was not available and so therefore the alternative fuel would be diesel. While it quoted the "dependable capacity" derived on a similar basis to that used in the 1985 Sogreah studies as 75 MW, this was not used in the economic analysis. Instead an equivalent capacity equivalent to the installed capacity of 136 MW was used.

Response: Why then did EGAT calculate the 'dependable capacity'?

25. Based on similar considerations to that presented above in relation to the Sogreah analysis, an equivalent thermal capacity of 107 MW[174] is derived. As noted previously, this type of analysis is considered to be conservative since it uses the EGAT 90% exceedance criterion for capacity as limited by head, whereas a 50% exceedance is more in accord with modern practice. However, if the 107 MW were to be adopted, the equalizing discount rate presented in EGAT's report would have

reduced from 19.8% to about 18 %. Clearly, the decision to proceed further would not have been altered.

Response: Same remarks as after clause 21 applies.

26. The rationale presented previously for not de-rating capacity based on energy is even more valid when considering the load shape existing in 1988. Examination of the load curve for the period of maximum demand for 1988 (Figure 4.2), (which incidentally occurred in September a high flow month for Pak Mun) reveals that although the four hour peak remained, its magnitude had increased to about 900 MW. If dispatched last, Pak Mun would only need to generate about 0.7 hours per day during week days and for 0.5 hours over a full week. Clearly, energy was not a constraining factor to capacity.

Response: It implies that every plant, even the most inefficient can be justified on the basis that it will be dispatched last. In the end the best value of the plant is measured by the payments EGAT would be willing to pay Pak Mun if it was a Small Power Producer.

World Bank Appraisal (October 1990)

27. As explained previously, the thermal equivalent method was not used for Bank appraisal, a more rigorous comparison of alternative expansion plans being preferred. However, it is useful to compare assumptions. Although EGAT's approach in considering a locally constructed gas turbine as an alternative had merit, the Bank preferred to conservatively use a system-wide analysis. In the alternative expansion plan, a gas turbine was again chosen as an alternative to Pak Mun, but it was assumed to have similar characteristics to other gas turbines being planned for the system. Thus new units would burn natural gas, but such gas would have to be diverted from existing steam turbine plants and heavy fuel oil substituted. As a proxy for this substitution, the gas turbine plant in the model was assumed to burn heavy fuel oil at gas turbine efficiencies. While EGAT was currently planning 100 MW gas turbines an installation of 3 x 50 MW was initially chosen since it was judged that the effective capacity would have a similar system reliability contribution to Pak Mun after differing plant availabilities were taken into account. In keeping with modern trends, average values of capacity (as limited by head) and energy (computed on a calendar month basis) were input to the model. The results validated the assumption of the 150 MW installation size since the LOLP of the alternative expansion plan was 15 % higher than the expansion plan including Pak Mun. Evidently the effects on system reliability of lower mechanical availability, larger unit size and de-rating were more than enough to offset the effects of Pak Mun capacity limitations in two months of the year, and possibly occasional energy limitations. Assumptions concerning thermal plant were as used by EGAT in preparation of its PDP, except that with regard to fuel, oil prices were assumed to escalate at a 3 % real rate rather than the 6.9 % real escalation shown in Annex 10 of PDP 90-03[175].

Response: 'in keeping with modern trends' refers to a single paper on the subject. In our opinion modern trends are to simulate for all years of hydrology (using concurrent hydrological series for each hydro) for all years of the planning period.

Of course if the variability of the outputs (P,E) are ignored, the thermal equivalent would have more capacity than the hydro.

Thus, modern trends are to measure the value of a plant in terms of the value of a contract between the buyer/distributor and the producer/SPP. Even more modern would be the prices that Pak Mun could fetch (including penalties for non-delivery) in a pool market for power.

28. As reported in the SAR, the equalizing discount rate, resulting from the appraisal analysis was 15.7% decreasing to 13.6 % with a 20 % reduction in fuel prices and 13.9 % with a 10 % increase in the cost of Pak Mun. One could infer a drop to 12.8% if both adverse effects occurred, but this was still above the hurdle rate of 12 % demonstrating the robustness of the decision to changing

circumstances. About half the drop in equalizing discount rate from EGAT's calculation of 19.8 % to 15.7 % can be attributed to increased cost estimates. The remainder must be generally attributed to the more rigorous evaluation methodology employing a system-wide approach. However, in that regard it should be noted that the appraisal analysis conservatively did not allow for possible transmission reinforcement costs for the alternative expansion program, which might have been required to import power to the North East region. Both the EGAT and the appraisal analyses were also conservative in that they did not take into account the likelihood that Pak Mun would have an even higher value to the system if part of its capacity were to be devoted to system ancillary services rather than peak lopping.

Response: The supply of these ancillary services are not measured and not priced by EGAT. They are either insignificant or EGAT is not trying to minimize costs by ensuring that these services are provided by the cheapest provider(s) in the system.

Bank ICR Analysis

29. The Bank Implementation Completion Report (ICR) ex-post analysis attempts to determine whether the original investment decision was the correct one in the light of ensuing events. The two main factors affecting the outcome were the increased costs of Pak Mun and lower fuel prices than were projected at appraisal. Both factors were largely beyond EGAT's control. Ideally, it would have been beneficial to recreate the original appraisal analysis, taking into account actual costs, actual oil prices and revised projections and possibly a revised expansion plan. The ICR team considered it was unnecessary to undertake such an exercise which is essentially academic in its nature, and therefore attempted to carry out a thermal equivalent analysis recreating as far as possible the assumptions of the appraisal analysis taking into account actual costs and fuel price movements up until the date of the analysis and the appraisal projections into the future.

Response: Why did the ICR team rely on such second best analysis as "a thermal equivalent analysis" when they could have asked EGAT to run a sophisticated model with and without Pak Mun

30. Since the rigorous appraisal analysis had validated the assumption of a 3 x 50 MW installed capacity as the gas turbine alternative, this was retained. The assumption of heavy fuel oil being burnt at gas turbine efficiency was retained. While the fuel price escalation projected at appraisal had not yet occurred, it was assumed that it could still occur in the future and the appraisal assumption of three percent real escalation per year up until 2006 was retained.

Response: Same remarks after point 21.

31. The ICR analysis indicated that equalizing discount rate had reduced from the appraisal estimate of 15.7% to 11.9 %, not surprising since the two main risks identified at appraisal (higher Pak Mun costs and lower fuel prices) had both occurred and to a higher degree than anticipated as likely. The exchange rate devaluation that usually accompanies large cost increases had not occurred. Nevertheless, the robustness of the appraisal analysis was confirmed in that the equalizing discount rate was still close to the hurdle rate in use at the time of the appraisal. Another development since appraisal was reduction of the hurdle rate by NESDB in view of the greater availability of capital to Thailand's thriving economy. This shows up in EGAT's later PDPs, wherein the discount rate used in development of the least-cost expansion plan was 10 %. Thus the statement of the ICR that the equalizing discount rate was "…above the opportunity cost of capital of 10 % in Thailand."

ICR Update

32. Since completion of the ICR two major factors have occurred which have some bearing on the ICR conclusion. Firstly, the overdue devaluation of the Thai Baht has actually occurred and the long anticipated increase in real oil prices has also eventuated. If the analysis were to be repeated at

this time, with no further real increase in oil prices, and the final 1999 costs from the WCD Report, the equalizing discount rate would be much higher.

Response: That is an unsubstantiated statement.

The WCD Report Analyses

33. Numerous equalizing discount analyses are presented in Annex 1. The results of these analyses should be reexamined in several respects.

- The report confuses the various factors which can result in reducing thermal capacity below nameplate capacity of the power plant. It states incorrectly that "reliability of a gas turbine plant is typically much higher than that of a hydroelectric power plant'. It uses a 98 % operating reliability, misunderstanding that this is a de-rating factor that was used by EGAT at the time, separate from the planned and forced outages and plant auxiliary use that they also apply in their PDP process. These factors need to be added to get an overall availability which at the time of appraisal was close to 80 % for a gas turbine.

- It confuses the two factors through which hydropower plant output might fall below rated capacity, applying EGAT's rule for capacity constraint through reduced hydraulic head, to capacity constraint through energy.

- It persistently applies the assumption made by Sogreah in 1983, that "dependable capacity" could be constrained by the energy available in a four-hour peak period over the year. This assumption which was conservative in 1983 had become inappropriate by 1988, and more or less invalid with the development of EGAT's system since then.

Response: The concept of "reliable capacity" has been replaced by the concept of 98% mechanical reliability since all hydro is fungible and whatever water Pak Mun can save in the storage dam will be available to fill in the times when Pak Mun has no water. In this case the reliable capacity of Pak Mun is around 93 MW, calculated as the average maximum 4 hour peak production. The table below gives a calculation of daily average MW, assuming that the storage dams will perfectly hedge for Pak Mun shortfall.

Peak hours	Daily average MW at peak
4	93.51
3	100.54
2	108.70
1	118.40
0.01	128.38

This shows that the maximum maximorum capacity of Pak Mun is 128 MW. It is possible that if it was an SPP the capacity payment would be zero.

- It argues that the four-hour assumption should be revised to a 13 hour assumption in view of the flattening of EGAT's load curve through demand side management. However, inspection of the current load curve (Figure 3) [176] shows that there are three peaks within this 13 hour period and the energy requirement of the 1180 MW of capacity meeting this 13 hour "peak" is equivalent to about four hours average generation (less than three hours per day on a weekly basis). Moreover, the energy requirement for the top 150 MW of plant is less than half an hour daily. Reduction of

the 136 MW Pak Mun capacity to that which can continuously serve a 13 hour peak is therefore unjustifiable.

As, in 1988, it could hardly have been predicted how the load curve would change, it is a bit academic to discuss the effects of a 13 rather than 4 hour peak. Again the assumption of this clause is that other hydros would not compete for coverage of the extreme peak as they would suffer from the same drought.

The WCD report in its final form has removed reference to 13-hour period.

- In system planning it is not conceivable that a 20 MW gas turbine could be considered to be equivalent to a 136 MW hydropower plant.

Response: In system planning a concurrent 20, 30 or 40 year time series of capacity and energy output of all hydros should be used and least cost development plans with and without the project be derived with satisfactory LOLP values.

34. In view of these questionable assumptions made in the WCD analyses, a detailed review of the numerous cases run is not considered to be worthwhile.

Response: Pak Mun was needed to solve problems of the electricity supply in the NE region. However the WB and EGAT analysis assume that the whole of the integrated grid of EGAT was considered. If not the NE region, but rather the grid as a whole was considered, why then were the 50 MW gas turbines the only alternative taken into account? Was Pak Mun selected while it was in the NE region, or because it was a system-wide least cost option?

There seem to be two further points worth considering:

- was it legitimate to ignore an the analysis based on an average hydrological year of Pak Mun?
- How does Pak Mun compete with other hydros in covering the extreme peak during periods of drought? Is it enough to produce 136 MW for just half an hour as part of the whole system, or is its dependable capacity related to the 4-hour peak in the NE region?

10.5 Annex II - Aquatic Bio-diversity and Fisheries

10.5.1 Part 1: World Bank Comments

Introduction

1. The Report presents a view of the impact of the Pak Mun Dam on aquatic diversity and fish production. The result, however, is an inconsistent presentation of information with seemingly contradictory conclusions with regard to the data provided in the body of the report, its annexes, and other supporting documents on aquatic biodiversity and fisheries that were prepared as part of the assessment of the impact of the project. The report emphasizes perceived adverse environmental impacts on aquatic biodiversity and fisheries by the Dam while not giving due attention to indications of benefits derived from the available data.

2. The following discussion on aquatic biodiversity and fisheries is based on the information provided in a number of November 1999 draft studies that were prepared for the WCD and the draft June 2000 Report. A discussion of the consistency in survey methodology among these studies was not included in the reports. Nevertheless, this is the information upon which the Report's conclusions have been drawn and also the basis for the following discussion.

Analysis

3. The Report (page 45) indicates that before dam construction there were 265 fish species in the Mun River and after construction the number fell to 96 species in the upstream area. The reference for the 265 species dates to a 1945 study for the Mekong and Mun Rivers and the 96 species refers to a 1997 study of the fishes identified above the dam in the Mun River only. What the report fails to mention is the more detailed information on the loss of species discussed in the November 1999 draft "Social Aspects of Fisheries" report prepared for the WCD and entered below in Table 1.

4. As can be seen from the information in Table 1, the impact on the reduction of the number of species has been quite significant in the project area before the Pak Mun Dam was built. The dam was constructed between 1990 and 1994. Data from fish diversity studies in the Mekong and Mun Rivers shows a radical decline between 1945 and 1967 surveys. This loss was largely attributed in the Report to an increase in pollution discharge, particularly from Ubon Ratchathani upstream of the dam site, and intensification and kinds of fishing done in the river. Upland deforestation and resultant soil erosion may have also contributed.

Table1. The Number of Fish Species Identified in Mun and Mekong Rivers in the Vicinity of the Pak Mun Dam[13]

Year	Mekong and Mun Rivers	Mun	Mekong
1945	265		
1967	141		
1969		115	
1982		73	
1991		68	
1992		70	
1995		109	93
1997		96 (Upstream)	

5. Two studies in 1991 and 1992 identified 68 and 70 species in the Mun River, respectively. A 1995 study following construction of the Dam showed an increase in the number of species in the area upstream of the Dam, following the nadir of 68 of species in the Mun River recorded in 1991. This finding is particularly notable in that the fish ladder that was constructed as part of the project at the dam site has been noted in the Report (summarizing other studies) as being ineffective for fish migration due to design and being built in a bad location. It is thus possible that the fish ladder was more effective than has been indicated and also that the head-pond may be an important nurturing habitat for those fishes that reach it. Among them would be both those fishes that spawn upstream and downstream of the dam site and migrate to the head-pond.

6. Another study in 1997 showed that the number of species declined from 109 species in 1995 to 96 species in the upstream areas. This could be in part be attributed to increased fishing pressure in the area that may have continued to rise between 1995 and 1997 as was the case between 1992 and 1996. Between 1992 and 1996, the number of households involved in fishing increased from 302 to 613 as reported in Annex 3 of the Report for the project area. Also, dam protesters have been fishing at the fish pass that not only can affect the number of species able to migrate upstream but also the resultant productivity of fishes in the head-pond and upstream waters. This is due to the capture of the juveniles and brood fish and the prevention of their having the opportunity to grow out to market/consumable size and spawn upstream, respectively.

[3] 1. Based on referenced data provided in the draft report on "Social Aspects and Fisheries" by Dr. Sansanee Choowaew of Mahidol Univeristy dated November 1999; a WCD report entitled "Fish and Fisheries Up- and Downstream of the Pak Mun Hydropower Dam" also dated November 1999; and this Report.

7. It seems that among the impacts to aquatic biodiversity, the Pak Mun Dam and head-pond may not have had that significant an effect over other impacts in the area. For some species, the project may have been beneficial, such as for those that flourish in lake-like environments such as that created by the Pak Mun head-pond.

8. Although a paucity of data exists on the Pak Mun Dam's impact on the aquatic ecology of the Mun River, there is enough to indicate that the Dam's impact on aquatic diversity may be relatively low compared to other prior and on-going cumulative impacts. This becomes especially apparent when considering the time it was built in relation to historical trends and the other impacts that occurred during and after its construction.

9. The catches from the Mun River and head-pond are difficult assessments to make, for often only the commercial catch (sales) is reported and not the subsistence catch. This difficulty is further compounded by the fact that fisherfolk are being compensated by the Government for losses in fish catch. This can lead to underreporting. Moreover, fish production can be affected by a wide range of events, some of which are anthropogenic (e.g., fishing intensity, enforcement of regulations, deforestation, pollution discharges, etc.) and others that are natural phenomena such as the timing and quantities of precipitation. Therefore, there is a complexity of factors that can affect records of fish yields that often require many years of baseline data collection and analysis to determine not only what all the impacts are but also what weight should be applied to each in making an assessment of changes in fish production.

10. Table 2 below was derived from information in reports that were prepared for the WCD about fish production in the vicinity of the Pak Mun Dam and fish ladder. This data as a case in point shows highly divergent and inconsistent reporting of fish production. Nevertheless, it can be assumed that construction of the dam did have a significant impact on the aquatic environment. To what degree, however, this may have affected overall fish production is not clear. Table 2 below separates the data by river area in which it was documented and includes that information for which the year and annual fish catches by household was reported and could be calculated. The norm of annual fish catches per household are often used in these reports which can be difficult to interpret due to in many cases not knowing how many households were fishing. There is one exception for the data noted under "Project Area" in Table 2 in which the number of households involved in fishing was provided. Without the number of households, it is difficult to determine the overall impact on fish production due to not being able to calculate the overall catch from year to year. The following discussion looks at the reported information found in Table 2 by year and area as characterized in the reports.

Table 2. The reported annual fish catch per household (kg) [1]

Year	Lower Mun River	Upper Mun River	Project Area (HH)
1982	929.4 and 688[2]	1170	
1992			118 (302)
1994			
1995	763.5	652	
1996		421.97	778 (613)
1998		1,317.65[3]	
1999		706.275[3]	

1. Based on referenced data provided in the draft report on "Social Aspects and Fisheries" by Dr. Sansanee Choowaew of Mahidol Univeristy dated November 1999 and a WCD report entitled "Fish and Fisheries Up- and Downstream of the Pak Mun Hydropower Dam" also dated November 1999.
2. The 929.4 kg/yr/household figure is from Dr. Sansanee Choowae's report and the 688 kg/yr/household figure is from the June 2000 Report and referenced to the Faculty of Fisheries at Khon Kaen University.

3. It is not certain whether these figures pertain to the Upper Mun River, for there is no direct reference. They follow a discussion about fisheries in the Upper Mun. These figures are calculated from average daily fish catch statistics from households and extrapolated to a year round basis.

11. As can be seen for the Lower Mun River, reported fish production documented in 1982 varied between 929.4 kg/household/yr to 688 kg/household/yr from two different sources. The next available data are from a 1995 report where the catch per household per year was reported at 763.5 kg. Although the dam likely had an effect on the fish catch in 1995, the Lower Mun River during the 13-year period between 1982 and 1995 may have also had other significant impacts that could have affected the fishery. Based on the data in Table 2 for the Lower Mun, there is a possibility that the catch per household went up or down in this area of the river during this period, depending on which 1982 data is used. For the Upper Mun River, the annual catch per household before (1982) and after (1995) construction appears to vary considerably with no clear trend or rationale. Also, the 1982 figure predates the impact of dam construction and operation by a decade. It is also not clear from the text whether the catch from the head-pond was included in the calculation of the fish catch from the Upper Mun in any or all of the surveys. Also, there is considerable discussion in the report about increasing pollution discharges from Ubon Ratchathani and other upstream communities that can also significantly affect fish production. The June 2000 Report notes on page 9 that between 1965 and 1975 the river changed from being clear and warm to cold and muddy. Clearly, the aquatic environment of the Mun River has been heavily impacted over the past 35 years at least.

12. The data from the Project Area, as taken from Annex 3 of the June 2000 Report, compares the annual catch per household at the beginning of the construction period and the year after construction. This is the only data available that includes the number of households engaged in fishing with the number rising from 302 in 1992 to 613 in 1995. The annual catch per household increased as well from 118 kg to 778 kg or a gross overall increase in fish yields from about 35.6 t to 476.9 t.

13. This production increase was most likely due to the expansion of aquatic habitat (60 square km) that also benefited from the relatively large catchment area (117 000 square km) from which considerable nutrient runoff. These nutrients would enter the head-pond, be retained, and is the base for primary productivity as a key driving force in the food chain. The stocking program of indigenous freshwater prawns and fish took further advantage of this increase in natural feed availability.

14 In summary, all of the above observations on the Pak Mun Dam's impacts on aquatic biodiversity and fisheries are based on data in the reports prepared for the WCD, and the above interpretation of that information would need to be verified. Verification could best be done by looking at the original data collected and the methodologies used in collecting and analyzing it and making the calculations of fish production and aquatic biodiversity. It is thus obvious that an analysis be conducted to verify the consistency in data collection methods and to resolve the inconsistencies in available data to the degree possible.

10.5.2 Part 2: Response from the Fisheries Study Team to The World Bank's Comments

1. <u>Mr. Roel Schouten, Seatec International Consulting Engineers</u>

The case study clearly states "the difference in number of species in fish surveys before and after dam construction also may well be exacerbated by the cumulative impacts of many different developments in the watershed, including the construction of the dam" (page 46).

The case study mentions all the different effects and impacts on aquatic biodiversity in the Mun Chi Watershed by other developments than Pak Mun (pages 4 to 10).

The case study mentions also the number and the names of fish species in the Mun/Chi watershed before and after construction of the dam. Chavalit's list of fish species is not from 1945. He was not even born at that time. His species list is from the late ‘80s and beginning ‘90s.

The case study also clearly mentions that from interviews of fishermen at villages between the Pak Mun dam and Ubon, only 1 fish species was noticed by fishermen to have disappeared completely. However at some of the different villages certain fish species did disappear from their catch. 51 fish species have been caught significantly less after dam construction. Of these 51 fish species, 17 are likely to have declined from the catch in some villages solely as a result from the construction of Pak Mun Dam. All these 17 are migrating fish species (migration route is blocked off by the dam)and are depending on rapid habitat (rapid habitat upstream of the dam has disappeared as result of inundation). Also specific fishing gear traditionally used to catch these species have disappeared upstream of the dam after dam construction. The same fishing gear is still used downstream of the dam.

The case study clearly states the decline in fish catch. And comes up with a rough, but conservative estimate of decline in annual fish catch upstream of Pak Mun dam. This estimate is less than the yearly compensation paid to fishermen by EGAT for loss of fish catch during construction phase.

The WB comments in Annex 2 mentions fish production many times. The Case study never has used the word fish production. The Case Study only analyses annual fishing yields. Fish production and fishing yields are two completely different words with two completely different meanings.

Based on the Census data (annex 3) mentioned in the case study, the WB comments are jumping to conclusions:

First of all primary production did not necessarily increase after dam construction. The Pak Mun run-of-the-river reservoir (or headpond) has a low water retention time. Phytoplankton is flushed out rapidly in run-of-the-river reservoirs. Periphyton, an important contributor to primaryproduction in the Mun River between Ubon and the Mekong before dam construction has disappeared completely from the headpond area, due to raised water levels.

Regarding the Census data. These have not been used in the fisheries section of the case study, because: (1) The data do not show where the fish has been caught. A lot of fish in the area are caught in the rice paddies, canals, and other wetlands. The Case Study is focussing on the Mun River upstream of the dam only. The census data do include fish catch from any water body. The census data also does not separate the fish caught upstream and downstream of the Pak Mun. Fishermen living upstream of Pak Mun Dam often obtain their catch downstream of the Pak Mun Dam. Much of the fish caught in the area stems from aquaculture based activities. The Census data do not seperate wild catch from catch due to aquaculture based activities. No conclusion as Annex 2 of the WB comments is making can be made from the census data. Any conclusion based on the census data concerning fish catch in the Mun river upstream of the dam after dam construction is not valid.

The Case Study comes up with a conservative estimate of annual loss in fish catch up- and downstream of Pak Mun dam.

On the summary of WB comments Mr. Roel Scuhouten's comments are:

To item 17 and 31: Why did the WB not make these comments during review of the EIA of Pak Mun Dam ?

To item 18: Charles H. Clay wrote Design of Fishways and Other Fish Facilities in 1961. He clearly advises to locate the entrance of a fishway at hydropower dams as close as possible to the turbine outlets. The wrong location of the entrance of the fishway is blamed by Clay as the main reason of failure in performance of fishways.

To item 18 as well: Monitoring studies of fish catch after dam construction not implemented. Monitoring studies of fish migration after dam not systematically carried out. Not only fishermen but also fish consumers, fish traders and fish transporters to be consulted.

The comments also refer to exaggarated decline in fish species and exaggarated loss in fish catch. How do they know if no efforts have been undertaken to estimate annual fish catch before dam construction and no efforts have been made to monitor fish catch after dam construction? These monitoring activities should form the basis for fisheries compensatory measures.

The Pak Mun dam was expected to generate economic benefits from increased fisheries according to the EIA. However, a loss in fisheries has been realized. There is no doubt that there is a considerable decline in fish catch, some fish populations (migrating species, and species depending on rapids as aquatic habitats) have been hit harder by the construction of the dam than other fish species. Disappearance after dam construction of specific fishing gears upstream of the dam (but still in use downstream of the dam)are confirming decline in certain fish populations.

Increase in water elevations by impoundment has destroyed aquatic habitats as rapids. Increased water levels has also required fish species to change their feed sources. Some species can not adapt to this. Periphyton, an important food source during the dry season of many fish species in the Mekong Basin has completely disappeared in the headpond area. As the EIA of Pak Mun has pointed out, fish catch in the dry season is much higher than in the wet season. The headpond has simulated wet season conditions in a 60km2 area, with decreased fish catch.

2. Response of Dr. Chavalit Vidthayanon (Royal Thai Fisheries Department, Government of Thailand) to World Bank comments

Reponse to the WB's, inluding EGAT's former comments on biodiversity result of the Pak Mun Dam area:

- The result of species number at pre-impoundant is taken from recent surveys using several methods; seinnets, electrofishing and especially from artisanal fishing activities that penetrated all microhabitats, nearly all year round. Our survey was conducted since 1990 and also included the results of Tyson Roberts, W.J. Rainboth in the last two decades. Due to updating of freshwater fish systematic (taxonomy) knowledge, many species from the old reports (Thanthong & Siriphan, 1969 and so on) are corrected, some taxa found out that from more than one species, and most of the species in the WCD report are taken from the recent survey in the past 5 years before dam. There is no reason why many species from the old report disappeared before our survey, because nearly all species from that are very common species. This is the reason to believe that more 250 species occurred pre-impoundment (we exclude ca. 10 introduced species). This report is the recent publication for an updated fish biodiversity survey in the Mun River.

- 96 species found during the WCD survey is taken from short surveying period. We cannot escape the fact that species diversity losses by impoundant have occurred in every damed river in the Mekong region. In the Pak Mun case; at least 50 species of rapid-dependent fishes are found disappeared for ca. the past 4 years of our surveys, and many species declined radically, according to the fishermen interviews. The cleaing of rocks for the dam water channel is the main cause of habitat losses. Definitive findings on the number of species disappeared would have to be based on long-term investigation, a period of at least three years.

- The report also pointed out that Dam is not the only reason for biodiversity losses, but included several anthropogenic factors. However, dam might have induced or speeded up the decline by influencing other factors.

3. Dr. Sansanee Choowaew's response to World Bank Comments:

EIA as tool for project sanction: The project endorsement was not supported by EIA. The studies / reports conducted in 1980s and afterwards, those on which the project endorsement was based, are not EIA and should not be referred to as EIA, both by law at the time and by technical standards.

- The WCD may review the EIA criteria / guidelines / standards / processes / methodologies applicable *worldwide* during 1980-1990 and analyse if studies / reports supporting this project endorsement could have been better prepared and examined. Could the project endorsement have been based on supporting studies of higher quality as well as better screening process of the international development agency in 1990?
- The project complied with the standards of the Cabinet at the time, it was thus approved. If the project also complied with the international development agency's standards in effect at the time of appraisal in 1990, then there are lessons to be learnt by both the government recipient and the loaner. *In the future,* the preparation and decision-making processes for any type of dam project in the country as well as in the region must be conducted with higher standards and better quality of analysis of pros and cons. The international development agency should have and play much more efficient role based on broader experience and higher technical standards, overseeing or examining the feasibility studies and EIA documents before giving a loan.

Mitigation measures and impact: The project provided several mitigation measures, yet the only key measure to facilitate fish migration, the provision of a fish ladder, was based on very little knowledge and experience. To this day, the capacity of the ladder to facilitate fish migration is highly debateable. Another lesson learnt was that, this mitigation plan was not there at the time the project preparation and decision-making was made. This mitigation plan came out at the time the dam construction was almost completed, and even this important plan was not well-prepared.

- It has been realised by almost all of the stakeholders that this project planning, decision-making, implementation and mitigation has been and is being conducted with inadequate base-line information, especially on fisheries, the most serious and controversial issues. This undoubtedly led to the chaotic manner in which the social aspects of fisheries have been and are being handled.
- Following traditional assessment of previous dam projects, the major impacts in focus remained in inundated areas and resettlement issues. This project happened to be the first run-off-river type of dam, there was no reservoir and impacts due to flood and resettlement were not as serious as of other big dam projects. The worst part of this project was that, impacts on fisheries and social aspects were underestimated and overlooked. No study ever predicted that fisheries issues would become problematic, during construction or implementation.
- The fisheries impacts were, at the first place, beyond this project's expectations. Dam/reservoir development has been a strategy for increasing fisheries productivity, the Pak Mun Project has given an expensive lesson that expected benefits from fisheries could turn losses through unexpected costs for fisheries management, for fisheries compensation, and for complicated conflict-resolution concerning social aspects of fisheries. *This could be considered a new lesson learnt.*

Lessons learned: The Pak Mun Project, not only provided a new lesson learnt by the country about fisheries impacts, but also could be learnt by the region. The Pak Mun Dam was the first run-off-river type of dam in the region. More careful and thorough analysis concerning fisheries must be made in the future dam project preparation.

- Most stakeholders by now realised that it is important to differentiate between the impact on fisheries of the project and the adverse impacts caused by many other factors. The project failed to foresee these issues during the preparation and the decision-making process. The World Bank standards also failed to cover these issues. Moreover, during the project implementation and mitigation, the impacts on fisheries were not solved because several mitigation measures have been flawful, e.g. fish and prawn stocking discontinued, the fish ladder monitoring abandoned. *Who is supposed to actively manage the situation: the Cabinet, the EGAT, the Fisheries Center,*

the people? What would other good projects in the world do with their mitigation plans and measures? *This could have been a lesson learnt too. I am not sure if there has been discussion somewhere.* Another interesting lesson should have been learnt but yet to be learnt, *whom and when and how* the World Bank, who stands ready to assist, can actually assist.

- The World Bank viewed that it was not possible to determine the number of fishermen that were actually affected or the loss of income they had suffered and this resulted in exaggerated and ever-increasing claims for compensation. This could also be viewed that this resulted in hidden number of sufferers and claims for compensation.

NRDC data: During the final stakeholders meeting early 2000, there was discussion concerning the use of NRDC Village Cencus Data. *I am not sure if this point has been reported or summarized somewhere.* According to my experience, those who ever used this data source realise its aims and objectives, methodological framework and how the data derived, when and how much the data can be used, how to refer to and interprete the data, limitations, and so on. Whenever time and budget are available, most researchers who are working on specific issues will also search for additional primary data sources and more specific data set on specific issues for fresh analysis.

- Working on the Pak Mun Project, one of the most difficult parts has been lack of base-line data and inconsistencies in data. A number of studies and reports available cannot be used for comparison over time and for comparison on several points and aspects, including social aspects of fisheries. Major reasons include differences in objectives and methodologies.

Findings concerning social aspects of fisheries were derived from separate assessment mainly based on the field study in 1999 but partly referred to available data from previous studies / reports. Realising that time and budget were limited, I carefully planned and conducted in-depth interviews of NGO's representatives, the Chief of Fisheries Conservation Center, and village heads, as well as interviews of household heads, as many as possible. *As already described in my first draft report submitted to the WCD in November 1999,* compilation from 4 different sources (EGAT; Pak Mun Agricultural Cooperatives; Agricultural Development Cooperatives; and New Alternative Agriculture Cooperatives) indicated that there was a total of *3 948 – 4 002 affected fishing households in 61 villages of 10 tambons of 3 amphoes in Ubon Ratchathani.* The village and household survey for data collection conducted during 17-18 and 24-26 October 1999, used the sample survey or partial enumeration method based on 90% confidence level, involved using the structured questionaire for intensive interview of 63 households *(2%)* in 12 villages *(20%)* in 5 tambons *(50%)* of 3 amphoes *(100%)* and the indepth interview of 10 village leaders *(91%)*, the manager and 3 committees of different Cooperatives *(100%)*, and 1 local fish trader. *The samples of surveyed households could be considered very small but well-distributed and supported by over 90% of visits and indepth interviews at village level.* The surveyed area was along both banks of the Mun River and was divided into 4 zones : upper upstream, lower upstream, dam site (reallocated area), and downstream. The distribution of sampled cases was: 3 villages in upper upstream (21 cases); 6 villages in lower upstream (24 cases); 1 village at the dam site (6 cases); and 2 villages downstream (12 cases). *Among the total surveyed households, 76.2% were on the list of affected and compensated fishing households (consisting of members of all 3 established Cooperatives) and 23.8% were not on the list, did not received compensation, and were not members of any of those 3 Cooperatives.* Comparative study was made between 4 zones, between before-dam, after-dam, and present-dam conditions, and between households on the list and not on the list for fishery compensation. Fish markets at Khong Chiam and Phibun Mungsaharn were also observed. *Although the study was conducted in a short period of time, sampling was done without any bias ensuring representatives of all groups and conditions be covered. All interviewees were at home in their village at the time of visit. Only bias was that, I intended not to contact people at the dam site, not to go near the dam site during my field study, and not to interview any of those people. The sampled household heads included even local officers who also fished in the Mun. Although the number of samples was too small, the consistency of the data derived plus the indepth interview results, provided significant findings. Most analysis in this assessment compared the data derived* ***from each individual case*** *:* ***before, during and after dam****. I paid much attention on*

the trend of change. Since there were no available and reliable figures on several points and parameters on social aspects of fisheries at the first place. The trends of key parameters indicated what actually happened and what were ignored and not quantified since the project

10.6 Annex III Social Aspects

Part 1: World Bank's comments

Resettlement and Compensation

1. The WCD draft report presents a somewhat unbalanced view of resettlement and compensation issues, and fails to take note of the very significant achievements of the Pak Mun resettlement program. While it is acknowledged that the resettlement program got off to a slow start, significant progress was made during implementation to make it one of the good practice examples of resettlement associated with dams. Four factors adversely affected the implementation of the resettlement program in the initial phases. These were: (a) deficiencies in the baseline data on affected people; (b) absence of a comprehensive resettlement plan; (c) lack of good quality consultations with affected people and mechanisms for grievance redress in the early stages of the project; and (d) the continuous adversarial stance of the Project for Ecological Recovery (a Thai NGO), which refused to engage in a constructive dialogue with EGAT or the World Bank.

2. The project evolved into a best practice on many aspects of resettlement implementation. Resettlement impacts were minimized through design changes; very generous levels of compensation were paid; people had to relocate over extremely short distances, thus preserving social networks and community relationships; the physical infrastructure in the project area was substantially improved and effective mechanisms to resolve problems and complaints were established. The above aspects of the project eventually made it one of the best resettlement programs in the region, which was confirmed by the fact that people affected by other projects in Thailand demanded that their resettlement should be carried out along the lines of Pak Mun Project.

3. The decision to change the location and height of the dam, that resulted in reducing resettlement by a factor of 16, is one of the best examples of implementing the basic principle of the Bank's resettlement policy – to minimize resettlement to the extent feasible. The project required a limited number of households to move, and that too a couple of hundred meters, at the most, away from their current locations. This helped preserve community relations and networks among resettlers, which usually poses a major challenge in most resettlement programs. Others not affected by the project but living in its vicinity were also offered assistance. Based on people's demand, cash compensation for the affected land was increased from Bt 8000 to Bt 35000 per rai, which was considered to be very generous compensation paid in Thailand at the time. Also, when people turned down the offer of fully developed replacement agricultural land that was being provided in addition to the cash compensation, they were paid a second time for the affected land, at the same rate of Bt 35,000 per rai. This is one of the few cases in a World Bank assisted project where affected people were paid twice for the same piece of affected land.

4. Follow up surveys showed that the affected people were able to use their cash compensation for productive purposes, and incomes among resettlers showed rising trends until the financial crises of 1997. The affected villages were also provided with physical infrastructure, such as roads, health centers, schools etc. that was significant improvement to the infrastructure that existed prior to the project.

5. Regarding loss of income from fisheries, though the problem was not reported by the affected people during the initial World Bank supervision missions in the field, it was raised as a major issue during the final stages of project implementation. Also, while fairly responsive local institutions tried to address the issue of fisheries compensation, and there were times when it seemed to have been

adequately resolved, they could not deal with the increasing number of new claims that were successively received after resolving prior sets of claims. When the Government announced that it would compensate fishermen for the loss of income at the rate of 30,000 Baht/year for three years, almost 4 000 fishermen raised a claim for this amount. If this number is analyzed, it would result in an annual yield of 6 000 tons of fish catch at the rate of 20 Baht/kg. This is a doubtful figure, indicating that either there were not 4 000 household affected or that all these households did not earn 30,000 Baht/year from fishing. In this regard it is interesting to note that the NLDC Census for 1996 lists 613 freshwater fishermen households in the "project affected area and 1 529 such households in the "compensation" area, and the modal yearly house hold income is in the order of 15,000 Baht.

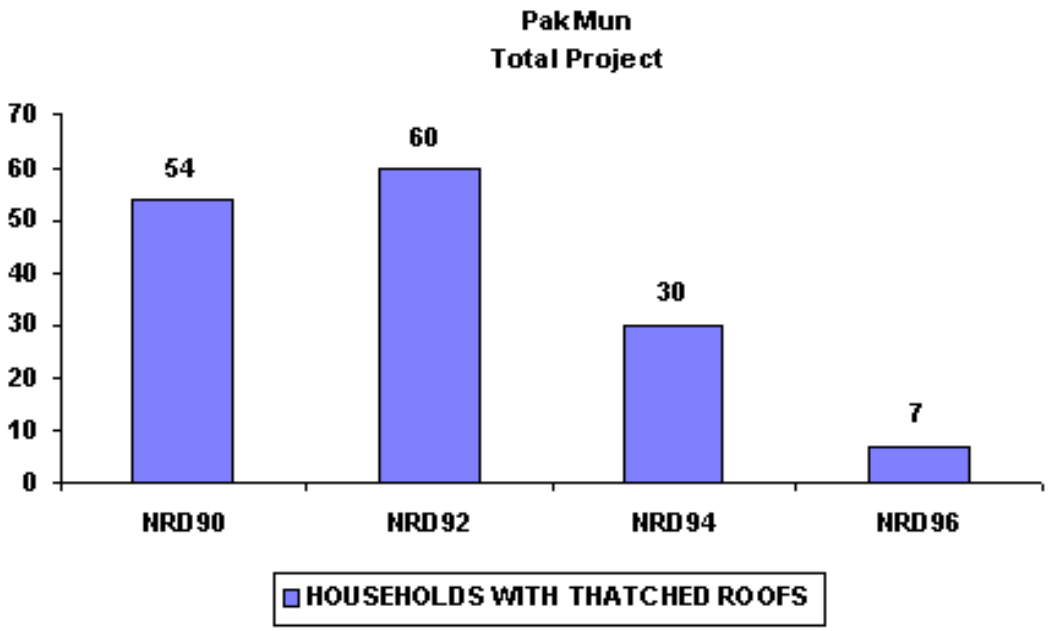
6. One of the main reasons for the success of the resettlement program was the formation, during the later stages, of responsive provincial level agencies to resolve issues related to compensation, infrastructure development and grievance redress. The agencies consisted of regional technical officials as well as representatives of the districts affected by the project. EGAT provided the necessary funding and technical assistance to implement the recommendations of these agencies. This institutional structure of resettlement implementation has emerged as one of the successful models of resettlement institutional design.

National Rural Development Committee (NRDC) Census

7. The WCD report prior to the stakeholder's meeting, gave due recognition to the NRDC census and presented conclusions based on the data. However, in the current version of the report, NRDC census data has been placed in Annex 3. It is interesting to note that this analysis and conclusions based on this data have been substituted, without explanation, by a revised Section 4.6.2 Actual Impacts: Fresh assessment and affected people's views. Below is some material from the February 23, WCD report, to draw attention to the uncertainties:

Whether or not the socio-economic dynamics of the 11 villages comprising 1 283 households and a total population of 5 918 in 1996 which make up the Pak Mun project area can be linked to the construction of the dam in 1992 and its subsequent operation, it is clear from the NRDC census data that remarkable changes did take place over the period, which positively affected people's livelihoods. As primary indicator of the prevailing general economic conditions and labour productivity, the average daily hired labour wage rate rose by 55% from 59.55 baht in 1992 to 92.22 baht in 1996. The opportunities for the people to make their livelihoods in different occupations reflected in the number of multiple-occupation households, were far greater. Classified by occupations, the proportion of households with single occupation fell from 30% in 1992 to 18% of the total number of households engaged in various occupations in 1996. Taking together the reported income from various occupations and the reported number of households engaged in each respective occupation, the average yearly income per household as represented by the mean for all single- and multi-occupation households in the project area rose by 44% from 6 697 baht to 9 663 baht over the four-year period between 1992-1996 (Appendix C, Tables C-4.1a, C-4.1b). Corrected for inflation, the rise represented a real increase in mean income of 20%.

The number of villagers working outside the local district (the *tambon*) in which the 11 villages comprising the project area are situated also appeared relatively stable, increasing 13% from 691 in 1992 to 782 in 1996, whereas for the rest of Ubon Ratchathani province, labour out-migration similarly defined over the same period increased 44%. The relative stability, compared to the rest of province outside of the project area, of out-migration labour and the shorter length of stay indicated greater local economic opportunities working at home or near to home (Appendix C, Table C-5.1 – C-



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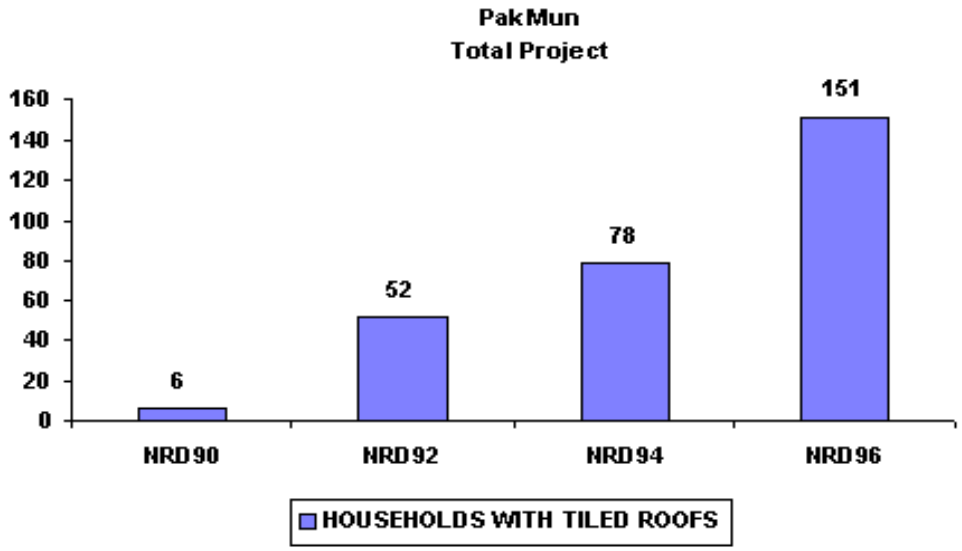
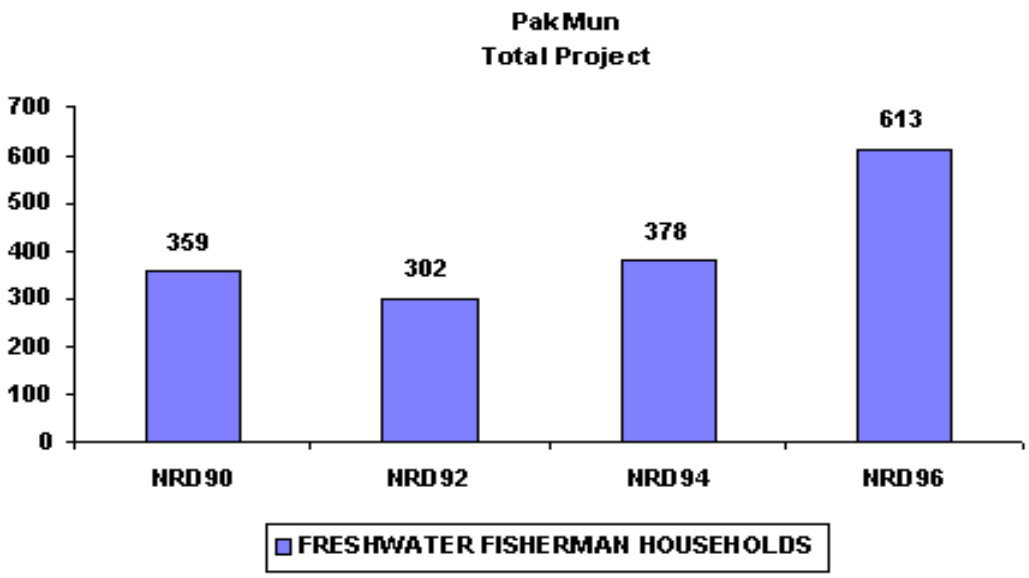


As a proxy indicator of the rapid change in local wealth and income evident since Pak Mun dam was constructed, the number of households in the project area with thatch as roofing material declined from 60 in 1992 to mere 7 households in 1996, whereas those with corrugated iron roofs increased from 1 031 to 1 125 households, and those with tiled rooftops – the most permanent and expensive material – from 52 to 151 households. As an indicator of the local quality of life, the number of households with clean drinking water throughout the year – only 19% of the total project area households in the benchmark year of 1992 - increased by over 4 times in the project area from 1992 to 1996, whereas in the rest of Ubon Ratchathani province the number slightly more than doubled over the same period.

The NRDC census database contains no information on ownership of consumer durables, except for ownerships and numbers of pick-up vehicles and motorcycles which apart from being indicators of income and wealth are also functions of lifestyles as well as of local transport infrastructures. The picture of the changes up to 1996 is rather mixed, starting from an initial index value of 100 in 1992. For the number of households with pick-up trucks, the core project area showed an index value of 196, the rest of the compensation area a value of 352, and the rest of Ubon Ratchathani a value of 267. It seemed that the compensation area did rather better than the core project area or the whole province. The same was true for the number of the vehicles themselves rather than the number of owning households. For the number of households with motorcycles, the core project area showed an index value of 124, the rest of the compensation area a value of 167, and the rest of Ubon Ratchathani a value of 226 in 1996. The relative changes for the whole province were greater than in the project or the compensation areas. This was again also true for the number of motorcycles rather than the number of owning households.

In the context of evaluating the impact of the dam on fishery, a major element of the dam's claimed benefits, it should be noted in particular that the number of households reportedly making their living in freshwater fishery rapidly rose since Pak Mun dam's construction. In the benchmark year, the 1992 census recorded 302 freshwater fishery households, 26% of the total number of 1 144 households in the project area, with derived average yearly income of 2 480 baht. The 1996 census showed the number of households listing freshwater fishery as their occupation has more than doubled to 613, or 48% of the total of 1 283 households in the project area, with derived average yearly income per household of 15 000 baht. And whereas in 1992 no household reported being occupied *exclusively* in fishery for livelihood, there were 36 households in 1996 which listed fishery as their single exclusive occupation, with mean annual income of 22 000 baht per household in this group. In relative terms, by 1996 freshwater fishery income accounted for 58% of all the total reported income derived from all occupations of all the households in the project area, whereas in 1992 the share of fishery was only 8%.



The changes in fishery as livelihood in the core *project area* of 11 villages may be compared to similar changes in the rest of the wider area consisting of 66 villages in which compensations have been paid out – the *compensation area* - in recognition of the impact of the dam on people's properties and livelihoods. Against an initial index value of 100 for the benchmark year of 1992, the number of fisherman households

in the core *project area* in 1996 showed an index value of 203
in the rest of the *compensation area* a value of 533
in the rest of the entire province of *Ubon Ratchathani* an unchanged value of 100.

But the relative changes are more significant in terms of the average modal yearly income from fishery: against an initial value of 100 for 1992, the fishery modal annual income index

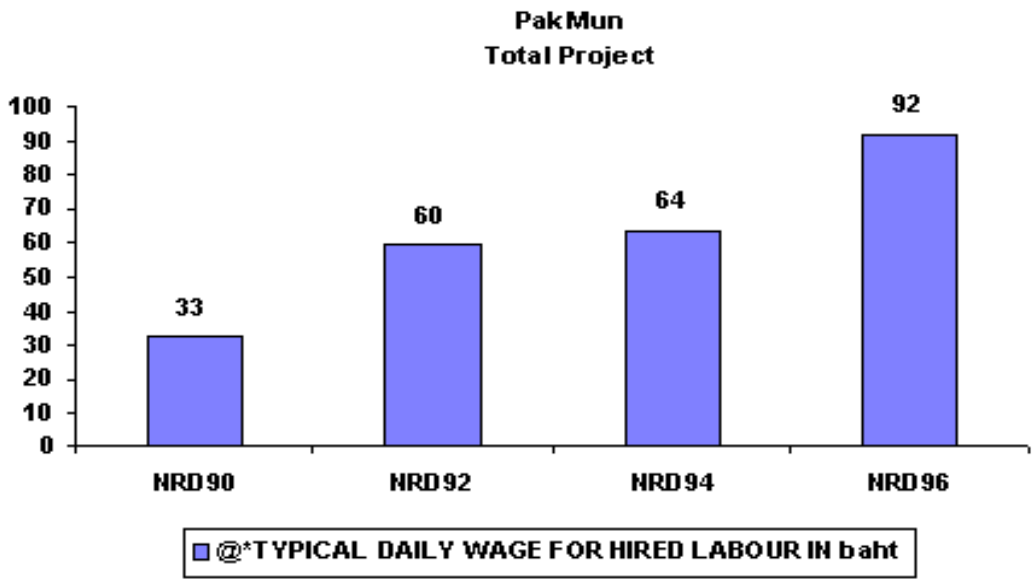
in the core *project area* increased *over six times* by 1996 to a value of 605
in the rest of the *compensation area* to a value of 280
in the rest of the province of *Ubon Ratchathani* to a value of 162.

In absolute as well as in relative terms, the income changes of households due to fishery have been most pronounced in the core project area villages adjacent to the dam reservoir. The details are shown in Appendix C, in which the changes reported in the NRDC village census database for the 11 villages of the core project area are shown against similar changes in other villages over the wider area of 66 villages where households have been compensated, and in all the rest of the total of 2 191 rural villages (in 1996) of Ubon Ratchathani province.

In contrast to the rise in modal income and the number of households engaged in fishery for their livelihood in the project area, a general and progressive decline was evident in other main and supplementary occupations. The changes were particularly acute in paddy production. The income of households exclusively engaged in paddy production in the project area declined from 81% of the total reported income from all occupations in 1992, down to only 23% in 1996 (Appendix C, Tables C-4.1b, C-4.2b).

Table 5 shows the changing structure of livelihoods over the period in terms of the declining number of households by occupation. In 1996, no village in the project area reported any household exclusively selling labour as means of livelihood.

Table 5



Occupation by Households in Project Area

Household Occupation	1992	1996
Paddy production, exclusively	469	240
Selling labour, exclusively	30	
Dry season cropping	135	50
Raising chicken and ducks for sale	305	138

Again, the changes within the core project area of 11 villages may be compared to similar changes over the wider area of 66 villages in which households have received compensations to date from the authorities in recognition of the dam's impact on their properties and livelihoods. In perspective, they may also be compared to those in the larger context of the entire province of Ubon Ratchathani as recorded by the NRDC census.

From an initial index value of 100 in 1992, the core project area of 11 villages showed a decreased value of 51 by 1996 for the number of households exclusively engaged in paddy production, whereas the other villages in the compensation area of 66 villages showed an index value of 68, and the rest of all rural villages in Ubon Ratchathani province an increased index value of 106.

Over the same period and from the same initial value of 100 in 1992, the core project area reported no households exclusively engaged in selling labour for their livelihood by 1996, whereas other villages in the compensation area showed an index value of 106, and the rest of the villages in the province an index value of 75.
For households deriving supplementary income from dry-season cropping, the index value for the project area showed a drop by 1996 to 37, compared to a similarly declining value of 42 for the rest of the compensation area, against an increase in index value to 111 for the rest of Ubon Ratchathani province.

The same pattern is found for the number of households that raised chicken and ducks for sale as an occupation for supplementary income. For this census variable, the index value for the project area showed a decline to 45 by 1996, against a lesser declining value of 71 for the rest of the compensation area, but a rise in the variable index value to 109 for the rest of the province.

Traditional hydropower planning used parameters such as firm energy and dependable capacity as parameters to estimate the value of a hydropower plant to the system. However, at the time of the Pak Mun appraisal, it was already widely recognized that, while such parameters may be useful in the context of an isolated system strongly dependant on hydropower, their use will greatly undervalue "run-of-river" hydropower and other intermittent forms of generation such as wind-power, in the context of a large diversified generation system. Since reliability of thermal power plant is treated stochastically, it is logical that hydropower should be similarly treated. Comprehensive studies of this matter were carried out in the United States by the Federal Energy and Regulatory Commission (FERC) in the 1980s, in the context of the PURPA legislation which encouraged the development of small hydropower, other renewables and co-generation. These studies are reported in several technical journals including the proceedings of the Hydropower 1989 conference in the United States. (Mittelstaadt, "Determining Hydropower Dependable Capacity" Waterpower '89). The conclusion was that average capacity and energy values for hydropower could be used for planning purposes in large diverse systems. EGAT's system falls into that category

Part 2: Response from the study team
Professor Chayan Vaddhanaphuti's response to the World Bank's Comments on Social Aspects

The social aspect of the report focuses upon the view expressed by the affected people in Pak Mun project area and is also based on the KKU evaluation report, which is also the basis of the World Bank OED report. The social aspect report aims to present data, which has been neglected or not mentioned by the OED report which is also unbalanced.

The deficiencies in the baseline data on affected people, the absence of a comprehensive resettlement plan and a lack of good-quality consultations with affected people, as mentioned in the Work Bank's response to the WCD report are obviously indicative of a poor resettlement planning and implementation of the Pak Mun project. In fact, the actual resettlement plan was based on the original Resettlement Report of the Pak Mun dam, which was initially planned to build at Kaeng Tana, 1.5kms downstream of the present site. When decision was made to build the dam at Ban Hua Hue, no resettlement study was redone in order to assess the actual impacts of the inundated area. Until the dam was nearly completed, the people in the project area were not informed about the area that would be inundated, causing confusions and uncertainty among villagers. It was the villagers themselves who made their demand to EGAT to reveal the information of the would-be inundated area.

In addition, when EGAT decided to construct the Pak Mun dam at Ban Hua Hue, EGAT did not inform nor consult with the villagers about the blasting of the rocks and rapids. The blasting generated disturbing loud noise and caused a large amount of debris and dust to fly over Ban Hua Hue. Most villagers of Ban Hua Hue decided to move to other places. They split into four groups: the first group moved to live in a forest reserve area 4kms from their original village, the second group resettled in a resettlement area arranged by EGAT, 1.5km from the dam site (later, they decided not to stay there) , the third group moved to the resettlement area 1.5km opposite to the second group, and the fourth group to another resettlement area around 1.5km from their former village. This resettlement shows not only the distance that the affected people had to move from their former village, but also the way the affected people were resettled.

It is true that <u>some</u> affected people had to move "a couple of hundreds meters, at most, away from their current locations", but there are <u>many of them</u> who had to move far from their former villages, such as, some villagers from Ban Hua Hue, Ban Wang Sabaeng, Ban Tung Lung. So it is not accurate to conclude that the affected people had to move only "a couple of hundreds meters". Even though it is true that the design changes had reduced the number of people to be resettled, but the design itself (i.e., building dikes to prevent inundation) caused many houses to be surrounded by water. Many villagers, who did not move from their current locations, faced inconveniences in their daily life. It is difficult for them to move around or to bring their cattle to the fields, and it is also dangerous for their children to live near water.

The resettlement of affected people, whether near or far, has reduced community relations and networks among themselves and between them and those who are not affected. First, those who had to move from their former villages found it difficult to maintain regular contact with their former neighbors. Distance prevents regular daily interaction among villagers and flow of communication, particularly about official affairs. In addition, the decline of fish in the Mun river forced affected people, particularly the young members of the households to look for job in town. Second, before the dam was constructed, strips of land along the river banks were used for summer gardening. This was this place where people interacted and met each other. Social solidarity and bonds were strengthened through interactions and mutual help. In addition, they used to gather annually at rapids in the dry season to offer foods to Buddhist monks, to pay respect to the river and to celebrate their traditional New Year celebration. Nowadays, such meaningful communal event can no longer be organized. Third, after there was a plan to build the Pak Mun dam, villagers were polarized into two groups: those who opposed to the dam and those who supported the dam. The polarization and conflicts

among the villagers under the project area were caused by the way in which the project was implemented. It was a strategy to silence those who opposed the dam. That is, one group of villagers was supported to be a counterforce against another group who were against the dam. This was a kind of practice which the World Bank did not include in it's the OED report.

The fact that the resettlers and affected people have maintained strong community relations and networks is largely due to the fact that they share a common problem. They have consolidated into a group because they have not received justice from state authorities and EGAT, not because they did not move far from each other, as argued by the World Bank.

It will be difficult to claim that the resettlement program of the Pak Mun project is one of the best resettlement programs in the region as claimed by the World Bank. First of all, there was a big discrepancy between the resettlement plan and the actual implementation. The first resettlement area (known as the 11 units) was unrealistic because the house was too small for ordinary Northeastern Thai extended family. The land allocated was of poor soil quality and no water supply was available as promised. Several families found the houses built by EGAT too small for them; thus nine houses were sold to outsiders. In the second resettlement area (known as the 60 units), there were only 47 houses available for the resettlers. Again, land allocated for the resettlers was to small and the area around the settlement became rock dump area. A water tank was constructed, but was not maintained as promised. Second, several occupational trainings were organized for the affected people, but they were neither appropriate nor adequate to prepare rural people to start their own business. As a result, many had chosen to work as wage labor in construction works or sugar cane plantations until the economic crisis in 1997. Fish-raising was also introduced to the villagers, but it required bringing water to fill the ponds and cash investment to buy fish feeds. The project was not successful. It is true that there have been efforts to redress the problems faced by affected people after the dam was constructed, and there were provincial level agencies to resolve issues related to compensation, infrastructure development and grievance redress. In reality, however, the efforts to redress the problems were not carried out with consultation of the affected people or were poorly conceived. It is true that infrastructure in the project area was improved, but these villagers were entitled to improved infrastructure without having to sacrifice their livelihood any way. It should be noted that additional number of affected villagers who were given compensation were villagers who were originally pro-dam, but their names were later submitted for compensation based on the recommendation by the provincial government as those who had done "good things" to the government agencies.

It should be pointed out that all compensation from the dam construction and resettlement the affected people have so far received came largely from the persistent demands and struggles by the villagers themselves. Many lost their time and income in making their grievances heard before they could get compensation from the government. They had to deal with the bureaucracy of the state authorities and the tactics of EGAT. They and their children were often labeled as "mobsters". They faced tremendous psychological stress in making their demands and submitting their grievances, and usually found out that their demands and grievances were ignored. A case in point is with the World Bank itself. The villagers staged their protest against the dam in front of the World Bank office in Bangkok in October 1991 even before after the World Bank decided to support the construction of the Pak Mun dam. Central to their protest was the issue of the loss of fisheries after the dam construction. However, the World Bank did not listen to the view expressed by the would-be affected people, but went on to support the Pak Mun project. In the World Bank response to WCD report, it was even mentioned that the issue of the loss of income from fishing was not reported by the affected people during the initial World Bank supervision missions.

Response from an independent source on reliability of NRDC data
Comments on NRDC data by Tonkla Group for Alternative Economics Studies, Faculty of Economics, Kasetsart University

The conclusion about living conditions of people in project-affected villages derived from NRDC data is completely different from the conclusions of the people themselves. In academic world, we can come out with the different conclusion. Therefore, the different conclusion is not the issue. The issue is how reliable the data you use to draw your conclusion. Use of NRDC2C data as the ONLY information to draw the conclusion may not appropriate. It implies that NRDC2C data is highly reliable data. However, in the experience of faculty members in my Department (Department of Agricultural and Resource Economics), NRDC2C data does not have these essential characteristics***. A translation of the comment of NESDB (the Office of National Economic and Social Development Board) has the following to say on the NRDC2C data***

"The data collection process still lacks of participation from the officers in four main ministries, as well as lacks of participation from the villagers. Most of the time the questionnaires are filled by the development officers and the stakeholders are asked to check and sign. However, in some areas, the persons who sign never check, therefore, it leads to unacceptable and questionable about the sources of information" NESDB, 1995, Thai Rural Situation 1994, NESDB Bangkok, (in Thai), pp. 157.

It is clear that NRDC2C data is the village data level, not household level. Moreover, it has always been done by one officer or village headman (see TDRI appendix) without the real participation from the villagers. Therefore, the word "NRDC2C census" used in the WCD annex is highly questionable and possibly exaggerated. In original Thai version, no one in Thailand calls this series "census" (or Summano in Thai language). We always call it data (or Kormun in Thai language).

Further complications arise from other biases. If we take into consideration that, during the construction (and protesting) period, officers and village headmen sided with EGAT, it is clear that NRDC2C data is an unreliable source of information and possibly unacceptable to the villagers. Even from EGAT's own information, it is clear that the fishery income in 1992 is much higher than 2 480 THB/household. From the report for EGAT by Khon Kaen University (1997), it is clear that the fishery income was reduced during the period of 1994 to 1996. Khon Kaen University presents that the fishery income was reduced from 13 429 THB in 1994 to 8 694.84 THB to 1996. It is not necessary to say about other abundant literatures, which show the different conclusion.

Note by the WCD: Given reservations expressed on the reliability of NRDC data, the study used data generated by the team. Besides, NRDC data for the period beyond 1996 was not available. Thus, in addition to 1997 OED study on Pak Mun, fresh data generated by the study team was used to make comparison and arrive at conclusions.

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4 X 35 MW plant (D=6.0 m)
[19] Electricity Generating Authority of Thailand.(1988). Summary Report, Pak Mun Multipurpose Development Project Report No. 31100-3103, Hydro Power Engineering Department, mimeo, p. 33
[20] Electricity Generating Authority of Thailand(1989). Pak Mun Project, Definite Study, Phase 2, Final Report, Volume 1: Main Report, mimeo. p.114
[21] The World Bank(1991). Staff Appraisal Report, Thailand: Third Power System Development Project, mimeo., p.56.
[22] Electricity Generating Authority of Thailand.(1999). Pak Mun Hydroelectric Project Units 1-4, Project Cost and Final Estimate Expenditure, Construction Administration Department, Hydro Power Division, mimeo table.
[23] The World Bank. (1996). Implementation Completion Report, Thailand, Third Power System Development Project (Loan 3423-TH), p.22.
[24] Electricity Generating Authority of Thailand.(1999). Pak Mun Hydroelectric Project Units 1-4, Project Cost and Final Estimate Expenditure, mimeo table.
[25] 38 Baht = 1 US$
[26] 38 Baht = 1 US$
[27] "Chain" calculation based on:
Bank of Thailand Web site http://www.bot.or.th.
Bank of Thailand.(1993). Quarterly Bulletin, Vol. 33, No. 1, Table 64, p.95.
The World Bank.(1991). Thailand Economic Memorandum (Report No. 9627-TH), p. 68.
[28] 38 Baht = 1 US$
29 EGAT.(1999). Private communication with the author
[30] Electricity Generating Authority of Thailand(1988). Summary Report, Pak Mun Multipurpose Development Project Report No. 31100-3103, Hydro Power Engineering Department. mimeo, p. 38.

[31] The World Bank.(1991). Staff Appraisal Report, Thailand, Third Power System Development Project, mimeo., p.20.
[32] The World Bank. (1996).Implementation Completion Report, Thailand, Third Power System Development Project (Loan 3423-TH), p.3.
[33] EGAT. (1999). Private communication with the author.
[34] Strictly speaking the concept of gross water to power conversion was not used in the planning stages of the Pak Mun dam. However, since predictions were made about the average run-off of the Mun river at the Pak Mun dam and predictions were made concerning yearly power output, implicitly assumptions were made about the dams water to power conversion efficiency.
[35] Electricity Generating Authority of Thailand. (1999). EGAT Power Development Plan (Revised PDP 99-01), General Information, Generation System Development Planning Department, System Planning Division. mimeo, p. 32.
[36] Electricity Generating Authority of Thailand. (1988). EGAT Power Development Plan (1988-2001) (Based on adjusted load forecast) of February 1988, Report No. 10600-3105, System Planning Department. mimeo, p. 23.
[37] Electricity Generating Authority of Thailand. (2000). 5 years Experience of The PAK MUN DAM, Prepared for Discussion On PAK MUN Dam Mekong River Basin Thailand, World Commission On Dams. mimeo, Annex p.38-40.
[38] Electricity Generating Authority of Thailand (1988). Summary Report, Pak Mun Multipurpose Development Project Report No. 31100-3103, mimeo, p. 2.
[39] Electricity Generating Authority of Thailand, (1988). EGAT Power Development Plan (1988-2001) (Based on adjusted load forecast) of February 1988, Report No. 10600-3105, mimeo, p. 23.
[40] EGAT. (1999). Private communication with the author.
[41] Electricity Generating Authority of Thailand. (1989). Pak Mun Project, Definite Study – Phase 2, Final Report, Volume II: Appendices, mimeo, page D-2.
42 Electricity Generating Authority of Thailand.(1989). Pak Mun Project, Definite Study – Phase 2, Final Report, Volume II: Appendices, mimeo, page D-1.
[43] EGAT. (1999). Private communication with the author.
[44] Dam started recorded production on August 1994, but data are only available from 1 may 1996 onwards.
[45] Data up to 31 August 1999 only.
[46] EGAT October 1999. Private communication with the author
[47] Electricity Generating Authority of Thailand. (1985). Pak Mun Multipurpose Development Feasibility Studies, Final, Volume I, Main Report, mimeo. p. 25
[48] In fact more recent records show that in 1996 the head was reduced to around one centimetre for a few days.
[49] Electricity Generating Authority of Thailand. (2000). 5 years Experience of The PAK MUN DAM, Prepared for Discussion On PAK MUN Dam Mekong River Basin Thailand.World Commission On Dams, mimeo, Annex p.38-40.
[50] Electricity Generating Authority of Thailand. (1988). Summary Report, Pak Mun Multipurpose Development Project Report No. 31100-3103, Hydro Power Engineering Department, mimeo, p. 2.
[51] Electricity Generating Authority of Thailand. (1988). EGAT Power Development Plan (1988-2001) (Based on adjusted load forecast) of February 1988, Report No. 10600-3105, , System Planning Department. mimeo, p. 23.
[52] EGAT. (1999). Private communication with the author.
[53] Mr Anuwat Wathanapongsiri
[54] Benefit/Cost ratio, calculated at a 12% discount rate.
[55] Net Present Value, calculated at a 12% discount rate.
[56] Electricity Generating Authority of Thailand. (1988). Summary Report, Pak Mun Multipurpose Development Project Report No. 31100-3103, Hydro Power Engineering Department. mimeo, p. 49, second line.
[57] In the case of an economic cost benefit analyses, costs including up front cost, replacement costs, and Operation and Maintenance ("O&M") costs have to be compared with the benefits, in this case the benefit of electricity produced. The economic value of power is related to the cost of goods and services produced by the electricity. For the domestic sector this is usually taken as the willingness to pay. In cases of power shortages the value of the electricity is the value of the economic losses or costs of un-served energy and load shedding etc. A net project benefit vector is calculated by deducting the sum of the cost vectors from sum of the benefit vectors. The resulting net benefit vector is discounted using a rate that represents the shadow cost of capital in the country at the time of the analysis. This yields the Net Present Value of the project. The IRR is the discount rate at which the net present value of the net benefit vector is zero. The Equalising discount rate is used in a Least Cost Analysis to compare a proposed project with the next best alternative to make sure that the switching value is larger than a threshold value. This involves comparing the costs of the proposed project with the costs of the next best alternative project producing the same electricity as the project. In effect in this analysis, the project benefits are assumed as be costs avoided by not investing in an equivalent project.

[58] The World Bank. (1979). Staff Appraisal Report, Thailand, Khao Laem Project, Report 2568a-TH, mimeo.
[59] The World Bank. (1979). Staff Appraisal Report, Thailand, Bang Pakong Thermal Power Project, Report 2271-TH, mimeo.
[60] Electricity Generating Authority of Thailand. (1988). Summary Report, Pak Mun Multipurpose Development Project Report No. 31100-3103, , Hydro Power Engineering Department. mimeo, p. 49.
[61] The World Bank. (1991). Staff Appraisal Report, Thailand: Third Power System Development Project, mimeo., p.109.
[62] The World Bank. (1996), Implementation Completion Report, Thailand, Third Power System Development Project (Loan 3423-TH), p.25.
[63] i) The study team could not find system planning outputs, nor seen documents referring to system studies.

(ii) Pak Mun is situated in the NE region. According to many reports this region needed peaking capacity and for this reason Pak Mun was justified. This is not in line with WB and EGAT now treating Pak Mun as a component of the whole system. Were there no better alternatives to Pak Mun in the whole of Thailand?

The kWh cost of Pak Mun with an investment of US$ 240 million and a 10% discount rate is about US$ 0.12 per kWh and about half to two thirds of it is produced during off-peak hours during the wet season. The marginal cost in the Thai system in off-peak hours is about US$0.02 per kWh. That implicitly means that the peak hour kWh costs of about US$ 0.22 to US$ 0.32 per kWh. If this were produced by gas turbines, which at a discount rate of 10% would roughly cost:

Capacity	$600 (investment for small GT) x 0.13 (CRF) / 1460 (hrs peaking) =US$ 0.053	
OMR	3% of investment cost= $600 x 0.03 / 1460	US$ 0.012
Energy	12000 kJ/kWh / 43.5 GJ/ton x US$ 200 per ton	US$ 0.055

Total	US$ 0.120	

Note that the investment, OMR and fuel price in this estimate are on the high side, and yet the peaking power kWh price is only US$0.12 compared with US$ 0.22 to 0.32 for Pak Mun, indicating a B/C ratio of about 0.55 to 0.37, which matches with the EIRR computed in our version.

It is clear that the conclusions derived by this study hold true.

[64]EGAT. (1988). Summary Report: Pak Mun Multipurpose Development Project, Hydropower Engineering Department, (Report No. 31100-3103), p.43
[65]/ Ibid., p.27
[66] Environment and Ecological Investigation of Pak Mun Project by TEAM Consulting Engineers, Ltd., (hereafter EEI)
[67] For example, while impoundment of the reservoir will inundate certain areas, it will enhance recreation opportunity and tourism. Emigration for more employment will increase, see EEI
[68] EEI, p. IV-47
[69] EEI , p. III-91
[70] EEI, p. IV-15-23
[71] EEI, p.IV-42.
[72] EEI, p.IV-43.
[73] EEI, p. IV-46.
[74] EEI, p. IV-43.
[75] According to EEI, p.VI-220, an estimated 41 000 tourists visited Kaeng Saphur every month during March-May.
[76] This view is drastically different from EEI report. Although many villagers are rice farmers, they depend on fishing for cash income. A common expression used among the villagers, "Growing rice on the back of fish," an analogy for "catching fish to trade with rice" suggests the relation between fish and rice for the Pak Mun villagers. This view is from interviews with Mae Sida Phosuwan and Mae Kampui Sanohwathee from Ban Kan Leum, Mae Sompong Viengchan from Ban Wang Sabaseng Tai, Mae Chareon Kongsook from Ban Hua Heo, etc.
[77] Information was collected through field surveys and personal communications with local people, community leaders, NGO representatives, and local government officers, in April 1999. The village and household survey

was conducted during October 1999. In depth interviews of village leaders and the manager and committees of the Cooperatives of compensated fisher-folk were undertaken during the same period. Fish markets at Khong Chiam and Phibun Mungsaharn were observed and local fish traders were interviewed. The analyses also draws from the compilation of secondary data from previous studies, documents and reports relating to fisheries and socio-economic conditions in the lower Mun River and the Pak Mun Dam Project area. (Choowaew, 1999).

[78] Interviews with Mae Sompong Viengchan from Wang Sabaengtai, Poh Charoen Srihatham, experienced fishman from Wang Sabaengtai, Poh Tern Tharatana from Ban Tung Lung.

[79] OED, World Bank. (1998). Recent Experience with Involunatry Resettlement, Thailand-Pak Mun, June 2, 1998, p. 12.

[80] Interview with a fish buyer from Khong Chiam in Ban Weun Buek who buys fish from Laos and sell to local markets.

[81] Interview with Mae Chareon Kongsook from ban Hua Heo who refused to be relocated in EGAT' s resettlement area, Ban Hua Heo Mu 4, and also Mae Kab Muangthong, one of the leaders of Ban Hua Heo Mu 4.

[82] Inteview with Poh Jane Pimchan from Ban Don Punchat near Kaeng Saphur Rapids.

[83] Interview with Poh Dam Chatapan from Ban

[84] Interview with Mae Kampui Sunthornwathee from Ban Kan Luem.

[85] Mae Sida from Ban Kan Luem.

[86] The Final Report on the Follow-up of Changes and Environmental Impacts: Socio-Economic Aspects of the Resettlement of the Pak Mun Project affected People by Khon Kaen University, 1997.

[87] EEI, p. VI-112.

[88] Personal communication with a committee member.

[89] The common species found in this forest area are Heing *(Diptero-carpus intricatus),* Pluang *(D. tuberculatus),* Teng *(Shorea obtusa),* Rang *(Pentacme suavis),* Pak *(Melanorrhoea usitata),* Yor-pa *(Morinda elliptica),* Ta-bag *(Lagerstroemia calyculata),* Ka-bog *(Irvingia malayana),* Meard *(Symplocos sp),* Pa-yom *(Shorea floribunda),* Kradon *(Careya aborea),* Makartar *(Sindora siamensis),* Wah *(Eugenia cumini),* Ma-pok *(parinaria anamese),* Shun-Yod *(Gardenia coronaria),* and Daeng *(Xylia Kerrii).*

[90] 1 US$ = 40 Baht).

[91] The Additional points on Public Health Issue (made by the EGAT):

1. According to TEAM & Mahidol University (1984) and our field studies in the project area in 1994 to 1999, *Bithynia sp.*, snail first intermediate host of the liver fluke was found to inhabit the rice fields, ponds etc. but not the Mun River itself or its tributaries. The villagers in the project area ate the uncooked cyprinoid fish collected from the Mun River. This fish would not be infected with the liver fluke as the epidemiology or life cycle of *O. viverrini* in the Mun River was not completed. Thus, the villagers got the liver fluke infection from eating the uncooked fish collected from the rice field or ponds.
   Although the copious population of *Neotricula* (=*Tricula*) *aperta*, beta race, snail intermediate host of *Schistosoma mekongi*, are in the Mun River or the project area. But the endemic area of the blood fluke, *Schistosomiasis mekongi*, is in Khong Island, southern Lao PDR. It is located more than 150 kilometers from the project area and downstream of the Mun River or dam site.
2. Also, our field studies in the Mun River, the project area, began in May 1994 and continued monthly until April 1999. The population of *N.aperta*, beta race, were found decreasing than prior to the construction of the Pak Mun Dam

[92] from the interview, November 1999

[93] Electricity Generating Authority of Thailand. (1980). Pak Mun Multipurpose Development Up-dated Feasibility Studies, Text, mimeo. p. 56.

[94] Electricity Generating Authority of Thailand. (1980). Pak Mun Multipurpose Development Up-dated Feasibility Studies, Text, mimeo. p. 8.

[95] Electricity Generating Authority of Thailand. (1985). Pak Mun Multipurpose Development Feasibility Studies, Final, Volume I, Main Report, mimeo. p. 22

[96] Electricity Generating Authority of Thailand. (1987). Pak Mun Project, Definite Study, Phase 1, Final Report, Volume 1: Main Report, mimeo. p. 44,45.

[97] Electricity Generating Authority of Thailand. (1987). Pak Mun Project, Definite Study, Phase 1, Final Report, Volume 1: Main Report, mimeo. p. 45.

[98] Electricity Generating Authority of Thailand. (1987). Pak Mun Project, Definite Study, Phase 1, Final Report, Volume 1: Main Report, mimeo. p. 47.

[99] Electricity Generating Authority of Thailand. (1988). Summary Report, Pak Mun Multipurpose Development Project Report No. 31100-3103, Hydro Power Engineering Department, mimeo, p. 30

[100] Electricity Generating Authority of Thailand. (1988). Summary Report, Pak Mun Multipurpose Development Project Report No. 31100-3103, Hydro Power Engineering Department, mimeo, p. 31, 43

[101] Electricity Generating Authority of Thailand. (1989). Pak Mun Project, Definite Study, Phase 2, Final Report, Volume 1: Main Report, mimeo. p. 57.
[102] The World Bank. (1991). Staff Appraisal Report, Thailand: Third Power System Development Project, mimeo., p.45, 108.
[103]/ SOGREAH, (1985). Pak Mun Multipurpose Development Project: Feasibility Studies: Final Report: Volume I –Main Report.
[104]EGAT. (1988). Summary Report: Pak Mun Multipurpose Development Project, Hydropower Engineering Department, (Report No. 31100-3103) pp. 31,43
[105]/ Ibid., p.48
[106]/ Ibid., p.46
[107]/ Ibid., p.6
[108]/ World Bank. (1996). Thailand: Third Power System Development Project (Loan 3423-TH) – Implementation Completion Report, Report No. 15744, June 18, 1996 Appendix B. p.6
[109] Electricity Generating Authority of Thailand. (1988). (1988). Summary Report, Pak Mun Multipurpose Development Project Report No. 31100-3103, Hydro Power Engineering Department, mimeo and
The World Bank. (1991). Staff Appraisal Report, Thailand: Third Power System Development Project, mimeo.
[110] Electricity Generating Authority of Thailand. (1988). Summary Report, Pak Mun Multipurpose Development Project Report No. 31100-3103, Hydro Power Engineering Department, mimeo.
[111] Electricity Generating Authority of Thailand. (1988). Summary Report, Pak Mun Multipurpose Development Project Report No. 31100-3103 Hydro Power Engineering Department, mimeo., p. 30, 43
[112] Electricity Generating Authority of Thailand. (1988). Summary Report, Pak Mun Multipurpose Development Project Report No. 31100-3103, Hydro Power Engineering Department, mimeo., p. i
[113] The World Bank. (1991). Staff Appraisal Report, Thailand: Third Power System Development Project, mimeo, p. 55.
[114] Electricity Generating Authority of Thailand. (1988). Summary Report, Pak Mun Multipurpose Development Project Report No. 31100-3103, Hydro Power Engineering Department, mimeo., p. 32
[115] The World Bank. (1991). Staff Appraisal Report, Thailand: Third Power System Development Project, mimeo., p. 55
[116] Electricity Generating Authority of Thailand. (1988). Summary Report, Pak Mun Multipurpose Development Project Report No. 31100-3103, Hydro Power Engineering Department, mimeo.., p. 31, 43
[117] Electricity Generating Authority of Thailand, (1988). Summary Report, Pak Mun Multipurpose Development Project Report No. 31100-3103, Hydro Power Engineering Department, mimeo., p. 43
[118] The WB SAR refers this as Internal combustion peaking turbines
[119] The World Bank. (1991). Staff Appraisal Report, Thailand: Third Power System Development Project, mimeo., p.108.
[120] Electricity Generating Authority of Thailand. (1988). Summary Report, Pak Mun Multipurpose Development Project Report No. 31100-3103, Hydro Power Engineering Department, mimeo., p. 48
[121] The World Bank. (1991). Staff Appraisal Report, Thailand: Third Power System Development Project, mimeo., p.108.
[122] Electricity Generating Authority of Thailand. (1988). Summary Report, Pak Mun Multipurpose Development Project Report No. 31100-3103, Hydro Power Engineering Department, mimeo, p. 47
[123] The World Bank. (1991). Staff Appraisal Report, Thailand: Third Power System Development Project, mimeo., p.108.
[124] Electricity Generating Authority of Thailand. (1988). Summary Report, Pak Mun Multipurpose Development Project Report No. 31100-3103, Hydro Power Engineering Department, mimeo, p. 47
[125] Electricity Generating Authority of Thailand. (1988). Summary Report, Pak Mun Multipurpose Development Project Report No. 31100-3103, Hydro Power Engineering Department, mimeo, p. 47
[126] Electricity Generating Authority of Thailand. (1988). Summary Report, Pak Mun Multipurpose Development Project Report No. 31100-3103, Hydro Power Engineering Department, mimeo. p. 47
[127] The World Bank. (1991). Staff Appraisal Report, Thailand: Third Power System Development Project, mimeo., p.109.
[128] Electricity Generating Authority of Thailand. (1988). Summary Report, Pak Mun Multipurpose Development Project Report No. 31100-3103, Hydro Power Engineering Department, mimeo. p. 48
[129] The World Bank. (1991). Staff Appraisal Report, Thailand: Third Power System Development Project, mimeo., p.108.
[130]World Bank. (1991). Thailand: Third Power System Development Project – Staff Appraisal Report, Report No. 9173-TH
[131]World Bank. (1991)., Thailand: Third Power System Development Project – Staff Appraisal Report, Report No. 9173-TH, Annex 21 p.1

[132]/ Ibid., Annex 21 p.2
[133]/ World Bank. (1996). Thailand: Third Power System Development Project (Loan 3423-TH) – Implementation Completion Report, Report No. 15744.
[134]/ Ibid., Appendix C p.13, p.10
[135] The number of the final amount of affected villagers given compensation is based on the document submitted to the Committee for the Assistance and Development of the Fishing Occupation in the Affected Area, April 19, 1999 and personal communication with a committee member.
[136] Mr. Anuwat Wathanapongsiri
[137] Monitoring and Evaluation Report on the Redressing of the Environmental Impacts of the Pak Mun Hydroelectric Power Project, Uban Ratchathani Province by the Office of National Economic and Social Development Committee, 1992; Report on the Pak Mun Hydroelectric Project's Impacts on Fishing Occupation by the Subcommittee for Survey and Study on the Pak Mun Hydroelectric Project's Impacts on Fishing Occupation, Ubon Ratchathani Province, 1994; The Final Report on the Follow-up of Changes and Environmental Impacts: Socio-Economic Aspects of the Resettlement of the Pak Mun Project affected People by Khon Kaen University, 1997.
[138] EGAT. (1994). Report on Redressing of the Pak Mun Project Environment Impacts, No. 51101-3720.
[139] Interview with Mr. Supan Wangphol, former village headman of Ban Hua Heo and another headman from Ban Kan Peuy who belongs to the kamnan and headmen group.
[140] Interview with Mae Kampui Watheesanoh from Ban Kan Leum.
[141] Customary land is defined by some degree of legal entitlement for the user, as provided by one of a number of various land title documents.
[142] For instance, the Land Act 1954, the Forest Act 1942, the Forest Reserve Act 1963, the National Park Act 1961, the Fishery Act 1947, or the Navigation in Thai Water Act 1893.
[143] 1rai = 6.25 hectares
[144] EGAT, Report on the Pak Mun Hydroelectric Power Project, prepared by Hydro Construction Division. No date.
[145] For example, articles 46, 56, 76, 79. 289
[146] 25 Baht = 1 US$
[147] The result of species number at pre-impoundment is taken from surveys that used several methods - seinnets, electrofishing and especially from artisanal fishing activities that penetrated all microhabitats, nearly all year round. Survey conducted since 1990 also included results of Tyson Roberts and W.J. Rainboth in the last two decades. Due to updating of freshwater fish systematic (taxonomy) knowledge, many species from old reports (Thanthong & Siriphan, 1969 and others) are corrected.

[148] If such records are indeed kept, the study team did not have access to them.

[149] The definition of Dependable Capacity currently used by EGAT for Hydropower is slightly different from the one declared by EGAT in March 1988 [149]. It is defined as follows:

"*Dependable Capacity of Hydropower Plants*: This is defined as the unit output at the reservoir water levels corresponding to 90% of the water level frequency based on the long-term reservoir simulations, using historical hydrological records" [149]

The formula is:
minimum of the 90% of the Highest of $HydroCapacity_d = Energy_d * 1000 /24$ hours in day_d

Where: $HydroCapacity_d$ is the capacity for each day of a year calculated based on total water flow history, and

$Energy_d$ is expressed in GWh

The new rule is just a little less demanding than the earlier version. In effect the earlier rule required an operating capacity reliable 91.66% of the time. Since EGAT uses monthly data to enter the Dependable Capacity of a plant, the new rule and the old rule are operationally the same.

Using EGAT's definition of Dependable Capacity, the Pak Mun hydropower project Dependable Capacity is 20.81 MW if one assigns all available power to a 4-hour peak demand period. -Power component -P.41

[150] The actual record, based on daily power generation data supplied to the study by EGAT, indicates that an average of about 44% of the total GWh could be generated as peak power. However based on simulations made by SOGREAH, it is more likely that only about an average of 72% of the Peak Generation can be achieved. This means that it is likely that only about 32% of the GWh are produced at peak time.

[151] Prior to the 1999 WCD study, the WB OED had also recorded the decline in fish catch and fishing income based on the Khon Kaen university study. P.11, Recent Experience with Involuntary Resettlement, Thailand, Pak Mun, 1998.

[152] In this respect, it should be noted that Pak Mun is not a pure run-of-river project. It does have sufficient storage to enable flows to be regulated at least on a daily basis when flows are less than the capacity of the turbines to operate throughout the day.[WCD's reponse: According to this definition there are no real run-of-the-river dams (notice the contradiction in the terms). Since none operate around the clock and all involve at least some form of dam. Only a paddlewheel installed on a riverbank would classify as truly run-of-the-river.] During periods of low flow, it can operate on a weekly cycle if required and in very dry periods on a monthly cycle. [Response: This is not how EGAT operated Pak Mun]

[153] An attempt to explain the analysis in layman's terms, as presented to the Pak Mun Stakeholders Meeting is included as Annex A. While this explanation has been included in Annex 9 to the Report no reference has been made to it in the body of the Report nor in the Executive Summary. It also appears that no adjustments have been made to the original draft in response to this explanation.

[154] A case where the thermal alternative could be clearly identified would be a new hydropower plant replacing a new diesel plant in an all diesel system.

[155] Commonly in the hydropower industry (including in the reports prepared by Sogreah and EGAT) the equalizing discount rate is referred to as an EIRR, considering the hydropower project as the costs and the avoided costs of thermal as a benefit. The Bank agrees with the Report that this is an incorrect nomenclature.

[156] Sogreah October, 1985 page 14 quotes availability (after forced outage) figures of 98%, 95% and 90% for hydro, thermal and gas turbine respectively, but does not quote planned outages. Appendix 4 Section 2.2.1 quotes "dependable capacities" of 95 % for thermal, 90% for existing gas turbines and 80% for new gas turbine. Comparison with those provided above indicate that these availabilities also reflect forced outages. Appendix 7 Page A7 quotes forced and scheduled outage rates for hydropower as 2% and 3% respectively.

[157] This is conservative. EGAT currently uses 100% for planning, assuming forced outage as negligible and planned maintenance fitted into times of low demand.

[158] Overall availabilities extracted from a comprehensive tabulation of thermal plant characteristics included in Appendix A to World Bank Technical Paper No. 106, August, 1989.

[159] Net head = Reservoir level – Tailwater Level – Hydraulic losses through the powerhouse waterway

[160] This criterion is considered to be conservative. Modern practice would tend towards inputing calendar monthly average capacities into the planning program, a more precise treatment of EGAT's traditional definition of "dependable capacity" (based on head limitations) quoted in Sogreah, 1993 (Appendix IV p. A4-6) which quotes " the average of the installed and minimum generation capability of that hydropower plant, based on long term reservoir simulation using past hydrological records".

[161] The analysis is usually carried out on a monthly basis.

[162] Sogreah, 1985, Volume 1, Page 25.

[163] (0.95/0.78) plus conservative 3% for different effects on system reliability.

[164] This was not mentioned in the Sogreah report but later reports showed that the North Eastern Region is a net importer.

165 . On the face of it the decision to use energy which could be generated in the peak period over the full period of the simulation as a basis for determining capacity limitations might be considered non-conservative (an alternative approach might be to use a 90 percent exceedance month as EGAT now assume for capacity as limited by head). However, as indicated in footnote 8, modern trends in relation to planning in the context of a diverse mixed system would be to use average values.

[166] There were no plans at that time to draw down for Kaeng Sapphue tourism and simulations showed that peaking operation only varied reservoir level by 50cm, not sufficient to reduce head below rated head.

[167] As noted earlier, the 90 percent criterion itself is considered to be conservative, and modern practice would tend to use 50 percent

[168] Sogreah Appendix 1 Table 1.8.

[169] $(8.5/11.0)^{1.5}$

[170] 1.35*1.12

[171] Pak Mun Multipurpose Project. Summary Report.

[172] Table 3.2 of the EGAT report shows the 1987 to 2001 PDP which includes three combined cycle plants. The June 1990 PDP includes 200 MW of simple cycle gas turbines.
[173] The average energy estimates were reduced from 317 GWh to 280.2 GWh, presumably as a result of the new operation studies carried out as part of Sogreah's detailed design, taking into account varying reservoir levels during January to May and for lowering reservoir for high flows to minimize backwater effects.
[174] 92.5(95.0/82.5)
[175] EGAT. (1990). Power Development Plan(1990-2006) Systems Planning Department1990.
[176] Load for April 28, 1998, from PDP 1999-01 of January, 1999 latest available.