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RESEARCH REPORT

No. 2006-RR1

The Implementation of Effluent Taxes for Cambodian Industry: An Assessment of Pollutant Levies

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This study looks at how the Cambodian government might introduce a pollution levy system to address the country's industrial pollution problem. Using information drawn from a variety of sources, including a recent industrial survey, it estimates the levels of pollution charges that would reduce pollution by 25%-85%. It also calculates the overall revenue that such levies would produce and estimates the costs that industry would have to bear in terms of abatement costs and pollution charges.

Based on these findings, the study proposes a phased introduction of the levy system, to produce an eventual reduction in pollution of 65%. Revenues from the scheme would initially be used to strengthen its implementation and enforcement.

Published by the Economy and Environment Program for Southeast Asia (EEPSEA)
Tanglin PO Box 101, Singapore 912404 (www.eepsea.org)
tel: +65-6235-1344, fax: +65-6235-1849, email: eepsea@idrc.org.sg

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Library and Archives Canada Cataloguing in Publication

Biotechnology product development, biosafety regulation and environmental risk assessment in the Philippines / Linda M. Penalba … [et al.].

(Research report, 1608-5434 ; 2005-RR13)
Includes bibliographical references: p.
Co-published by: International Development Research Centre.
ISBN 1-55250-234-1

1. Biotechnology--Law and legislation--Philippines.
2. Biotechnology--Research--Philippines.
3. Biotechnology--Risk assessment--Philippines.
4. Intellectual property--Philippines.
I. Penalba, Linda M.
II. International Development Research Centre (Canada)
III. Economy and Environment Program for Southeast Asia
IV. Series: Research report (Economy and Environment Program for Southeast Asia) ; 2005-RR13.

TP248.195.P6P46 2006 343.599'0786606 C2006-980165-7

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June 2006

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EEPSEA was established in May 1993 to support research and training in environmental and resource economics. Its objective is to enhance local capacity to undertake the economic analysis of environmental problems and policies. It uses a networking approach, involving courses, meetings, technical support, access to literature and opportunities for comparative research. Member countries are Thailand, Malaysia, Indonesia, the Philippines, Vietnam, Cambodia, Lao PDR, China, Papua New Guinea and Sri Lanka.

EEPSEA is supported by the International Development Research Centre (IDRC); the Swedish International Development Cooperation Agency (Sida); and the Canadian International Development Agency (CIDA).

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ACKNOWLEDGEMENTS

The author wishes to thank Dr. David Glover, EEPSEA Director, for his confidence, cooperation, and advice in the review of this proposal and drafting of this report.

The author also thanks Dr. Benoît Laplante, EEPSEA resource person, for his contribution, precious advice and support in formulating the underlying economic analysis, and in the selection of the report methodology.

The author further thanks H.E. Muth Kieu, Secretary of State of the Ministry of Environment of Cambodia, for his support and contribution.

The author further thanks Dr. Herminia Francisco and Ms. Catherine Ndiaye for their confidence and support.

Last but not least, the author expresses the sincere appreciation for the cooperation and support provided by the following individuals who helped develop this report: Ou Pitu, Hov Sophea, Siv Kung, Sarin Prasidh, Hak Mao, and Sang Lundy.

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LIST OF ABBREVIATIONS

AC	Administration Council
Av.	Average
BOD	Biological Oxygen Demand
DPC	Department of Pollution Control of the Ministry of Environment
EEF	Environment Endowment Fund
GMAC	Garment Manufacturers' Association of Cambodia
KHR	Cambodian Riel (USD 1 = KHR 3,840)
MAC	Marginal Abatement Cost
Max.	Maximum
Min.	Minimum
MIME	Ministry of Industry, Mine and Energy
MOC	Ministry of Commerce
MOE	Ministry of Environment
MOF	Ministry of Finance
NIS	National Institute of Statistic
PPP	Purchasing Power Parity
USD	United States Dollar
WWTP	Wastewater Treatment Plant
kg	Kilogram

km	Kilometer
kWh	Kilowatt hour
m^3	Cubic meter
mg/l	Milligram per litre

The Implementation of Effluent Taxes for Cambodian Industry: An Assessment of Pollutant Levies

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EXECUTIVE SUMMARY

This research explored the implementation of effluent taxes for Cambodian industry. There is a general consensus amongst economists that market-based pollution control instruments have cost advantages over command and control strategies. The study's objective was therefore to identify the most cost-efficient fee levies that would meet different BOD reduction targets.

Data from polluting industries was compiled from various sources and completed using a survey of polluting firms (in 2004). As Cambodian abatement costs are unreliable, MAC from China and Vietnam were used to assess fee levies. This project targeted 250 large-scale firms. Of these, 247 were textile plants that discharged at least 10 m^3/day of effluent. The other three were large beverage firms. The BOD emissions from these targeted plants were 1,384 tons per year.

Four BOD reduction targets were selected. These ranged from 25% to 85%. Given these targets, and the two sets of MAC estimates from China and Vietnam, the study's calculations produced eight different fee levies. The fee levies calculated using MAC estimates from China were between USD 1 to USD 13 per ton of BOD. Those for MAC estimations from Vietnam were between USD 29 and USD 521 per ton of BOD. Fee levies from USD 104 to USD 521 per ton of BOD were selected as the best option as these were shown to be sufficient to achieve at least a 40% BOD reduction target.

Given the wide range of MAC used, a sensitivity analysis was conducted using three different scenarios. In Scenario 1 it was assumed that BOD emissions increased by between 16% and 45%. The result of this simulation showed that the selected fee levies would still be sufficient to meet the 40% of BOD reduction target. In Scenarios 2 and 3, the MAC values were converted into their Cambodia equivalent costs by using the purchasing power parity and per capita income methods. The result showed that to meet at least a 40% BOD reduction target, the fee levies should be USD 234 and USD 182 per ton of BOD for Scenarios 2 and 3 respectively.

In order to minimize costs, this paper recommends the following pollution abatement strategy: The application of a pollution fee levy of USD 104 per ton of BOD for an initial year of operation. This fee would then be raised to USD 260 in the second year. This would help to reduce BOD emissions by between 40% and 65%. It would generate between USD 10,093 and USD 68,463 per year in revenue.

Some amendments of existing laws and regulations would be necessary to ensure the effective monitoring and inspection of such a strategy. For example, the fine for non-payment of assigned fees or penalties should be higher than it currently is. This paper also suggests the establishment of an Agency for the management of the effluent fee. This would have three operational units (Monitoring & Enforcement, Program & Revenue Distribution and Finance & Fee Collection). This new Agency could be under

the control of the Ministry of Environment, or the Ministry of Finance or it could be an independent agency. For the first two years of the operation of this strategy, 80% of revenues should be dedicated to building the capacity of the agency and training its staff. However, this amount should be reduced gradually in order that, eventually, 80% of revenue could be used to subsidize pollution reduction efforts by firms.

1.0 INTRODUCTION

Cambodia has a population of over 13 million inhabitants and is one of the poorest countries in the world. Subsistence farming employs 70% of the workforce, while tourism is of growing economic importance. Over half of Cambodia is forested, but illegal logging is robbing the country of millions of dollars of badly needed revenue.

After 28 years of war, Cambodia has started a reconstruction program, financed largely by foreign aid. Economic development in recent years has brought more industrial firms to Cambodia. These have established themselves especially on riverbanks, wetlands, and coastal zones. Political stability has allowed national efforts to concentrate on the environmental issues associated with this development, in particular water pollution control.

The results of the World Bank funded "Water Supply and Sanitation" project, show that, in 2003, about 60% of Cambodia's population had access to safe water. However, according to the 2004 inter-census of population, only 44% of household in Cambodia have access to safe water sources[1] (NIS 2004). Those with safe water supplies are mostly urban people and wealthy households in rural areas. All main sources of water take water from rivers. Therefore, pollutant discharges to rivers lead to additional water treatment expenses that, in turn, lead to increased water prices.

The remaining households (the rural and urban poor) get their water without any treatment from often unsafe sources such as rivers (34%) and wells (43%). Water pollution affects them directly. Therefore, the protection of fresh water sources through the regulation of effluent discharges is a very urgent task, from both an economic and a public health perspective.

1.1 Description of the problem

An Environment Endowment Fund (EEF) was created in 1996 by a law on environmental protection and natural resources management. The Ministry of Environment administers the fund (MOE 2002). The EEF gets contributions from the Government, grants from international organizations and NGOs and donations from the public. However, in 2002, effluent quality analysis fees and penalty revenues[2] were the main sources of funding for the EEF, as the government and foreign aid contributions were scare. This means that the EEF is not operational under its current financial situation, as its revenues are just sufficient for staff and administration expenses alone.

In 1999, the Ministry of Environment of Cambodia issued a sub-decree on water pollution control which contained the standards for effluent discharges to river systems. This states that firms that discharge at least 10 m^3/day must obtain an emission permit (see Appendix 2 for more detail). All pollution sources that do not comply with this standard are subject to a penalty of up to KHR 50 million (USD 11,904). So far, enforcement of these standards has been limited to a few water pollution sources and there have been very few formal actions taken against non-compliant facilities. This is

[1] Main safe water sources are piped, tube/pipe well, or local distributors.
[2] Total revenues represent up to KHR 63.8 million - about USD 15,190 (Source: MOE 2003)

because the inspection and enforcement capabilities of the Department of Pollution Control are limited. Technical staff also need training. However, there has been some limited action, with a number of old discharge sources investing in end-of-pipe treatment facilities. Meanwhile, new polluters are legally obliged to invest in pollution control technology when they set up.

Most of Cambodia's industrial firms enjoy free access to water for their production processes and this makes it difficult to quantify water use. Industrial firms located on riverbanks discharge their effluents directly to rivers, while all other discharges end up in wetlands. In 2002, an assessment was made of the quantity of industrial effluent[3] produced by 240 large-scale industrial plants located in Phnom Penh, and in the province of Kandal. Officials from Department of Pollution Control of the Ministry of Environment undertook the study (MOE 2003). They estimated that the plants produced 4.6 million m^3 of effluent, this was a 14% increase over the amount produced in 2001. The actual amount of pollution produced in Cambodia is likely to be many times this amount since there are a large number of smaller sources that were not covered by the MOE report in 2002. An industrial survey in 2000 showed that the manufacturing sector accounts for 7,857 plants, of which 1,106 employed at least 10 workers (NIS 2003).

There are serious concerns about the deterioration of water quality (both surface and underground water) that is being caused by the multiplication of pollution sources from Cambodia's rapidly developing industrial sector. As pollution abatement technology needs enormous investment, and as the prevention of water pollution is a top priority, it is vital that an approach is found that will maintain the quality of the aquatic environment at the lowest possible cost. A system of effluent taxes is one option that has many legal and economic aspects in its favour.

1.2 Background information on industry

This paper focuses on the country's industrial sectors that are responsible for large-scale pollution. Such sectors include: garment manufacturing, pulp and paper, food and beverage, metal treatment and chemical and plastic products. From 1990 to 2001, the average annual growth rate for Cambodia's industrial and manufacturing sectors was 10.2% and 8.2% respectively. The corresponding value for the agricultural sector was only 1.8% (WDI 2003). This sector made up 28% to country's gross domestic product in 2004.

Garment manufacturing has been one of the fastest growing industrial sectors in Cambodia. Sales have risen from USD 4 million in 1994 to USD 1.6 billion in 2003. From 1994 to 2005, the textile and garment sector enjoyed growth of at least 10% annually. Garment manufacturing is the largest industry in Cambodia. It currently employs more than 230,000 workers directly, and an estimated 1 million people are dependent on it indirectly. It contributes up to 36% of Cambodia's gross domestic product (PPP 2004). This sector is also the largest polluter in the country.

The food and beverage industry is the second largest source of water pollution in Cambodia. This sector has enjoyed rapid growth since early 1994. In 1993, this sector was the main source of water pollution in Cambodia. It was responsible for 60% of all

[3] According to the Department of Pollution Control, this estimation is based on water consumption.

organic water pollutants (WDI 1998). In comparison, the pulp and paper sector is still at a low level of development. It was responsible for only 3.5% of total water pollution loads in 1993.

Since 1999, when the sub-decree on water pollution came into force, industrial effluents have been analysed regularly. Most effluent discharges that have been assessed exceed levels allowed under national regulations, especially those from the garment industry. Where there is adequate primary treatment, effluent discharges have been brought in line with regulatory standards. In some firms that have installed primary treatment faculties, the BOD concentration of effluent is lower than the standard level of 80 mg/l. This highlights the importance of end-of-pipe treatments as a mechanism for reducing effluents.

1.3 Existing industrial database

There are various databases on industrial activities that have been set up by public institutions in Cambodia. A comprehensive survey of industrial establishments was also carried out by the National Institute of Statistics in 2000. Information from these sources was combined together by the Ministry of Environment, to create a unique list of industrial activity. This was then used to conduct a new survey. The database contains details of ownership, production, and employment. The survey contains information on wages, production costs, and revenue. The Ministry of Environment data contains information on production activities, water use, wastewater generation, treatment facilities, and discharge points.

Table 1: Existing database and surveys of industrial firms

Database Name	Survey Unit	Frequency, availability	No. of plants	Description
Company profile of the Ministry of Commerce (source: MOC 2003)	Export firms	Annual, 2002	186	Basic data includes capital expenditures, raw materials, export destinations, employment, and production.
Factory registration of the Ministry of Industry, Mines & Energy (source: MIME 2003)	Firms	Annual, 1994-2002	336	List of industrial firms registered, contains information on ownership, licenses, production, and employment.
Survey of Industrial Establishments of the National Institute of Statistics (source: NIS 2003)	Industrial establishments	2000	8,089	Survey gathered data on establishment-based industrial activities, including employment, wages & salaries, products, revenues, costs of items & input materials, indirect taxes & subsidies, the value of stocks, fixed assets, and depreciation.
Inspection on polluted firms of the Ministry of Environment (source: MOE 2003)	Firms	Annual, 2003	199	List of polluting firm monitored by the Department of Pollution Control, contains information on water used, wastewater generation, treatment facilities, and discharged points.

(*continued*)

Table 1. concluded

Database Name	Survey Unit	Frequency, availability	No. of plants	Description
Member list of the Garment Manufacturer's Association of Cambodia (source GMAC 2005)	Firms	Annual, 2005	250	List of industrial firms registered, contains information on number of staff, ownership, and production.
Quality analysis of polluted firms by the Ministry of Environment.	Firms	From 2000 to 2005	40	Analysis results for major pollutant parameters especially BOD, COD, TSS[4] & Chloride.

[4] BOD: Biological Oxygen Demand. COD: Chemical Oxygen Demand. TSS: Total Suspended Solid.

2.0 RESEARCH METHODOLOGY

2.1 Research objectives

The general objective of this research project was to find out the most cost-efficient fee levies and options for their implementation. This was done using a simulation study to observe the impact of different fee levies on industrial firms and their pollution emissions. The study also investigated the revenue that such fees could generate. The specific objectives were to:

- Identify the firms and pollutants that will be targeted by effluent taxes. This research was only concerned with large-scale firms and Biological Oxygen Demand (BOD) pollutant.
- Measure pollution loads, classified by factors such as industrial sector and geographical distribution.
- Assess different fee levies according to their impact on specific pollutants. (Fees should be high enough to have a significant effect on effluent discharges.)
- Evaluate the total pollution reduction engendered by the effluent fees.
- Value the total revenue generated by this policy, and
- Investigate how to use the revenues from effluent fees to help industrial firms reduce their polluting emissions and so minimize environmental damage.

2.2 Research questions

The study sought to answer the following questions:

- Should all large-scale industrial firms be targeted by effluents fees? Or only enterprises from some industrial sectors (textile, food & beverage, pulp & paper)?
- What should be the level of the fees for BOD pollution?
- How will enterprises respond to such fees?
- What are the estimated water pollution reductions that such fees will produce?
- What are the best methods for collecting effluent fees?
- What lessons about effluent fees can be learnt from other developing countries?
- How much revenue will such fees generate?
- What is the best way to use revenues from effluent fees?

2.3 2004 survey of polluting firms

At the beginning of this research project, a survey was undertaken to get information about the pollution produced by major industrial sectors. These included the food, beverage, tobacco, textile and wearing apparel, pulp and paper, and chemical industry sectors. A team of three surveyors and a supervisor was assembled. The surveyors all had experience of pollution inspection work. Two other technicians were also included in the team to quantify effluent emissions using a flow meter.

Firm management teams were questioned about factors such as: production activities, ownership, water consumption, effluent loads, the presence of wastewater treatment plants, discharge points, and abatement expenditure. About 570 large-scale firms were initially short-listed for the survey, of these 412 actually took part. Among these, 91% belonged to the textile and food and beverage sectors (373 plants). The survey showed that the textile and wearing apparel and food and beverage sectors were the largest polluter since they accounted for 97% of BOD emissions.

Then, to assess effluent fee levies, 250 plants were assessed. The effluent discharges from these plants made up 94% of the effluent volume (or 90% of BOD emissions) from all of Cambodia's industrial sectors. It was also equivalent to 20% of all wastewater emissions from households in the country.[5]

Table 2: Effluent and BOD emissions from targeted plants (by volume)

Emission sources	**Number of plant**	**Volume of effluent** (million m^3/year)	**BOD emission** (ton/year)
Targeted plants	250	7.14	1,384
Plants from all sectors	412	7.61	1,542
Household	5,260,000	57.1	6,801

Sources: author's survey 2004, and NIS 2004.

2.3.1 Geographical distribution of the 250 targeted firms

The majority of the targeted firms were located in the capital Phnom Penh (83%) while 14% were located in Kandal, a neighboring province of Phnom Penh. The large majority of firms (77%) were inland and their effluents were discharged into surrounding wetlands. About 20% of the plants were on the riverbank of the Mekong. They used river water under a free, open-access scheme. Other firms were located in the urban centre of Phnom Penh and used the municipal water supply for their operations.

Table 3: Number of plants according to geographical distribution

Selected sector	**No. of plant**	**Phnom Penh**	**Other provinces**	**River**	**Inland**	**Costal**
Food & beverages	3	1	2	1	1	1
Textile & garment	247	206	41	49	192	6
Total	**250**	**207**	**43**	**50**	**193**	**7**

Source: Author's survey in 2004.

[5] For emission sources from households, this project only considered the population living in districts where industry was established. The water consumption in urban and sub urban in Phnom Penh is 131 and 100 l/day per capita respectively. In other provinces, the water consumption in urban area and rural areas is estimated at 80 and 50 l/day per capita respectively. The wastewater return index is at 80%. The median BOD concentration for household wastewater is 119 mg/l.

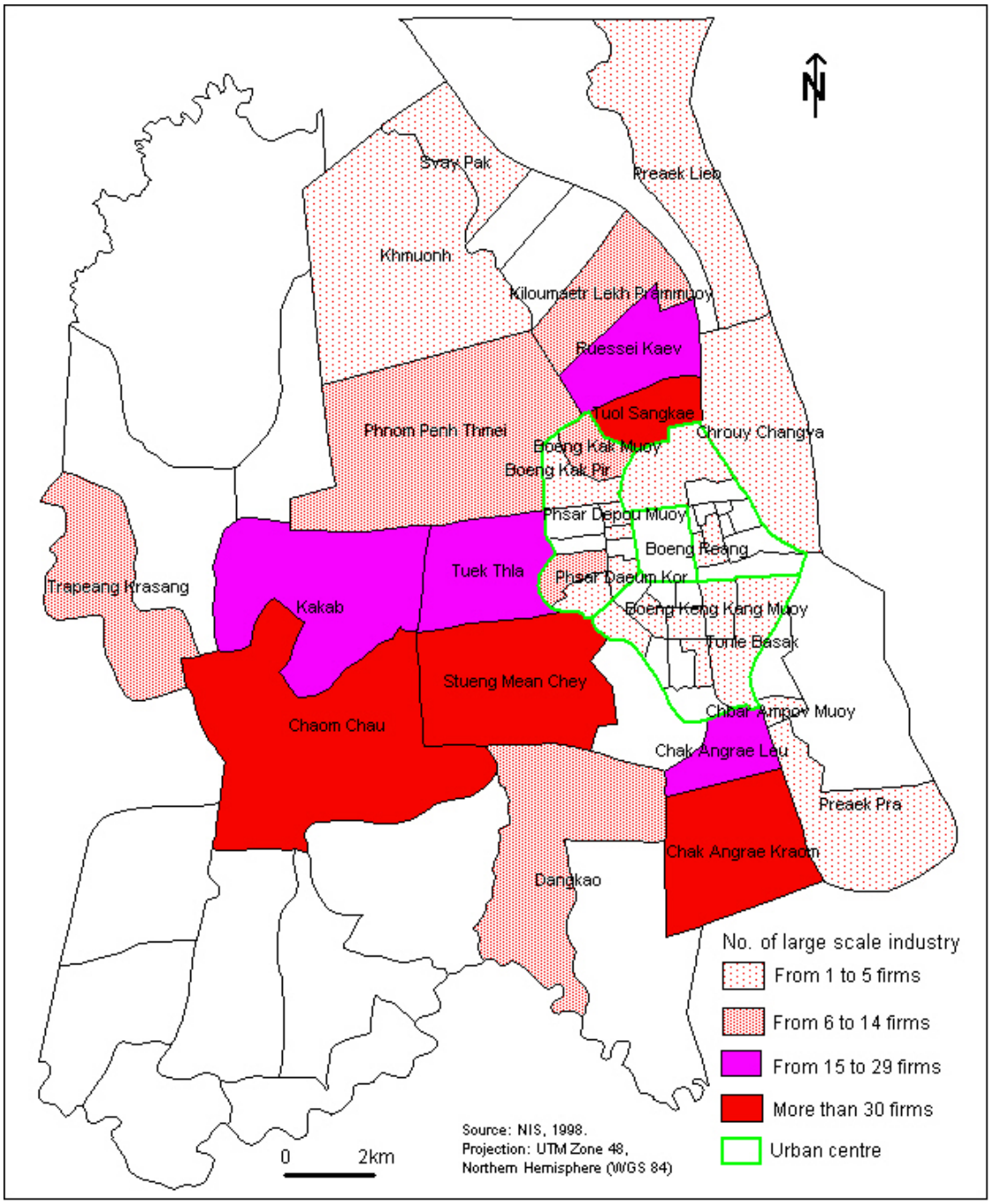

Figure 1: Geographical distribution of firms located within Phnom Penh

Figure 1 shows that the urban centre of Phnom Penh is surrounded by heavy industrial activity on all sides except the east. About 26 textile and wearing apparel, two tobacco and one food firms are within this zone and discharge their effluents directly into the public sewage system. There are two industrial parks in Cambodia. These are at the Canadia and Vattanak sites. Both are located within the Chom Chau commune of Phnom Penh (see Figure 1). They accommodate 15 large-scale plants, all of which use municipal pipe water for their production processes. There is no wastewater treatment plant at these two sites.

The recent inter-census report (NIS 2004) showed a close correlation between demographic and industrial expansion in the red and purple areas of Phnom Penh (see

Figure 1). This is because huge numbers of shelters have been constructed to house more than 270,000 industrial workers in Phnom Penh.

2.3.2 Employment and ownership of the 250 targeted firms

The 250 firms targeted by this study employed nearly 300,000 workers. More than 99% were employed in the textile and wearing apparel industry. Of the 250 firms, 36% employed more than 1,000 workers. These, in turn, accounted for up to 65% of all employment. About 69% of the textile firms were members of that sector's most powerful lobbing associations, the Garment Manufacturer's Association in Cambodia (GMAC 2005) which has 250 active members. Large numbers of the 250 plants were foreign owned (87%), of these, 131 plants belonged to China, Hong Kong, Taiwan and Macao, 36 plants to Singapore and Malaysia, 20 plants to Korea and 31 plants to western countries especially England and Australia.

Table 4: Distribution of firms according to employment and ownership

Selected sector	**Employment**				**Ownership***		**Source of water***		
	Min	Max	Av.	Total	Cambodia	Foreign	Pipe	River	Well
Food & beverages	156	960	430	1,292	0	3	0	1	2
Textile & garment	60	8,538	1,208	298,307	32	215	131	37	79
Total				**299,599**	**32**	**218**	**131**	**38**	**81**

Note: * explain the number of firms. Source: author's survey in 2004.

2.3.3 Effluent and BOD emissions of the 250 targeted plants

The estimated water consumption (in 2004) of the 250 targeted plants was 10.5 million m^3. They were also estimated to generate about 7.14 million m^3 of effluents. By volume, treated effluent emissions represented up to 58% of these discharges. In terms of BOD emissions, they represented only 19% (Table 5). The effluent concentration of the 30 most-polluting plants exceeded the MOE discharge standards for BOD concentrations (80 mg/l). Among the 30 plants that had installed effluent treatment, four plants had BOD concentrations greater than the 80 mg/l standard. The effluent treatment plants that had been installed, on average, reduced BOD emissions by 79%. However, a very large number of plants remained non-compliant (90%).

Table 5: BOD emissions in firms without wastewater treatment plants

Targeted industry sectors	**BOD concentration** (mg/l)			**Effluent** (m^3/year)	**BOD emission** (ton/year)			
	Min.	Max.	Av.		Min.	Max.	Av.	Total
Treated effluent								
Food & Beverages	-	-	112.1	755,737	10.23	62.73	28.23	84.69
Textiles & garment	21.1	119.2	59.0	3,356,216	0.36	35.30	6.79	183.46
Aggregate				4,111,954				268.15
Untreated effluent								
Food & Beverages	222.0	473.0	347.5	-	-	-	-	-
Textiles & garment	116.4	1,200	312.4	3,032,284	0.59	180.97	5.07	1,116.0
Total effluent				**7,144,238**				**1,384.1**

Source: Author's survey in 2004 and MOE 2003.

Of the 250 targetted plants, 43 had BOD concentration records that, between them, contained about 85 samples (the time scale for the BOD concentration records covered the period from 2000 to 2005). Of these, 22 plants had from two to five analyzed samples, while the other 21 plants had only a single sample. In plants that had many BOD samples, this project used the average BOD concentration to calculate BOD emissions. In plants that did not have any BOD concentration records, the project used the median effluent BOD concentration of 312 mg/l. The median effluent BOD concentration was 59 mg/l. This was lower than the existing standard for discharge into a public waterway (80 mg/l), but it was still higher than the standard for discharge into a protected public waterway (30 mg/l).

Table 6 shows that only a small number of plants (12%) had installed effluent treatment plants to comply with the 1999 sub-decree on water pollution control. Three of the largest beverage firms used secondary treatment technology. The majority of firms discharged effluent into wetlands (60%). Of these 124 plants discharged into two wetlands in Phnom Penh (Boeng Cheung Ek and Boeng Prayap). 8% of targeted firms discharged their effluent into the Mekong River and only six of these had installed treatment facilities. About 28% of firms, all located in Phnom Penh, discharged their effluent into the public sewage system and only nine of these had installed treatment facilities.

Table 6: Effluent treatment, sampling and records

Selected sector	Install treatment plant	No. of plant with BOD analysis records*	No. of BOD concentration samples
Food & beverages	3	1	4
Textile & garment	27	42	81
Total	**30**	**43**	**85**

Source: author's survey in 2004, except * MOE 2003.

Table 7 shows clearly that the majority of BOD emissions were discharged into wetlands (68%). The wetland surrounding Phnom Penh received 89% of these emissions. The sewer network in Phnom Penh was the outlet for 19% of all BOD emissions.

Table 7: Number of plants and BOD emissions according to discharge points

Selected sector	River		Wetland		Sewer		Costal zone	
	No. of plant	BOD emission	No. of plant	BOD emission	No. of plant	BOD emission	No. of plant	BOD emission
Food & beverages	1	10.22	1	11.54	0	0	1	62.93
Textile & garment	20	63.36	149	944.77	71	258.61	7	27.71
Total	**21**	**78.58**	**150**	**956.31**	**71**	**258.61**	**8**	**91.64**

Source: author's survey in 2004, except * MOE 2003.

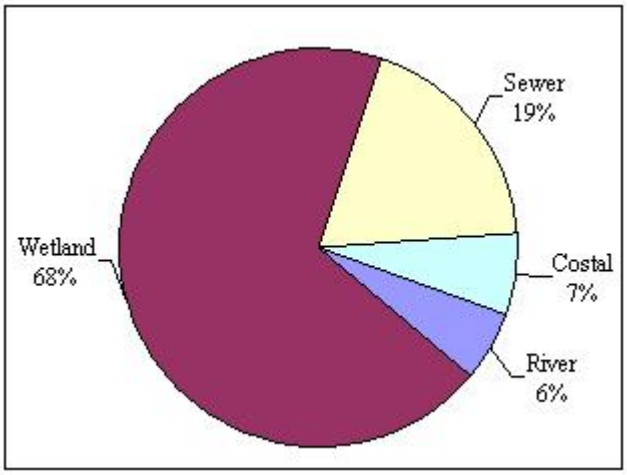

Figure 2: BOD emissions from targeted industry according to the discharge point

3.0 ASSESSMENT OF POLLUTION FEE LEVIES

3.1 Target BOD reductions

This project examined different BOD reduction targets according to two factors – the geographical distribution of plants and discharge points. About 85% of all BOD emissions from targeted plants were from those in Phnom Penh (1,175 ton per year). All BOD emissions to the sewer network in Phnom Penh end up to wetlands and then flow to the Mekong river. This industrial effluent discharge is a major cause of water quality degradation in the Mekong River. This has been escalating since 1994, especially during dry seasons. Another reason for this degradation is the on-going reduction in the surface area of surrounding wetlands, due to extensive urbanization and industrialization. The industry sector in Cambodia grew by 10% from 1994 to 2005.

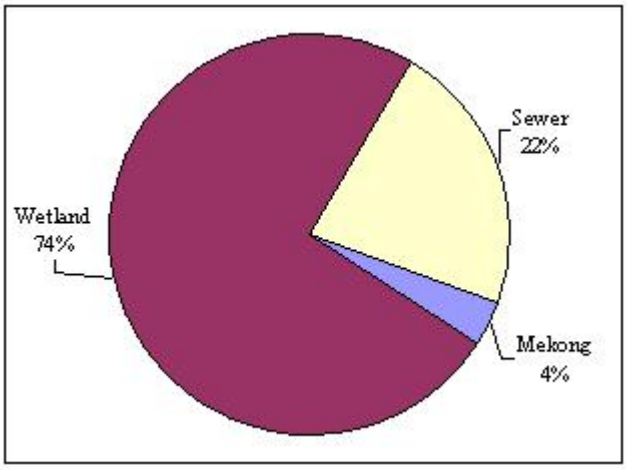

Figure 3: Discharge point distribution of BOD emissions in Phnom Penh

This project considered four targets for BOD emission. These ranged from 25% to 85%.

- **Target 1**: the first level of BOD reduction – a reduction of BOD emissions to 1,038 ton/year from the existing level of 1,384 tons/year (a 25% reduction).
- **Target 2**: the second level of BOD reduction – a reduction of BOD emissions to 830 ton/year from the existing level of 1,384 tons/year (a 40% reduction).
- **Target 3**: the third level of BOD reduction – a reduction of BOD emissions to 484 ton/year from the existing level of 1,384 tons/year (a 65% reduction).
- **Target 4**: is fourth level of BOD reduction – a reduction of BOD emissions to 208 ton/year from the existing level of 1,384 tons/year (a 85% reduction).

3.2 Determination of pollutant fees

Levies are normally charged to each pollution source based on the volume of effluent produced and its BOD concentration. A review of the literature and best practice elsewhere suggested that the following levy formula was appropriate to plants

in the textile sector and to the largest beverage firms. This formula is similar to a fee structure adopted by the Laguna Lake Development Authority. This authority has implemented an environmental user fee system in the Laguna de Bay region of the Philippines since 1996. The effluent fee consists of two components – a fixed and a variable fee. The fixed administration fee is based on the volumetric rate of effluent flow and is designed to cover the costs of discharge permits, inspections, monitoring and enforcement programs undertaken by the MOE. The variable fee is a uniform fee based on the volume of effluent and its BOD concentration.

The effluent fee formula is:

$$\mathbf{T_f = F_{adm} + L_j}$$

Where $L_j = \rho * C_{BOD} * W * 10^{-3}$

T_f = Total levy for BOD pollutants in Cambodian Riel (KHR).

ρ = National levy rate for BOD pollutants (USD/ton of BOD).

C_{BOD} = BOD concentration of effluent from each plant (mg/l).

W = Wastewater discharge volume from each plant (m3/year).

F_{adm} = Administration fee for each plant based on quarterly payment.

3.2.1 Marginal abatement costs

The industry survey conducted by the author in 2004 did not provide reliable data on the abatement costs that are accrued by industry in Cambodia. This project therefore used Chinese MAC. This was justified by the fact that 52% of the targeted plants were owned by citizens from China, Hong Kong, Taiwan and Macao. It was also justified by the fact that MAC estimates from China were based on the textile sector. However, for simulation purposes, this paper also used MAC estimates from Vietnam. The MAC estimates from Vietnam were the average costs accruing in all sectors. These were much greater than the MAC estimates from China.

Table 8: Marginal abatement cost for BOD reductions in selected countries

Rate of Abatement	**China MAC (1)**		**Vietnam MAC (2)**	
	Medium	Large	Medium	Large
10%	0.5	0.4	26.8	10.6
30%	0.7	0.6	38.8	16.9
60%	1.5	1.2	82.6	39.5
90%	9.6	7.5	518.1	250.6

Notes: All costs are in USD/ton of BOD (USD 1 = KHR 3,840).

Sources: (1) Dasgupta et al. 1996 ; (2) Huyen et al., 1998

3.2.2 Methodology for the assessment of BOD pollution fees

Targeted firms were divided into medium and large-scale categories according to the volume of their effluent loads. The medium-scale firms all discharged less than 50 m^3/day of effluent (equivalent total effluent load was 415 tons per year). The large-scale firms all discharged at least 50 m^3/day of effluent (equivalent total BOD effluent load was 969 tons per year).

The predicted cost of abatement depends upon MAC estimates and fee levies. Plants always chose abatement levels at which their MAC are lower than the fee levy they would otherwise have to pay. Figure 4 shows that without pollutant fees (F), the pollution emissions from medium and large-scale firms are at level P_{M0} and P_{L0} respectively. These firms are not abating pollution, thus the abatement costs are zero. When pollutant fees are implemented and firms do not choose to abate emissions, they will pay pollutant fees as represented by the rectangles (P_0-F-S_1-P_{M0}) and (P_0-F-S_2-P_{L0}), for medium and large-scale firms respectively.

If plants do choose to reduce emissions of which the MAC is equal or lower than the fee levy then the fees they have to pay will be reduced to the rectangles (P_0-F-M_1-P_{M1}) and (P_0-F-M_2-P_{L1}), for medium and large-scale firms respectively. Thus, the abatement costs accruing to the plants will be the triangles (M_1-P_{M0}-P_{M1}) and (M_2-P_{L0}-P_{L1}) for medium and large-scale firms. The reminding triangles (M_1-S_1-P_{M1}) and (M_2-S_2-P_{L1}) would represent the potential savings for each firm if they choose to abate pollution instead of paying the whole fee.

Thus, the predicted abatement costs will be equal to MAC estimate values. In turn these will correspond to the fee levy multiplied by the volume of effluent in medium and large-scale firms. The predicted revenue generated can be calculated by multiplying predicted BOD emissions by the fee levy. Therefore, the total costs paid by plants will be the sum of abatement costs and revenues generated.

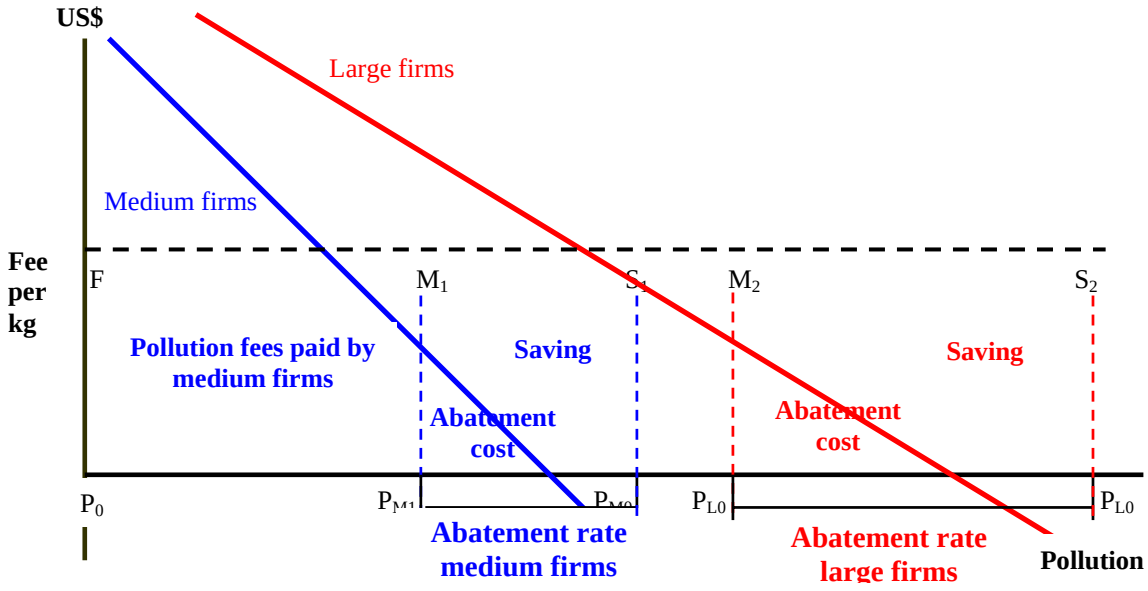

Figure 4: Method for fee levies assessment.

3.2.3 Result of fee assessment

To assess pollutant fee levies for Cambodian industry, a range of pollution reduction targets were chosen. These were 25%, 40%, 65% and 85%. Then the fees necessary to achieve each of these targets were assessed. Given four BOD reduction targets and two sets of MAC estimates (from China and Vietnam), eight pollution fee levies were calculated.

Table 9: Selected fee levies to meet different BOD reduction targets

	BOD reduction target 25%	**BOD reduction target 40%**	**BOD reduction target 65%**	**BOD reduction target 85%**
Fee (Chinese MAC)	1.0	1.6	7.8	13
Fee (Vietnam MAC)	29	39	260	521

Note: all values are in USD/ton of BOD. See Table 22 in Appendix 3 for more detail.

Table 9 shows that there are very large differences between the fee levies calculated using the different MAC estimates and BOD reduction targets. For example, to achieve the 25% BOD reduction target, the fee levy is USD 1 using the MAC estimate from China and USD 29 per ton of BOD using the MAC estimate from Vietnam.

Applying the MAC estimates from China, an effluent fee as low as USD 13 per ton of BOD would be sufficient to meet the 85% BOD reduction target for cost-minimizing plants. To meet the same target using the effluent fee from Vietnam would require a fee levy of USD 521 per ton of BOD. Overall, fees of between USD 29 and 521 a ton of BOD would meet at least one BOD reduction target for all MAC estimates.

Table 10: Predicted costs of abatement and revenue generated

Fee rate USD/ton of BOD	**Predicted cost of abatement** (USD/year) if MAC from:		**Predicted revenue generated** (USD/year) if MAC from:	
	China	Vietnam	China	Vietnam
1.0	931	0	1,009	1,442
1.6	1,588	0	1,060	2,163
2.6	1,951	0	1,442	3,605
7.8	1,951	0	2,054	10,814
13	12,350	10,051	1,802	16,761
18	12,350	16,082	2,523	19,931
29	12,350	26,983	3,965	30,132
39	52,987	53,303	4,866	26,490
52	60,556	53,303	5,767	35,320
104	75,695	71,089	10,093	57,673
182	151,390	71,089	10,093	100,927
260	151,390	271,441	14,418	68,463
417	151,390	271,441	23,069	109,541
495	151,390	271,441	27,394	130,080
521	151,390	448,447	28,836	72,091

USD 1 = KHR 3,840 (value in 2000).

Table 10 shows that for all MAC estimates the predicted levels of revenue that could be generated from targeted firms is quite low (< USD 4,000) for fee levies less than USD 2.6 per ton of BOD. It should be noted that if such fees were implemented, only BOD reduction targets relating to Chinese MAC estimates would be met. The predicted revenues would also be low (< USD 6,000) if MAC estimates from China were used and fees were less than USD 104 per ton. Fee levies between USD 104 and USD 521 per ton of BOD would achieve at the least the 40% BOD reduction target for all MAC estimates. The predicted total costs paid by plants for these fees would range

from USD 85,788 to 520,538 per year. The higher figure represents about one fifth of the MOE annual budget of USD 2.1 million (Table 11).

Table 11: Predicted total costs paid by plants according to different MAC

Fee rate (USD/ton of BOD)	**Predicted total costs paid by plant** (USD/year)	
	China MAC	**Vietnam MAC**
1.0	1,940	1,442
1.6	2,648	2,163
2.6	3,393	3,605
7.8	4,005	10,814
13	14,152	26,812
18	14,873	36,013
29	16,315	57,115
39	57,853	79,792
52	66,323	88,622
104	85,788	128,762
182	161,483	172,016
260	165,809	339,904
417	174,459	380,982
495	178,785	401,521
521	180,227	520,538

Notes: Total costs paid by plant are the sum of predicted cost of abatement and revenue generated. USD 1 = KHR 3,840 (value in 2000).

There are two main cost components involved in pollution abatement activity. These are: electricity prices and monthly labour costs. At the time of this study, electricity prices in Cambodia, China and Vietnam were USD 0.15; 0.08; 0.07 per kWh, respectively; monthly labor costs were USD 61; 120; 60. Given these prices, effluent fees for Cambodian industry should not be lower than the Chinese level of USD 30 per ton[6] of BOD. Taking the above arguments into account, it is clear that to meet at least the 40% BOD reduction target for all MAC estimates, fee levies should be between USD 104 and 521 per ton of BOD. These fees would generate minimum revenues of about USD 10,093 (using MAC estimates from China) or 72,091 (using MAC estimates From Vietnam).

3.3 Sensitivity analysis of selected effluent fees

This project considered fee levies from USD 1 to 521 per ton of BOD and BOD emissions of 1,384 tons per year as the initial case to conduct a sensitivity analysis. This analysis assessed variations in pollution loads and MAC values to observe how they would affect abatement costs and fee levy revenue. The main objective of this analysis was to evaluate, in terms of cost-efficiency, the merits of moving from a lower to higher effluent fee levy.

Three scenarios were tested. Scenario 1 analysed the impact of changes in pollution emission levels on the assessment of fee levies, while Scenarios 2 and 3 analysed the impact of MAC conversion techniques. This report used marginal

[6] Recommendation from the project on China effluent fee estimation (Dasgupta et al. 1996).

abatement cost estimates from two other countries, and these varied quite significantly. The MAC functions depends upon different variables, especially labour costs, energy prices (electricity, fuel, etc.) and the price of the materials used for constructing abatement plants, along with their operation and maintenance costs. As these variables are quite different from one country to another, this project chose two methods to calibrate the marginal abatement functions. This was done according to purchasing power parity (Scenario 2) and per capita income levels (Scenario 3) in each of the countries.

Purchasing power parity (PPP) is a currency conversion approach that compares the GDP and its components across countries. The PPP between two countries is the rate at which the currency of one country needs to be converted into that of a second country to represent the same volume of goods and services in both countries.

Per capita income level is often used as a measure of the wealth of the population of a nation, particularly in comparison to other nations. It is usually expressed in terms of a commonly-used international currency such as the US dollars, and is useful because it is widely known and produces a straightforward statistic for comparison.

3.3.1 Scenario 1

Scenario 1 assumed that pollution loads would increase by 16%, 30% and 45% (Option 1, 2 & 3). Thus, BOD emissions of 1,600; 1,800 and 2,000 tons per year were compared relative to existing levels of 1,384 tons/year for options 1, 2 and 3 respectively. The rationale for this analysis was as follows: Even after the withdrawal of a quota system had led to a large number of textile plants closing, Cambodia's textile exports still amounted to USD 445 million in the first quarter of 2005, 16% more than in first quarter of 2004 (CDRI 2005). Given that industry has enjoyed growth of 10% per year since 1994, there is a risk that effluent fees suitable for current pollution levels could soon become obsolete.

Table 12: Fee levies according to BOD emission targets in Scenario 1

Possible Options	**China MAC**				**Vietnam MAC**			
	1,038 tons	**830 tons**	**484 tons**	**208 tons**	**1,038 tons**	**830 tons**	**484 tons**	**208 tons**
Existing level (1,384 tons/y)	1.0	1.6	7.8	13	29	39	260	521
Option 1 (1,600 tons/y)	1.6	1.6	7.8	13	39	39	260	521
Option 2 (1,800 tons/y)	1.6	1.6	7.8	13	39	104	260	521
Option 3 (2,000 tons/y)	1.6	1.6	7.8	13	39	104	260	521

Notes: All values are USD/ton of BOD. See Table 23 in Appendix 3 for more detail.

If BOD emissions were to rise to 1,600 tons per year, Table 12 shows clearly that the fee levies will have to rise if the 1,038 ton/year BOD emission target is to be met for all MAC estimates. For the 830 tons/year emission target, BOD emissions would have to rise from their existing level of 1,384 tons per year to 1,800 tons per year to induce a fee levy increase. If BOD emissions were to rise to 2,000 tons per year,

Table 12 shows clearly that fee levies would not have to change to meet the BOD emission targets of 484 and 208 tons per year (for all MAC estimates).

For the BOD emission target of 1,038 tons/year, fees of USD 1.0 and USD 29 per ton of BOD would still be sufficient if BOD emissions were to increase by less than 6% from their existing levels. Fees of USD 1.6 and USD 39 per ton of BOD would be sufficient to meet the BOD emission targets of 830 tons/year even if BOD emissions were to increase by up to 22%.

For the BOD emission target of 484 tons/year, fees of USD 7.8 and USD 260 per ton of BOD would still be sufficient if BOD emissions were to increase by less than 82% from their existing levels. Fees of USD 13 and USD 521 per ton of BOD would be sufficient to reach the BOD emission target of 208 tons/year if BOD emissions were to increase by less than 50%. Above this value, the fees would have to shift to USD 39 per ton of BOD for Chinese MAC estimates.

3.3.2 Scenario 2

In Scenario 2, the purchasing power parity method (PPP) was used to convert MAC estimate values from China and Vietnam. Two MAC estimates for BOD abatement costs from the Philippines (Indab 2003) were also included in this simulation. MAC-1 are the average MAC from large-scale sector industries in the Philippines (except grain processing). MAC-2 are the cost values from the beverage sector in that country. The two MAC values for the Philippines were higher than those from Vietnam.

The 2000 PPP conversion rate from the 2002 World Development Indicators was used for all calculations. MAC estimates from China were in USD. These were first converted into Chinese RMB (see Table 24 in Appendix 3). The MAC estimates from Vietnam and the Philippines were in Dong and Peso respectively.

Table 13: MAC for BOD reduction according to PPP conversion factor

Rate of Abatement	**China MAC (1)**		**Vietnam MAC (2)**		**Philippines (3)**	
	Medium	Large	Medium	Large	MAC-1	MAC-2
10%	0.7	0.5	24.6	9.7	186.5	105.2
30%	0.9	0.7	35.6	15.5	248.1	139.7
60%	1.9	1.5	75.6	36.2	464.6	261.7
90%	12.2	9.6	474.5	229.5	2,203.1	1,241.5

Notes: All costs are in USD/ton of BOD (USD 1 = KHR 3,840). Sources: (1) Dasgupta et al. 1996; (2) Huyen et al., 1998; (3) Indab, 2003.

Table 14 shows that for MAC estimates from China, the fee levies were unchanged when official exchange rate or PPP conversion rates were used, except in the case of the 65% BOD reduction target. The fee levies in Scenario 2 were lower than in the initial case. They were reduced by between 5% and 10% for MAC estimates from Vietnam, and by between 17% and 37% for MAC estimates from the Philippines. In this scenario, fee levies of between USD 234 and USD 495 per ton of BOD would be sufficient to achieve at least a 40% BOD reduction for all MAC estimates.

As previously stated, the effluent fee for Cambodia should not be lower than that recommended for China[7] (USD 30 per ton of BOD). It should also not be greater than the fee in the Philippines[8]of Peso 50/kg of BOD. Therefore, by applying the PPP conversion rate, the fee for Cambodia should be between USD 38 and USD 833 per ton of BOD. Thus a fee range of USD 234 to USD 495 per ton of BOD would be suitable for application in Cambodia. This is true for levels of BOD reduction from 40% to 85% and for all MAC estimates.

Table 14: Fee levies according to target BOD emissions in Scenario 2

	BOD reduction target 25%		**BOD reduction target 40%**		**BOD reduction target 65%**		**BOD reduction target 85%**	
	Initial	Sce. 2	Initial	Sce. 2	Initial	Sce. 2	Initial	Sce. 2
Fee (Chinese MAC)	*1.0*	1.0	*1.9*	1.6	*7.8*	10	*13*	13
Fee (Vietnam MAC)	*29*	39	*39*	39	*260*	234	*521*	495
Fee (Philippines-1)		182		286		1,302		1,302
Fee (Philippines-2)		260		469		2,344		2,344

Note: all values are in USD/ton of BOD. See Table 25 in Appendix 3 for more detail.

3.3.3 Scenario 3

In Scenario 3, per capita income was used as the conversion factor to estimate the MAC for Cambodia. The MAC estimates from China, Vietnam and the Philippines were used for this scenario.

Table 15: MAC estimates for BOD reduction according to per capita income

Rate of Abatement	**China MAC (1)**		**Vietnam MAC (2)**		**Philippines (3)**	
	Medium	Large	Medium	Large	MAC-1	MAC-2
10%	0.16	0.12	18	7	66	37
30%	0.22	0.17	26	11	88	50
60%	0.46	0.36	54	26	165	93
90%	2.91	2.29	341	165	785	442

Notes: All costs are in USD/ton of BOD (USD 1 = KHR 3,840). Sources: (1) Dasgupta et al. 1996 ; (2) Huyen et al., 1998 ; (3) Indab, 2003.

Table 16 shows that in this scenario the fee levies were unchanged for BOD reduction targets of less than 40% for MAC estimates from China. The fee levies were from 20% to 30% lower than in the initial case for MAC estimates from Vietnam, and from 55% to 76% lower for MAC estimates from the Philippines. Fee levies from USD 182 to USD 495 per ton of BOD would be sufficient to achieve at least a 40% BOD reduction for all MAC estimates.

Table 16: Fee levies according to BOD emission targets in Scenario 3

	BOD reduction target 25%		**BOD reduction target 40%**		**BOD reduction target 65%**		**BOD reduction target 85%**	
	Initial	Sce. 3	Initial	Sce. 3	Initial	Sce. 3	Initial	Sce. 3
Fee (Chinese MAC)	*1.0*	1.0	*1.6*	1.6	*7.8*	2.6	*13*	7.8

[7] Recommendation from the project on China effluent fee estimation (Dasgupta et al. 1996).
[8] The fee applicable for all polluters indicated in the rules and regulations implementing the environmental user fee system in Laguna de Bay region, Philippines (December 1996).

Fee (Vietnam MAC)	*29*	29	*39*	29	*260*	182	*521*	417
Fee (Philippines-1)		104		104		495		495
Fee (Philippines-2)		104		182		1,302		1,302

Note: all values are in USD/ton of BOD. See Table 27 in Appendix 3 for more detail.

As previously stated, the effluent fee applicable for Cambodia should not be lower than that recommended for China (USD 30 per ton of BOD), and should not be greater than the fee in the Philippines (Peso 50/kg of BOD). Therefore, in this scenario, the fee for Cambodia should be between USD 9 and USD 297 per ton of BOD. Thus, a fee range from USD 182 to 495 per ton of BOD is suitable for application in Cambodia. This is true for levels of BOD reduction from 40% to 85% and for all MAC estimates.

In conclusion, in the initial case and in Scenario 1, a fee range of USD 104 to USD 521 per ton of BOD would be sufficient to achieve BOD reduction targets of 40% to 85%. In Scenario 2, fee levies from USD 234 to USD 495 per ton of BOD were found to be suitable for application in Cambodia to meet BOD reduction targets from 40% to 85% for all MAC estimates. In Scenario 3, fees ranging from USD 182 to USD 495 per ton of BOD were found to be suitable for application in Cambodia to meet BOD reduction targets from 40% to 85% for all MAC estimates.

As previously stated, fee levies applicable in Cambodia should not be lower than those recommended for China (USD 30 per ton of BOD), but should not be greater than the fee in the Philippines (Peso 50/kg of BOD). Using the combined PPP income per capita conversion method or official exchange rate, fees applicable for Cambodian industry should be between USD 30 and USD 297 per ton of BOD.

Table 17: Selected fee levies to meet different BOD reduction targets

	BOD reduction target 25%	**BOD reduction target 40%**	**BOD reduction target 65%**	**BOD reduction target 85%**
Fee applicable for Cambodian industry	39	104	260	521

Note: all values are in USD/ton of BOD.

Given the results from the three sensitivity analysis scenarios and taking into account the fact that BOD emissions are at a current level of 1,384 tons/year, it is clear that the recommended fee levies of between USD 104 and USD 521 per ton of BOD would be sufficient to meet BOD emission targets of between 25 and 85%.

4.0 STRATEGIES FOR FEE IMPLEMENTATION

4.1 Method for fee implementation

To implement effluent fee levies the MOE should first announce the effluent fee rate, the firms will then have to act. Metering should be installed at discharge points to gauge daily discharges. Plants should then be placed under an obligation to self-report quarterly on the volume of effluent they are producing and its BOD concentrations. Inspection and monitoring should be the responsibility of the MOE.

A uniform fee should be used for all levels of pollution. Payment could be done quarterly. If effluent measurement is impossible, effluent taxes should be collected based on estimations of pollution loads.

The lowest recommended fee of USD 104 per ton of BOD could be implemented in the first year of operation to minimize the impact of the fees on the competitiveness of Cambodian industry. In the second or third year, the fee should be raised to USD 260 per ton of BOD to induce plants to further reduce their BOD emissions.

Before the fee levy is raised further, to USD 400 or USD 521 per ton of BOD, more data on BOD emissions and MAC for Cambodian industry should be updated. Adopting a fee levy of USD 400 per ton of BOD could be done in the third or fourth year, but only with caution and based on a better understanding of BOD emission levels.

The fee levy should be immediately applicable to all large-scale textile industries that discharge at least 10 m^3/day of effluent, and to all large beverage firms throughout the country. The implantation of an effluent fee should extend (by year four) to all industry sectors that contribute to water pollution.

Table 18: Timetable for fee application and estimate of revenue generation

	Fee rate	**Targeted sector**	**BOD emission** (ton/y)	**Target BOD reduction** if MAC*			**Revenue generated** (thousand USD/year)		
				CN	VN	PH	CN	VN	PH
Year 1	104	Textile, beverage (>10 m^3/day)	1,384	96%	60%	25%	10.1	57.7	144.2
Year 2	260	Textile, beverage (>10 m^3/day)	1,384	96%	81%	25%	14.4	68.5	252.3
Year 3	260	Textile, beverage (>10 m^3/day)	1,384	96%	81%	25%	14.4	68.5	252.3
Year 4	469	All sectors (>10 m^3/day)	1,384	96%	81%	45%	26.0	123.2	259.5
Year 5	495	All sectors (>10 m^3/day)	1,452	96%	81%	45%	131.7	313.1	530.2
Year 6	521	All sectors	1,542	96%	90%	45%	131.9	315.6	531.9

Notes: *: MAC estimates: CN: China, VN: Vietnam, PH: Philippines. Fee rate is in USD/ton of BOD. The budget of the Ministry of Environment in 2003 is about USD 2.1 million. Thus, the effluent fee from USD 104 to 521 per ton of BOD would generate revenue of between 0.5% to 25% of the MOE' annual budget.

As previously mentioned an administration fee will have to be levied. This fee would cover the costs of monitoring and inspection by officials from the DPC. For daily effluent discharges of less than 50 m^3, the administration fee (F_{adm}) should be USD 50 per quarter. For effluent emissions of between 50 and 150 m^3/day, this fee should be USD 100. It should be USD 150 for discharges higher than 150 m^3/day. The total revenue from these administration fees would total more than USD 67,400 per year.

Effluent fees should be paid directly to the MOE. To facilitate payment, the MOE should issue invoices quarterly. Two fee collection scenarios should be considered: 1) Fee payments could be incorporated into a plant's water or electricity bill. This could be done for plants located in Phnom Penh that use at least one of these two utility services. 2) For firms that are not connected to any municipal water supply or state electricity company, fee collection could be done on-site in the first week of each quarter.

4.2 Establishment of a new Agency for effluent fee management

The Agency would be an institution made responsible in law for leading the coordinated implementation of the national strategy against water pollution. It would be a specialized institution dedicated to charging all polluters. It should integrate the effluent fee within a strong enforcement & regulatory program. The make-up of this institution would be very important – it must have the most appropriate agency structure, appropriately qualified personal, and adequate training systems and budgets to administer the program.

Pollution prevention using a market-based instrument needs personnel with administrative experience who can outline strategies and programs to combat water pollution, and conduct effective monitoring and inspection. The Agency should be headed by a Chief appointed for a four-year term. This should not be extended beyond a second term. Given the actual size of Cambodian industry, the post of Deputy Chief of the Agency should not be created for efficiency purpose. In the absence of the Agency's Chief, its day-to-day work should be under the control of an Administration Council. This would bring together representatives of all stakeholders involved in industrial development in Cambodia.

It is recommended that the Administration Council of the Agency should have a maximum of 12 members with equal representation from public administration (Ministry of Environment, Ministry of Finance, Ministry of Industry, and Phnom Penh and the Kandal Municipality where most plants are located) and industry institutions (textile industry association, chamber of commerce, etc.).

The role of this Council would be to approve the pollution reduction program, and the criteria for the revenue distribution scheme, that would be submitted by the Agency's Chief. The Agency should contain three operational units:

- Monitoring and Enforcement Unit: this would report directly to the Agency Chief.

- Program and Revenue Distribution Unit: This would submit proposals to the Agency Chief regarding the levying of fees. It would also develop multi-annual programs regarding pollution reduction and work out how and when the Agency

would intervene to get firms to act. Furthermore, it would examine firms' requests for financial assistances and define the rules and methods by which collected revenue would be distributed.

- Finance and Fee Collection Unit: This would be responsible for fund management. It would work closely with the Program and Revenue Distribution Unit.

Three options for the Agency structure are outlined below. These depend upon which institution the new Agency reports to. It could be under control of the Ministry of Environment or the Ministry of Finance or it could be an autonomous structure.

4.2.1 Option 1: Agency is under the MOE

Under this option, the MOE would appoint the Agency's Chief. The Minister or the Secretary of State of the MOE should head the Administration Council (AC). The six members of the AC should include two members from the Ministry of Environment, one from the Ministry of Commerce, one from the Ministry of Industry, and two from Phnom Penh and Kandal Municipalities. The Director or Deputy Director of the DPC should head the Monitoring and Enforcement Unit.

Advantages: this approach will strengthen the MOE's existing Department of Pollution control by providing it with new sources of revenue and the possibility of training technical staff to deliver better environmental management.

Disadvantages: it will be a time consuming process. The regulation of the Agency under the MOE's administration would involve some amendments to the existing law on environmental protection and natural resources management (1996) and to the sub-decree on water pollution control (1998). This would have to be done so that any revenue generated by the fee levies could be under the control of the Agency, and not the Ministry of Finance (as is currently the case).

4.2.2 Option 2: Agency is under the MOF

Under this option, the MOF would appoint the Agency's Chief. The Minister or the Secretary of State of the MOF would head the Administration Council (AC). The six members of the AC would include two members from the Ministry of Finance, one from the Ministry of Environment, one from the Ministry of Industry, and two from Phnom Penh and Kandal Municipalities. The Monitoring and Enforcement Unit should work closely with the DPC of the MOE.

Advantages: the Agency could be operational right after its creation. Existing rules and regulations are in favour to this agency structure.

Disadvantages: requires staff to be trained on environment program management, monitoring etc. Effective co-ordination with the MOE would be indispensable for monitoring and inspection, and implementing pollution reduction targets.

4.2.3 Option 3: Agency is an autonomous structure

Under this option, the Royal Government would appoint the Agency's Chief. The Council of the Ministers would head the Administration Council (AC). The six members of the AC would include one member from each of government Ministry: the Council of Ministers, the Ministry of Finance, the Ministry of Environment, and the Ministry of Industry, and two from Phnom Penh and Kandal Municipalities. This autonomous agency should being capable of establishing its own rules and its own reporting, and accounting, monitoring, and enforcement mechanisms. It would report directly to the MOE and the Council of Ministers.

Advantages: An autonomous structure is potentially a more efficient approach to the management of the environmental fund that placing the Agency under the control of a Ministry.

Disadvantages: its creation could take many years and would involve some amendments to existing laws and regulations.

The recommended roadmap for the establishment of the Agency is as follows: (a) announce the Agency's creation and the nomination of its Chief using the MOE's circular; (b) establish the Agency's three operational units, ensuring they have the capability and necessary funds to perform their respective proposed remits; (c) determine the functions and authority of the Agency in detail; and (d) prepare the Agency's organizational structure and implementation plan.

The Agency would be responsible for creating the sub-decree or law governing the proposed effluent fee levies. The following timetable is recommended for their implementation:

Table 19: Possible timetable for effluent fee implementation

Task	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Policy approval by the Ministry of Environment														
Consultation among stake holders & the public														
Creation of the Agency; approval of its structure & strategic approach														
Preparation of effluent fee law & regulation														
MOE approval of draft law - submit to Council of Ministers for approval														
Passage of draft law through National Assembly														
Resource allocation														
Selection, designation & appointment of Agency Chief and heads of operational units														
Recruitment & training of staff, set up AC*														
Start operation of the Agency, fee implementation begins														

Notes: Number 1 to 14 marks Month 1 to Month 14 respectively. * AC denotes the Agency's Administration Council. The bold character notes the most important step of the project.

4.3 Monitoring, inspection, enforcement and the role of the DPC

The 1999 sub-decree on water pollution control places the responsibility for installing flow meters and analyzing the BOD concentration of effluent on plant operators. Yet, it does not mention self-reporting. Thus, any new regulation on the implementation of effluent fees should order plants to self-report on the volume of effluent they are producing and on its BOD concentration. Monitoring and inspection would be used to check the information provided by plants and resolve any disputes.

The MOE should encourage people living close to plants to file complaints when water pollution is observed. Financial compensation should be offered to communities if it is confirmed that there has been an industrial pollution offence, in order to help them make good any environmental damage caused by effluent discharges.

Future rules and regulations governing the effluent fee levies should give a precise definition of all offences. Penalties for these offences should be much higher than under existing laws and regulations. It is essential that there should be effective action to make non-compliance to anti-pollution laws an offence and that prosecution should carry a high risk of being severely financially punished and/or imprisoned.

4.4 Effluent taxes revenue distribution scheme

The implementation of effluent fee levies would generate extra revenue for the Ministry of Environment. It is very important to note that the revenues from effluent fees should not be used to reduce pre-existing taxes that distort labor and capital markets. These revenues should not be included into the national budget (as are others taxes set previously by the Government), but they should be managed directly by the Ministry of Environment - without passing through the Ministry of Finance account.

For the first two years after the introduction of the fees, 80% of all revenues should be used by the Ministry for capacity building and personnel training. Administrative charges should be used for effluent fee management. The other 20% should be used for research. This should include an effluent discharge inventory, drawing together background information on the environment that is being polluted, developing priorities for pollution reduction, and identifying the actions that will have the greatest environmental gains.

From the third year of the fee program's operation, the budget for administration and research should be reduced to 70%, the remaining 30% should be used to subsidize pollution abatement efforts by industry. This amount should rise from 30% to 75% in the fifth year of operation. The subsidy could take the form of clean technology grants, and low-interest loans for investment in pollution abatement. The highest priority should be given to the 30 most polluting firms and to discharge points located in fragile environments or close to human settlements. The Ministry of Environment could use revenue from this economic instrument to finance its water quality improvement program. The money could be used for river quality restoration and to provide technical assistance for pollution control.

Table 20: Possible effluent fee revenue distribution scheme

Program description	Year 1	Year 2	Year 3	Year 4	Year 5
Administrative charges: Personal & administration Monitoring & enforcement Staff's capacity building Revenue collection	80%	70%	50%	30%	15%
Operation & research program: Measurement & inspection Research & study publication	20%	20%	20%	15%	10%
Subsidy of pollution abatement efforts: Fund treatment plant upgrading Environmental quality restoration Grant or low interest rate loans Reward to local community Technical assistance, and others	0	10%	30%	55%	75%

Notes: All values are in percentage of total revenue generated.

5.0 CONCLUSION

The survey of 412 industrial firms produced reliable information on production, ownership, employment, effluent discharges, and BOD emissions. However, abatement costs for BOD pollution were, generally, confidential and only a very few plants gave any information relating to this issue. Thus, MAC estimates from China and Vietnam were used to assess effluent fee levies for BOD emissions from Cambodian industry. Official exchange rates were used as conversion factors.

The results of the survey showed that the BOD emissions from 412 large-scale firms (employment > 50) were 1,584 tons per year. Subsequently, 250 firms were selected to assess the fee levies. The BOD emissions of these firms represented 90% of all discharges. Four BOD reduction targets were chosen (25%, 40%, 65 and 85% reductions). The results of the simulation showed that eight fee levies (USD 1 ; 1.6 ; 7.8 ; 13 ; 29 ; 39 ; 260 and 521 per ton of BOD) would help to meet one of the four BOD reduction targets (using the MAC estimates from China and Vietnam). These fees would generate annual revenues of between USD 1,009 to USD 130,080. For efficiency purposes, only fees that would generate at least USD 10,000 per year in revenues were selected. Thus fees of between USD 104 and USD 521 per ton of BOD were chosen. For those fees, the total costs paid by plants would be between USD 85,788 to 520,538 per year respectively.

As this project used marginal abatement cost functions from two other countries, and because these were significantly different, an extensive sensitivity analysis was carried out to estimate suitable effluent charge levels for Cambodia. In Scenario 1 (in which BOD emissions increase by between 16% an 45%) fee levies from USD 104 to 521 per ton of BOD were still found to be sufficient to meet the 40% BOD reduction target. In Scenarios 2 and 3, marginal abatement costs were calculated using purchasing power parities and per capita income levels. This analysis confirmed that the selected fee levies of between USD 104 and USD 521 per ton of BOD would achieve the desired pollution reduction targets.

In conclusion, this study shows that if the BOD reduction target is set at 40%, the fee levy should be set at USD 104 per ton of BOD. A fee of USD 260 per ton would be sufficient to meet a BOD reduction target of 65% (from the existing level of 1,384 ton per year). To achieve 85% BOD reduction the fee should be between USD 495 to 521 per ton of BOD.

The study also shows that if the fees are implemented then medium-scale plants (those that discharge less than 50 m^3/day of effluent) that opt to reduce the amount of pollution they produce, and so pay less fees, would achieve significant cost savings (up to 31%) compared to those plants that just pay the fees (see Table 29 in Appendix 4 for more details).

This project recommends the establishment of an Agency for effluent fee management. This should have three operational units (Monitoring & Enforcement, Program & Revenue Distribution and Finance & Fee Collection). This new Agency could be under the control of the Ministry of Environment or the Ministry of Finance or

it could be an autonomous agency. In the first two years of its operation, 80% of revenues should be used to cover capacity building of the Agency's staff. This amount should then be reduced gradually so that eventually 80% of revenue would be used to subsidize pollution reduction efforts by firms.

REFERENCES

CDRI (Cambodia Development Resource Institute). 2005. Flash report on Cambodian economy. CDRI Flash Reports. June 2005. Phnom Penh. 11 p.

Dasgupta, S., M. Huq, D. Wheeler, and C. Zhang. 1996. Water Pollution Abatement by Chinese Industry: Cost estimates and Policy Implications. WB Policy Research Working Paper 1630. Washington D.C. 23 p.

GMAC (Garment Manufacturer's Association in Cambodia). 2005. Member lists in 2005 (http://www.gmac-cambodia.org/members.asp).

Huyen, D. T., L. H. Thanh, N. T. Lan, P. T. Phoung, N. T. Quan, and K. Q. Vinh. 1998. Feasibility of an effluent charge for the food processing industry. EEPSEA Research Reports. Singapore. 57 p.

Indab, A. L., A. I. Guzman, and R. T. Bagarinao. 2003. An effluent charge for Sarangani Bay, Philippines: an ex-ante assessment. EEPSEA Research Reports. Singapore. 56 p.

MIME (Ministry of Industry, Mine and Energy). 2003. List of factories registered under Ministry of Industry, Mine and Energy, from 1999 to 2002. Phnom Penh.

MOC (Ministry of Commerce). 2003. List of export textile firms. Phnom Penh.

MOE (Ministry of Environment). 2002. Cambodian environmental law. Ministry of Environment of Cambodia. Phnom Penh.

MOE. 2003. Yearly report of environment affairs in 2002 and future plan for 2003. Ministry of Environment of Cambodia. Phnom Penh. 58 p.

Muong, S. 2003. Decision support system for urban wastewater management strategies: Simulation model of sewage network in Phnom Penh. Ministry of Environment. 24 p.

NIS (National Institute of Statistic). 1998. General population census of Cambodia - Final census results in 1998. Phnom Penh. 58 p.

NIS. 2003. Survey of industrial establishment in 2000 in Cambodia (http://www.nis.gov.kh/SURVEYS/SIE2000/Table2.htm).

NIS. 2004. Cambodia inter-censual population survey. Phnom Penh. 80 p.

PPP (The Phnom Penh Post) 2004. Garment chief eyes battle ahead, February 27 – March 11. pp. 2.

PPWSA (Phnom Penh Water Supply Authority). 2004. Statistical Year Book 2003 and Production Report. Phnom Penh.

Wang, H. and D. Wheeler. 1996. Pricing Industrial Pollution in China: An Econometric Analysis of the Levy System. Policy Research Department. WB Policy Research Working Paper 1644. Washington D.C. 30 p.

WDI (World Development Indicators). 1998. World Development Indicators database on water pollution (http://www.worldbank.org/nipr/wdi98/table3.6.pdf).

WDI. 2003. World Development Indicators database on growth of output (http://www.worldbank.org/data/wdi2003/tables/table4-1.pdf).

APPENDIX 1

Industry survey questionnaire

General information about survey	
Date of Interview:	Enumerator:
Time Interview Started:	Time Interview Ended:

This information will be strictly confidential and will be published only in consolidated form.

My name is Muong Sideth working for the Ministry of Environment and with the aid of a grant from EEPSEA. We are working for project on economic instrument for industrial effluent management. The main part of this project is to estimate pollution load from all industry throughout the country. We also want to know what the most common pollutant in each industry sector is. What is the status in pollution abatement in your plant? Finally, we wish to hear from you, how much percentage you would be able to reduce more your effluent with minimum impact on its production. In order to obtain a fruitful result for this project, we would like to invite you to reply sincerely, to these following questions:

1. IDENTIFICATION	
Name of Industry	
Address	
Commune, village	
District	
Province/Municipality	
Telephone	
Fax	
Name of Contact Person	

2. DURATION OF OPERATION

A. Year of Starting Operation/ Product	
B. Number of Months Operation in 2003	

3. PRODUCTION

A. Type of Products	
B. Export oriented Products (%)	

4. OWNERSHIP OF THE ORGANIZATION (Please Mark (X) in Box)

☐ Cambodia owned (1) ☐ Foreign owned (2)

5. PERCENTAGE OF FOREIGN STAKE

(Enter the percentage of share/Capital invest dated 2003) %

6. EMPLOYMENT

Sex	Male	Female
Total		

7. CONTRIBUTION TO ENVIRONMENTAL PROTECTION

Quantity of water consumption: [m^3/month]

Sources of water used ☐ Municipal pipe (1)

☐ Own Well (2) ☐ River (3) ☐ Others (specify) (4)

Install Treatment Basin ☐ Yes (1) ☐ No (2)

If yes, dimension of the treatment basin (m^3):

If yes, how many hours a day of its operation (hour/day):

Quantity of Effluent Discharge: [m^3/month]

Discharge point ☐ River (1) (specify)

☐ Public sewer (2) ☐ Lake (3) (specify)

☐ Other (4) (specify)

Do you have any record on effluents quality analysis since the operating date?

☐ Yes (1) ☐ No (2) ☐ Don't know (3)

If Yes, ask for a copy of those documents

Existence of local pressure to remove current pollution (complaints...etc)

☐ Yes (1) ☐ No (2)

8. POLLUTION ABATEMENT

Indicate (X) those pollution abatement activities that occurred at this facility in 2003.

A. Abatement technique:

	Yes	No	Installation Year
Physical techniques (containment, screening, filtration,)			
Biological techniques (activated sludge, dewatering)			
Chemical techniques (oxidation, reduction, coagulation)			

B. Pollution Abatement Costs, Expenditures (per month/year)

Pollution abatement capital expenditures USD

Pollution abatement operating costs USD/month

No. Personals Wage USD/month

Chemical products costs USD/month

Other costs USD/month

9. EXPENDITURE IN YEAR 2003

Wages & Salaries in 2003 USD/month

No	Description	Quantity	Value(USD)
1.	Electricity		
2.	Water purchase		

Total Expense of Industry in 2003 (USD):

APPENDIX 2

Effluent discharge standards

Table 21: Effluent standards for main pollutant parameters

Nº	Parameters	Unit	Allowable limits for pollutant substance discharging to	
			Protected public water area	Public water area and sewer
1	BOD_5 (5 days at 20°C)	mg/l	< 30	< 80
2	COD	mg/l	< 50	< 100
3	Total Suspended Solids (TSS)	mg/l	< 50	< 80
4	Sulphate (as SO_4)	mg/l	< 300	< 500
5	Sulphide (as Sulphur)	mg/l	< 0.2	< 1.0
6	Phosphate (PO_4)	mg/l	< 3.0	< 6.0
7	Chlorine (free)	mg/l	< 1.0	< 2.0
8	Chloride (ion)	mg/l	< 500	< 700
9	Arsenic (As)	mg/l	< 0.10	< 1.0
10	Iron (Fe)	mg/l	< 1.0	< 20
11	Cadmium (Cd)	mg/l	< 0.1	< 0.5
12	Chromium $(Cr)^{+3}$	mg/l	< 0.2	< 1.0
13	Chromium $(Cr)^{+6}$	mg/l	< 0.05	< 0.5
14	Copper (Cu)	mg/l	< 0.2	< 1.0
15	Lead (Pb)	mg/l	< 0.1	< 1.0
16	Mercury (Hg)	mg/l	< 0.002	< 0.05
17	Nickel (Ni)	mg/l	< 0.2	< 1.0
18	Zinc (Zn)	mg/l	< 1.0	< 3.0

Source: Sub-decree on water pollution of the Ministry of Environment in 1999 (MOE 2002).

APPENDIX 3

Selected Tables

Table 22: Predicted level of BOD emission according to selected fee levies

Fee rate (USD/ton of BOD)	**Existing emissions** (ton/year)	**Predicted level of BOD emissions** (ton/year)			
		China MAC		**Vietnam MAC**	
		Effluent	**%**	**Effluent**	**%**
1.0	1,384.1	968.9	30	1,384.1	0
1.6	1,384.1	678.1	51	1,384.1	0
2.6	1,384.1	553.7	60	1,384.1	0
7.8	1,384.1	262.9	81	1,384.1	0
13	1,384.1	138.4	90	1,287.2	7
18	1,384.1	138.4	90	1,093.4	21
26	1,384.1	138.4	90	1,093.4	21
29	1,384.1	138.4	90	1,051.9	24
39	1,384.1	124.6	91	678.1	51
52	1,384.1	110.7	92	678.1	51
104	1,384.1	96.9	93	553.7	60
182	1,384.1	55.4	96	553.7	60
234	1,384.1	55.4	96	553.7	60
260	1,384.1	55.4	96	262.9	81
286	1,384.1	55.4	96	262.9	81
313	1,384.1	55.4	96	262.9	81
339	1,384.1	55.4	96	262.9	81
417	1,384.1	55.4	96	262.9	81
443	1,384.1	55.4	96	262.9	81
469	1,384.1	55.4	96	262.9	81
495	1,384.1	55.4	96	262.9	81
521	1,384.1	55.4	96	138.4	90

Table 23: Predicted revenue generated and total costs in Scenario 1

Fee rate	**Predicted costs of abatement**						**Predicted revenue generated**					
	China MAC			**Vietnam MAC**			**China MAC**			**Vietnam MAC**		
	Option 1	Option 2	Option 3	Option 1	Option 2	Option 3	Option 1	Option 2	Option 3	Option 1	Option 2	Option 3
1.0	1.1	1.2	1.3	0	0	0	1.2	1.3	1.5	1.7	1.9	2.1
1.6	1.8	2.1	2.3	0	0	0	1.2	1.4	1.5	2.5	2.8	3.1
7.8	2.3	2.5	2.8	0	0	0	2.4	2.7	3.0	12.5	14.1	15.6
13	14.3	16.1	17.8	11.6	13.1	14.5	2.1	2.3	2.6	19.4	21.8	24.2
29	14.3	16.1	17.8	31.2	35.1	39.0	4.6	5.2	5.7	34.8	39.2	43.5
39	61.2	68.9	76.6	61.6	69.3	77.0	5.6	6.3	7.0	30.6	34.4	38.3
104	87.5	98.4	218.8	82.2	92.4	392.2	11.7	13.1	20.8	66.7	75.0	98.9
260	175.0	196.9	218.8	313.8	353.0	648.0	16.7	18.8	41.7	79.1	89.0	104.2
521	175.0	196.9	196.9	518.4	583.2	583.2	33.3	37.5	37.5	83.3	93.8	93.8

Notes: All values are in thousand USD except Fee rate is in USD/ton of BOD. USD 1 = 3,840 (rate in 2000)

Table 24: PPP and exchange rate in selected countries

Country	**PPP Conversion factor**	**Official exchange rate**	**Capital income** (USD)
Philippines	11	44.2	1,030
Cambodia	703.4	3,840	270
Vietnam	2,833.3	14,168	410
China	1.2	8.3	890

Notes: PPP conversion factor and official exchange rate are from local currency to USD (2000 value)

Table 25: Predicted abatement costs, revenue and total costs in Scenario 2

Fee rate	**Predicted cost of abatement** (USD/year) if MAC from:				**Predicted revenue generated** (USD/year) if MAC from:			
	China	Vietnam	Ph. M-1	Ph. M-2	China	Vietnam	Ph. M-1	Ph. M-2
1.0	1,078				1,009	1,442	1,442	1,442
1.6	1,840				1,060	2,163	2,163	2,163
10.4	10,056	9,399			2,739	13,409	14,418	14,418
13.0	14,304	9,399			1,802	16,761	18,023	18,023
39	61,378	49,844			5,407	26,490	54,068	54,068
182	175,367	66,477	145,567		10,093	100,927	176,622	252,317
234	175,367	253,830	193,405	258,153	12,976	61,617	227,086	291,967
260	175,367	253,830	193,405	343,435	14,418	68,463	252,317	252,317
286	175,367	253,830	362,294	343,435	15,860	75,309	158,599	277,549
469	175,367	253,830	362,294	643,077	25,953	123,233	259,526	259,526
495	175,367	419,352	362,294	643,077	27,394	68,486	273,944	273,944
1,302	876,836	419,352	1,718,434	643,077	18,023	180,227	180,227	720,907
2,344	876,836	419,352	1,718,434	3,049,429	32,441	324,408	324,408	324,408

Notes: Fee rate is in USD per ton of BOD. Ph. M-1, Ph. M-2 denote the Philippines' MAC-1 and MAC-2 respectively. USD 1 = KHR 3,840.

Table 26: Predicted total costs paid by plants in Scenario 2

Fee rate (USD/kg of BOD)	**Predicted total costs paid by plant (US$/year)**			
	China MAC	Vietnam MAC	Philippines MAC-1	Philippines MAC-2
1.0	2,088	1,442	1,442	1,442
1.6	2,899	2,163	2,163	2,163
10.4	12,795	22,808	14,418	14,679
13.0	16,106	26,160	18,023	18,023
39	66,785	76,334	54,068	54,068
182	185,460	167,404	322,189	252,317
234	188,343	315,447	420,491	550,120
260	189,785	322,293	445,722	595,753
286	191,227	329,139	520,893	620,984
469	201,320	377,063	621,820	902,603
495	202,762	487,838	636,238	917,021
1,302	894,858	599,578	1,898,660	1,363,983
2,344	909,276	743,760	2,042,842	3,373,837

Notes: Total costs paid by plant are the sum of predicted cost of abatement and revenue generated.

Table 27: Predicted abatement costs, revenue and total costs in Scenario 3

Fee rate	**Predicted cost of abatement** (USD/year) if MAC from:				**Predicted revenue generated** (USD/year) if MAC from:			
	China	Vietnam	Ph. M-1	Ph. M-2	China	Vietnam	Ph. M-1	Ph. M-2
1.0	578	0	0	0	577	1,442	1,442	1,442
1.6	578	0	0	0	865	2,163	2,163	2,163
2.6	2,571	0	0	0	685	3,605	3,605	3,605
7.8	3,657	7,215	0	0	1,081	10,056	10,814	10,814
29	22,417	38,262	0	0	2,775	19,426	39,650	39,650
104	44,834	51,030	137,765	130,594	5,767	57,673	57,673	100,927
182	224,170	194,847	137,765	244,535	2,523	47,924	100,927	100,927
417	224,170	321,907	137,765	244,535	5,767	57,673	230,690	230,690
495	224,170	321,907	653,448	244,535	6,849	68,486	68,486	273,944
1,302	224,170	321,907	653,448	1,159,570	18,023	180,227	180,227	180,227

Notes: Fee rate is in USD per ton of BOD. Ph. M-1, Ph. M-2 denote the Philippines' MAC-1 and MAC-2 respectively. USD 1 = KHR 3,840 (rate in 2000).

Table 28: Predicted total costs paid by plants in Scenario 3

Fee rate (USD/kg of BOD)	**Predicted total costs paid by plant (USD/year)**			
	China MAC	Vietnam MAC	Philippines MAC-1	Philippines MAC-2
1.0	1,155	1,442	1,442	1,442
1.6	1,443	2,163	2,163	2,163
2.6	3,256	3,605	3,605	3,605
7.8	4,739	17,271	10,814	10,814
29	25,192	57,688	39,650	39,650
104	50,601	108,702	195,438	231,521
182	226,693	242,771	238,692	345,462
417	229,937	379,579	368,455	475,225
495	231,018	390,393	721,934	518,480
1,302	242,192	502,133	833,675	1,339,797

Notes: Total costs paid by plant are the sum of predicted cost of abatement and revenue generated.

APPENDIX 4

Table 29: Information on costs of abatement and fee payments by each plants

(Fee rate of USD 260 a ton of BOD and Vietnam MAC as PPP conversion method)

Name code of Industry	No. of workers	Install treatment plant	Effluent volume (m^3/day)	BOD analysis record	BOD emission (ton/y)	Abatement cost (USD/y)	Fee payment		Total Costs	Saving
							No treatment	With treatment		
Text-A-1	600	N	12	N	1.42	107	369	148	255	114
Text-A-2	754	N	16	N	1.78	135	463	185	320	143
Text-A-3	792	N	16	N	1.87	141	487	195	336	151
Text-A-4	520	N	500	Y	57.01	13,085	14,847	1,485	14,569	277
Text-B-1	497	N	10	N	1.17	89	306	122	211	95
Text-B-1	695	N	14	N	1.64	124	427	171	295	132
Text-B-1	409	N	48	N	5.51	416	1,434	573	990	444
Text-B-2	1,079	N	22	N	2.55	193	663	265	458	205
Text-B-3	540	N	11	N	1.27	96	332	133	229	103
Text-B-4	796	N	16	N	1.88	142	489	196	338	151
Text-C-1	385	N	30	N	3.42	259	891	356	615	276
Text-C-2	933	N	19	N	2.20	167	574	229	396	178
Bev-C-1	156	Y	250	Y	10.23	2,347	2,663	266	2,613	50
Bev-C-2	176	Y	282	Y	11.54	2,648	3,004	300	2,948	56
Text-C-3	682	N	14	N	1.61	122	419	168	289	130
Text-C-4	1,000	N	60	N	6.84	1,570	1,782	178	1,748	33
Text-C-5	478	N	10	N	1.13	85	294	118	203	91
Text-C-6	722	N	15	N	1.70	129	444	178	306	137
Text-C-7	578	N	12	N	1.36	103	355	142	245	110
Text-C-8	579	N	12	N	1.37	103	356	142	246	110
Text-C-9	863	N	102	N	11.62	2,666	3,025	303	2,969	56
Text-C-10	2,372	N	49	N	5.60	424	1,458	583	1,007	451
Text-C-11	1,370	N	28	Y	2.92	221	760	304	525	235
Text-C-12	1,413	Y	29	N	0.63	48	164	66	113	51
Bev-C-2	960	Y	1,538	Y	62.93	14,442	16,387	1,639	16,081	306
Text-C-13	540	N	11	N	1.27	96	332	133	229	103
Text-C-14	791	N	16	N	1.87	141	486	194	336	151
Text-C-15	680	N	14	N	1.61	121	418	167	289	129
Text-C-16	652	N	13	N	1.54	116	401	160	277	124
Text-C-17	480	N	57	Y	4.27	981	1,113	111	1,092	21
Text-C-18	810	N	17	N	1.91	145	498	199	344	154
Text-C-19	637	N	13	N	1.50	114	392	157	270	121
Text-C-20	470	N	10	N	1.11	84	289	116	199	89
Text-C-21	1,761	N	36	N	4.16	314	1,083	433	747	335
Text-C-22	364	N	25	N	2.85	216	742	297	513	230
Text-C-23	543	N	11	N	1.28	97	334	134	230	103
Text-C-24	693	N	14	N	1.64	124	426	170	294	132
Text-C-25	1,226	N	25	N	2.89	219	754	301	520	233
Text-C-26	3,338	Y	1,103	Y	19.29	4,427	5,023	502	4,929	94
Text-C-27	911	Y	306	Y	3.32	762	865	86	849	16
Text-C-28	690	N	20	N	2.28	172	594	238	410	184
Text-C-29	1,084	N	30	N	3.42	259	891	356	615	276
Text-C-30	1,064	N	22	N	2.51	190	654	262	452	202
Text-C-31	688	N	14	N	1.62	123	423	169	292	131
Text-C-32	574	N	15	N	1.71	129	445	178	308	138
Text-C-33	422	N	50	N	5.68	430	1,479	592	1,021	458
Text-D-1	1,005	Y	119	Y	2.55	586	665	66	653	12
Text-D-2	761	N	16	N	1.80	136	468	187	323	145
Text-D-3	316	N	24	N	2.74	207	713	285	492	221
Text-D-4	375	N	200	N	22.80	5,234	5,939	594	5,828	111

Text-D-5	771	N	16	N	1.82	138	474	190	327	147
Name code of Industry	**No. of workers**	**Install treatment plant**	**Effluent volume** (m^3/day)	**BOD analysis record**	**BOD emission (ton/y)**	**Abatement cost** (USD/y)	**Fee payment**		**Total Costs**	**Saving**
							No treatment	With treatment		
Text-E-1	460	N	10	N	1.09	82	283	113	195	88
Text-E-2	629	N	13	N	1.48	112	387	155	267	120
Text-E-3	983	N	20	N	2.32	176	604	242	417	187
Text-E-4	496	N	10	N	1.17	89	305	122	211	94
Text-E-5	2,532	Y	299	Y	5.83	1,339	1,519	152	1,491	28
Text-E-6	1,361	N	28	N	3.21	243	837	335	578	259
Text-E-7	823	N	17	N	1.94	147	506	202	349	157
Text-F-1	518	N	43	N	4.90	371	1,277	511	882	395
Text-F-2	397	N	47	Y	2.77	210	722	289	498	223
Text-F-3	690	N	14	N	1.63	123	424	170	293	131
Text-F-4	1,138	N	24	N	2.69	203	700	280	483	217
Text-F-5	2,041	N	42	N	4.82	364	1,255	502	866	388
Text-F-6	431	N	100	Y	13.87	3,183	3,612	361	3,545	67
Text-F-7	458	N	48	N	5.47	414	1,425	570	984	441
Text-F-8	1,426	N	30	N	3.37	255	877	351	605	271
Text-F-9	2,790	N	58	N	6.59	1,512	1,715	172	1,683	32
Text-F-10	717	N	15	N	1.69	128	441	176	304	136
Text-F-11	2,174	N	45	Y	2.50	189	650	260	449	201
Text-F-12	534	Y	63	Y	1.36	311	353	35	347	7
Text-F-13	1,068	N	126	Y	18.41	4,225	4,794	479	4,704	90
Text-G-1	636	N	13	N	1.50	114	391	156	270	121
Text-G-2	700	N	14	N	1.65	125	430	172	297	133
Text-G-3	1,075	N	22	N	2.54	192	661	264	456	205
Text-G-4	1,881	N	222	Y	19.88	4,563	5,178	518	5,081	97
Text-G-5	996	N	21	N	2.35	178	612	245	423	190
Text-G-6	1,165	N	34	N	3.88	293	1,010	404	697	312
Text-G-7	866	N	18	N	2.04	155	532	213	368	165
Text-G-8	519	N	100	Y	11.40	2,617	2,969	297	2,914	55
Text-G-9	5,613	N	116	Y	7.42	1,704	1,933	193	1,897	36
Text-G-10	589	N	12	N	1.39	105	362	145	250	112
Text-G-11	786	N	16	N	1.86	140	483	193	334	150
Text-G-12	1,174	N	24	N	2.77	210	722	289	498	223
Text-G-13	514	N	11	N	1.21	92	316	126	218	98
Text-G-14	615	N	13	N	1.45	110	378	151	261	117
Text-G-15	1,370	N	28	N	3.23	245	842	337	581	261
Text-G-16	798	N	17	N	1.88	142	491	196	339	152
Text-G-17	550	N	11	N	1.30	98	338	135	233	105
Text-G-18	546	N	11	N	1.29	97	336	134	232	104
Text-G-19	1,013	N	21	N	2.39	181	623	249	430	193
Text-H-1	470	N	10	N	1.11	84	289	116	199	89
Text-H-2	556	N	12	N	1.31	99	342	137	236	106
Text-H-3	850	N	18	N	2.01	152	523	209	361	162
Text-H-4	486	N	10	N	1.15	87	299	120	206	92
Text-H-5	1,065	N	126	Y	14.34	3,290	3,733	373	3,663	70
Text-H-6	796	N	16	N	1.88	142	489	196	338	151
Text-H-7	531	N	11	N	1.25	95	326	131	225	101
Text-H-8	437	N	12	N	1.37	103	356	143	246	110
Text-H-9	2,142	N	44	N	5.06	382	1,317	527	909	408
Text-H-10	1,210	N	25	N	2.86	216	744	298	514	230
Text-H-11	681	N	14	N	1.61	122	419	167	289	130
Text-I-1	476	N	10	N	1.12	85	293	117	202	91
Text-I-2	628	N	13	N	1.48	112	386	154	267	119
Text-I-3	934	N	19	N	2.20	167	574	230	396	178
Text-I-4	990	N	24	N	2.74	207	713	285	492	221

Text-I-5	630	N	13	N	1.49	112	387	155	267	120
Name code of Industry	**No. of workers**	**Install treatment plant**	**Effluent volume** (m^3/day)	**BOD analysis record**	**BOD emission (ton/y)**	**Abatement cost** (USD/y)	**Fee payment**		**Total Costs**	**Saving**
							No treatment	With treatment		
Text-J-1	508	N	60	N	6.84	1,569	1,781	178	1,747	33
Text-J-2	832	N	30	N	3.42	259	891	356	615	276
Text-J-3	141	N	24	N	2.74	207	713	285	492	221
Text-J-4	807	N	17	N	1.90	144	496	198	343	154
Text-J-5	539	N	11	N	1.27	96	331	133	229	103
Text-J-6	645	N	13	N	1.52	115	396	159	274	123
Text-J-7	769	N	16	N	1.82	137	473	189	326	146
Text-J-8	6,715	N	139	N	15.85	3,638	4,128	413	4,051	77
Text-J-9	773	N	16	N	1.82	138	475	190	328	147
Text-J-10	2,345	N	49	N	5.54	419	1,442	577	995	446
Text-K-1	419	N	17	N	1.94	147	505	202	349	156
Text-K-2	468	N	10	N	1.10	84	288	115	199	89
Text-K-3	888	N	18	N	2.10	159	546	218	377	169
Text-K-4	1,440	N	30	N	3.40	257	885	354	611	274
Text-K-5	1,190	Y	160	Y	3.54	814	923	92	906	17
Text-K-6	1,236	N	26	N	2.92	221	760	304	525	235
Text-K-7	701	N	15	N	1.65	125	431	172	298	133
Text-K-8	1,288	Y	152	Y	3.27	751	852	85	836	16
Text-K-9	1,928	N	58	Y	7.77	1,783	2,023	202	1,986	38
Text-K-10	469	N	12	N	1.37	103	356	143	246	110
Text-K-11	513	N	11	N	1.21	92	315	126	218	98
Text-L-1	1,172	N	24	Y	5.37	406	1,398	559	965	433
Text-L-2	656	N	14	N	1.55	117	403	161	278	125
Text-L-3	463	N	10	N	1.09	83	285	114	197	88
Text-L-4	614	N	13	N	1.45	110	377	151	261	117
Text-L-5	509	N	11	N	1.20	91	313	125	216	97
Text-L-6	479	N	10	N	1.13	86	294	118	203	91
Text-L-7	1,428	N	30	Y	2.21	167	576	230	398	178
Text-L-8	1,230	N	25	N	2.90	220	756	302	522	234
Text-L-9	1,652	N	34	N	3.90	295	1,016	406	701	314
Text-L-10	1,172	Y	138	Y	2.98	683	775	78	761	14
Text-M-1	2,700	Y	319	N	6.86	1,574	1,786	179	1,753	33
Text-M-2	7,544	Y	891	N	19.17	4,399	4,991	499	4,898	93
Text-M-3	738	N	15	N	1.74	132	454	181	313	140
Text-M-4	624	N	13	N	1.47	111	384	153	265	119
Text-M-5	1,112	N	23	N	2.62	199	684	273	472	212
Text-M-6	2,500	N	52	N	5.90	1,354	1,537	154	1,508	29
Text-M-7	1,500	N	31	N	3.54	268	922	369	637	285
Text-M-8	683	N	14	N	1.61	122	420	168	290	130
Text-M-9	900	N	19	N	2.12	161	553	221	382	171
Text-M-10	806	N	80	N	9.12	2,094	2,375	238	2,331	44
Text-M-11	1,050	N	22	N	2.48	187	645	258	446	200
Text-M-12	492	N	10	N	1.16	88	302	121	209	94
Text-M-13	496	N	10	N	1.17	89	305	122	211	94
Text-M-14	780	N	16	N	1.84	139	479	192	331	148
Text-M-15	523	Y	11	N	1.23	93	321	129	222	100
Text-M-16	2,046	Y	242	Y	9.69	2,225	2,525	252	2,477	47
Text-M-17	900	N	19	N	2.12	161	553	221	382	171
Text-M-18	573	N	12	N	1.35	102	352	141	243	109
Text-M-19	3,673	N	76	N	8.67	1,990	2,258	226	2,216	42

Text-M-20	1,215	N	25	N	2.87	217	747	299	516	231
Name code of Industry	**No. of workers**	**Install treatment plant**	**Effluent volume** (m^3/day)	**BOD analysis record**	**BOD emission (ton/y)**	**Abatement cost** (USD/y)	**Fee payment**		**Total Costs**	**Saving**
							No treatment	With treatment		
Text-N-1	778	N	16	N	1.84	139	478	191	330	148
Text-N-2	702	N	15	N	1.66	125	432	173	298	134
Text-N-3	1,206	N	25	N	2.85	215	741	297	512	229
Text-N-4	1,013	N	21	N	2.39	181	623	249	430	193
Text-N-5	1,779	N	168	Y	13.55	3,110	3,529	353	3,463	66
Text-N-6	731	N	15	N	1.73	131	449	180	310	139
Text-N-7	728	N	20	N	2.28	172	594	238	410	184
Text-N-8	950	N	20	N	2.24	170	584	234	403	181
Text-O-1	1,555	Y	50	N	1.08	247	280	28	275	5
Text-O-2	1,178	N	24	N	2.78	210	724	290	500	224
Text-O-3	600	N	12	N	1.42	107	369	148	255	114
Text-P-1	530	N	11	N	1.25	95	326	130	225	101
Text-P-2	2,280	Y	269	Y	5.91	1,357	1,540	154	1,511	29
Text-P-3	654	N	14	N	1.60	121	416	166	287	129
Text-P-4	4,200	N	87	N	9.91	2,275	2,582	258	2,534	48
Text-P-5	789	N	18	Y	1.38	104	359	144	248	111
Text-P-6	580	N	12	N	1.37	104	357	143	246	110
Text-P-7	839	N	17	N	1.98	150	516	206	356	160
Text-P-8	804	Y	17	N	0.36	27	93	37	64	29
Text-P-9	925	N	19	N	2.18	165	569	227	393	176
Text-Q-1	8,538	N	200	N	22.80	5,234	5,939	594	5,828	111
Text-Q-2	950	N	20	N	2.28	172	594	238	410	184
Text-Q-3	2,117	N	44	N	5.00	378	1,301	521	899	403
Text-R-1	1,536	N	32	N	3.63	274	944	378	652	292
Text-R-2	680	N	14	N	1.61	121	418	167	289	129
Text-R-3	3,348	Y	1,225	Y	35.30	8,103	9,194	919	9,022	172
Text-S-1	611	N	13	N	1.44	109	376	150	259	116
Text-S-2	912	N	19	N	2.15	163	561	224	387	174
Text-S-3	226	N	106	N	12.09	2,774	3,147	315	3,089	59
Text-S-4	967	N	20	N	2.28	173	594	238	410	184
Text-S-5	1,489	N	31	N	3.51	266	915	366	632	283
Text-S-6	2,782	N	58	N	6.57	1,507	1,710	171	1,678	32
Text-S-7	688	N	14	N	1.62	123	423	169	292	131
Text-S-8	552	N	11	N	1.30	99	339	136	234	105
Text-S-9	966	N	20	N	2.28	172	594	238	410	184
Text-S-10	760	N	16	N	1.79	136	467	187	323	145
Text-S-11	600	N	12	N	1.42	107	369	148	255	114
Text-S-12	826	N	17	N	1.95	147	508	203	351	157
Text-S-13	971	N	115	Y	15.58	3,576	4,058	406	3,982	76
Text-S-14	508	N	30	N	3.42	259	891	356	615	276
Text-S-15	1,054	Y	22	N	0.47	36	122	49	84	38
Text-S-16	841	N	17	N	1.99	150	517	207	357	160
Text-S-17	582	N	20	N	2.28	172	594	238	410	184
Text-S-18	700	N	14	N	1.65	125	430	172	297	133
Text-S-19	586	N	12	N	1.38	105	360	144	249	112
Text-S-20	2,744	N	324	Y	89.62	20,570	23,339	2,334	22,904	436
Text-S-21	737	N	15	N	1.74	132	453	181	313	140
Text-S-22	520	N	11	N	1.23	93	320	128	221	99
Text-S-23	3,483	N	72	N	8.22	1,887	2,141	214	2,101	40
Text-S-24	978	Y	378	Y	5.43	1,246	1,414	141	1,387	26

Text-S-25	1,219	N	25	N	2.88	218	749	300	517	232
Name code of Industry	**No. of workers**	**Install treatment plant**	**Effluent volume** (m^3/day)	**BOD analysis record**	**BOD emission (ton/y)**	**Abatement cost** (USD/y)	**Fee payment**		**Total Costs**	**Saving**
							No treatment	With treatment		
Text-T-1	600	N	71	Y	8.08	1,854	2,103	210	2,064	39
Text-T-2	5,974	Y	705	Y	7.98	1,832	2,079	208	2,040	39
Text-T-3	4,969	N	103	Y	9.66	2,218	2,517	252	2,470	47
Text-T-4	981	N	20	N	2.32	175	603	241	416	187
Text-T-5	6,845	Y	808	N	17.39	3,991	4,529	453	4,444	85
Text-T-6	980	N	20	Y	2.10	159	548	219	378	170
Text-T-7	1,288	Y	152	Y	3.31	761	863	86	847	16
Text-T-8	751	N	16	N	1.77	134	462	185	319	143
Text-T-9	1,171	N	24	Y	1.87	141	486	194	336	150
Text-T-10	763	N	16	N	1.80	136	469	188	324	145
Text-T-11	743	N	15	N	1.75	133	457	183	315	141
Text-T-12	765	N	16	N	1.81	137	470	188	325	146
Text-T-13	472	N	10	N	1.11	84	290	116	200	90
Text-T-14	528	N	11	N	1.25	94	325	130	224	100
Text-T-15	1,745	N	40	N	4.56	345	1,188	475	820	368
Text-U-1	1,075	N	22	N	2.54	192	661	264	456	205
Text-U-2	652	N	13	N	1.54	116	401	160	277	124
Text-U-3	1,773	Y	610	Y	10.64	2,442	2,771	277	2,719	52
Text-U-4	60	Y	20	N	0.43	33	112	45	77	35
Text-U-5	3,438	N	406	N	46.28	10,621	12,051	1,205	11,826	225
Text-U-6	1,183	N	24	N	2.79	211	727	291	502	225
Text-V-1	1,100	N	23	N	2.60	196	676	270	467	209
Text-V-2	987	N	20	N	2.33	176	607	243	419	188
Text-V-3	1,802	N	37	N	4.25	322	1,108	443	765	343
Text-V-4	1,441	N	30	N	3.40	257	886	354	612	274
Text-W-1	857	N	18	N	2.02	153	527	211	364	163
Text-W-2	1,296	N	50	N	5.70	1,308	1,485	148	1,457	28
Text-W-3	1,148	N	24	N	2.71	205	706	282	487	218
Text-W-4	945	N	20	N	2.23	169	581	232	401	180
Text-W-5	2,221	Y	262	Y	4.02	922	1,046	105	1,027	20
Text-W-6	493	N	10	N	1.16	88	303	121	209	94
Text-W-7	4,365	N	90	N	10.30	2,365	2,683	268	2,633	50
Text-W-8	3,500	N	413	Y	180.97	41,536	47,129	4,713	46,249	880
Text-Y-1	1,186	N	25	N	2.80	212	729	292	503	226
Text-Y-2	110	Y	666	Y	9.68	2,222	2,521	252	2,474	47
Text-Y-3	2,100	N	43	N	4.96	375	1,291	516	891	400
Text-Y-4	900	N	19	N	2.12	161	553	221	382	171
Text-Y-5	670	N	14	Y	0.59	45	153	61	106	47
Text-Y-6	785	N	16	N	1.85	140	483	193	333	149
Text-Y-7	6,872	N	142	N	16.22	3,723	4,224	422	4,145	79
Text-Z-1	1,500	Y	180	Y	1.72	395	449	45	440	8
Text-Z-2	480	N	10	N	1.13	86	295	118	204	91
TOTAL	**299,599**	**31**	**19,573**	**84**	**1,384**	**253,830**	**360,453**	**68,463**	**322,293**	**38,160**

Notes: all values are in USD. USD 1 = 3,840 (the 2000 value). Y = yes, N = No.