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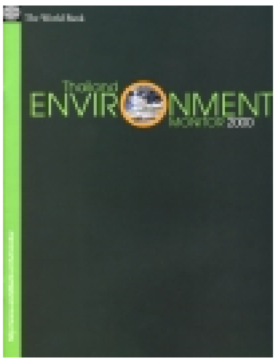
Thailand at a Glance

BANGKOK,JUNE2001

Thailand Environment Monitor 2000

presented a snapshot of general environmental trends in the country



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prefacE

The Thailand Environment Monitor series -initiated in 2000 -presents a snapshot of key environmental trends in the country. Its purpose is to engage and inform stakeholders of key environmental changes as they occur. Using charts and graphs, the 2000 Monitor benchmarked trends in various environmental indicators associated with water and air quality, and natural resources conservation. Environmental changes, however, occur over a period of time, and therefore, unlike economic indicators, annual variations are not easy to measure or assess. Thus, the series is designed to track changes in general environmental trends every 5 years. In the intervening years, the Monitor will focus on specific themes each year, to highlight critical and emerging problems. Water quality is the focus of the 2001 Monitor.

Why water? With thirty percent of all available water not suitable for most human activities, water availability is one of Thailand's most critical environmental issues. In terms of annual per capita availability of renewable water resources, Thailand ranks the lowest in Asia, and lower than the world average.

Domestic sewage, industrial effluents, and agricultural run-off all contribute to increasing pollution of surface, coastal, and ground water. Despite 90 percent access to public water supplies, contamination is particularly severe in the Bangkok Metropolitan Region. According to preliminary estimates, water pollution is estimated to cost between 0.6 and 1% of the GDP, annually.

The lack of an integrated approach combined with poorly enforced laws, weak capacity and insufficient investments, have exacerbated the pollution of Thailand's waters. Limited community participation, and the low involvement of the private sector has pushed the onus onto the government in addressing this issue.

The assessment of water quality is based on the evaluation of three main parameters: Biochemical Oxygen Demand; Dissolved Oxygen; and Total Coliform Bacteria. These parameters were chosen based on the availability of data at both the regional and national level. In the Water Quality Scorecard, these indicators have been benchmarked to form the basis against which future changes in water quality will be measured.

The information contained in the Monitor has been obtained from a variety of sources including published reports of government agencies, universities and nongovernmental organizations, unpublished data from individuals, and documents of the World Bank.

The Environment Monitor 2001 is broadly divided into the following six sections (i) Thailand Water Quality Overview; (ii) Costs of Water Pollution; (iii) Regional Water Quality; (iv) Water Policies and Laws; (v) Physical Investments in Water; and (vi) Spending on Water Pollution Control. Water quality reporting is based around the five administrative regions of Thailand -Central, Eastern, Northern, Northeastern and Southern.

To address water pollution, Thailand needs to develop an integrated approach for the management of surface and groundwater resources. This will involve **fostering** local community participation in water resources management; **harmonizing** functions and laws by addressing overlaps in institutions and jurisdiction, and gradually decentralizing functions to local governments; **strengthening** compliance with environmental standards, by providing incentives for pollution control; **improving** the efficiency of budget allocation and rationalize investments for the wastewater sector, **promoting** opportunities for private sector participation, and; **increasing** public awareness about the state of water quality.

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Methodology

Several methodologies were used to capture the extent of water pollution, estimate health costs associated with disease and forecast capital costs for wastewater treatment. A number of assumptions were made, with some caveats, are listed below:

Industrial sector BOD and TSS.[1]

Estimates were calculated using the Industrial Pollution Projection System (IPPS) developed by the Research Group[2] of the World Bank. IPPS exploits the fact that industrial pollution is heavily affected by the scale of industrial activity, its sectoral composition (industrial sector), and the process technologies which are employed in production. IPPS combines data from industrial activity (such as employment) with data on actual pollution emissions to calculate pollution intensities, i.e. the level of pollution emissions per unit of industrial activity. Pollution intensities for each sector were calculated by combining data from the United States Manufacturing Census (employment data) and the US National Pollution Discharge Elimination System (pollution data).

The applicability of using US-based estimates in other economies is a function of country-specific information, however, the pattern of sectoral intensity (one sector relative to another) may be similar and thus it is the relative ranking of sectors that is important, even if exact estimates are not possible. To the degree that the intensities are based on US technology, and that developing countries possess at least the same, if not older, pollution control technology, then these estimates should be understood as lower bound estimates.

In applying IPPS to Thailand, the pollution intensity of each type of factory (kg/employee) was multiplied by the number of Thai employees in the factory as reported by the industrial registration statistics in the Department of Industrial Works, 1999.

[1] See *Assessing Conventional Industrial Water Pollution in Thailand*, mimeo, Pollution Control Department and World Bank, 2000.
[2] See *The Industrial Pollution Projection System*, World Bank Policy Research Working Paper Series, No. 1431, 1995.

Agricultural BOD generation estimates.

Agricultural generation was calculated as the BOD loading per area[3] multiplied by the agricultural area reported in 1996, and extrapolated to later years using agricultural GDP as an indicator.[4]

Domestic BOD generation estimates.

Domestic wastewater generation was calculated by multiplying the population base with the BOD factor per person[5] developed by the Environmental Policy and Planning Division.[6]

Health costs of water pollution.

The data presented in the health costs section are based on the recently completed background study Valuing Health and Economic Costs of Water Pollution in Thailand.

1. These estimates are based on costs associated with reported cases of three water pollution related diseases -diarrhea, typhoid, and dysentery. In valuing the economic costs of these diseases, two types of costs are considered: (i) direct costs; and (ii) indirect costs. Direct costs include medical expenses. Indirect costs include the income forgone due to health impacts for the three diseases Impacts on public health are measured in terms of income forgone due to premature death mortality) and loss of productivity due to sicknesses (morbidity). Data from the Thai Annual Epidemiology Surveillance Report (1998) is used in this analysis.

2. The baseline data used to calculate the income foregone comes from the Centre for Health Economics, Chulalongkorn University. The value of a Thai life in this study is estimated at $45,000. There are, however, other estimates for a Thai life.

[3] As reported in the *Basin Development and Practical Planning Project*, Water Quality Management Division, Pollution Control Department, Ministry of Science, Technology and Environment, 1996.
[4] GDP values were obtained from the Office of the National Economic and Social Development Board, 2000.
[5] For the Central region the factor is 35 g/person/day and for the other regions it is 30 g/person/day.
[6] *Domestic Wastewater Management Project*, Environmental Policy and Planning Division, Office of Environmental Policy and Planning, Ministry of Science, Technology and Environment, 1995.

3. The costs of implementing urban sanitation and water pollution control measures are from other World Bank publications including Can the Environment Wait ? Priorities for East Asia, Nov. '97; and Thailand: Building Partnerships for Environmental and Natural Resources Management, Sept. '99.

Investments for Municipal Wastewater Treatment.

Estimates were made for new investments necessary to provide adequate treatment and collection for the municipal population in each region of Thailand. The required capacity and municipal coverage of existing facilities and those under construction[7] is estimated using the municipal wastewater production data calculated from municipal population statistics[8] and typical values for per capita wastewater production. The regional estimates do not include excess capacity in provinces such as Chonburi, Phuket or Prachuap Khiri Khan that have treatment capacity to accommodate tourist hotels. The amount of wastewater collected from systems currently covered by treatment was estimated to be 55% of the treatment plant design capacity based on performance data from 19 WWTS in Thailand. Costs of increasing capacity of treatment plants and collection systems were based on previous investments in Thailand and typical industry values. It should be noted that, as many municipalities may have urban areas that extend outside the municipal area, have large unregistered or growing populations, larger investments are likely needed to cover the entire urban area.

Investments for Industrial Waste Treatment

Information on total abatement costs for controlling industrial pollution are not easily forthcoming. Using information from a recent case study of in-plant treatment costs, estimation of pollution reduction costs for food and textile sectors have been made.

[7] Plant data from PCD, August 2000.
[8] National Statistical Office, 2000.

Abbreviations and Acronyms

BMA	Bangkok Metropolitan Administration
BMR	Bangkok Metropolitan Region
BOB	Bureau of Budget
BOD	Biochemical Oxygen Demand
DANCED	The Danish Cooperation for Environment and Development
DEQP	Department of Environmental Quality Promotion
DIW	Department of Industrial Works
DMR	Department of Mineral Resources
DO	Dissolved Oxygen
DoF	Department of Fisheries
DoH	Department of Health
DOLA	Department of Local Administration
EF	Environment Fund
EIA	Environmental Impact Assessment
EEPSEA	Economic and Environment Program for South East Asia
GDP	Gross Domestic Product
ISO	International Organization for Standardization
LAO	Local Administrative Organization
LGA	Local Government Authority
LTD	Land Transport Department
MoAC	Ministry of Agriculture and Cooperatives
MoF	Ministry of Finance
MoInd	Ministry of Industry
MoInt	Ministry of Interior
MoPH	Ministry of Public Health
MoSTE	Ministry of Science, Technology, and Environment
MoTC	Ministry of Transport and Communications
MoUA	Ministry of University Affairs
MPN	Most Probable Number
NEB	National Environment Board
NEQA	Enhancement and Conservation of National Environmental Quality Act
NGO	Non Governmental Organization
OAG	Office of the Attorney General
O&M	Operations and Maintenance
OECD	Organization for Economic Co-operation and Development
OEPP	Office of Environmental Policy and Planning
PEAP	Provincial Environmental Action Plan
PCD	Pollution Control Department
PSR	Pressure-State-Response
PWD	Public Works Department
RFD	Royal Forest Department
RTG	Royal Thai Government
TCB	Total Coliform Bacteria
TDRI	Thailand Development Research Institute
TSS	Total Suspended Solids
UNFDAC	United Nations Fund for Drug Control
WWTS	Wastewater Treatment Systems

Exchange Rate : 1 US $ = 42 Baht

Water Quality:Surfacing Concerns

Water pollution is one of the most serious environmental problems facing Thailand today. Thailand's main source of water is rainfall, which varies widely between the various regions. Rainfall provides the Southern region the richest source of water, compared with the other regions in the country.

Water quality monitoring of major river basins and lakes in Thailand has shown a steady rise in pollution levels over the last decade.

Surface water quality varies widely in the different regions of Thailand. The Central, Eastern and Southern regions were found to have poor water quality; while water in the Northern region was fair. The Central region has the poorest water quality, due to dense populations, and intense economic activity. The Southern region, where tourism, mining, and aquaculture industries have been growing, is facing coastal water pollution. These differences in type and extent of water pollution indicate the need for different strategies to address water quality in the regions. Lower reaches of Chao Phraya and middle and lower reaches of Tha Chin are almost biologically dead, and is a major cause of public health concern.

In addition to surface waters, coastal and groundwater quality is also being adversely affected by increasing pollution and external pressures. Groundwater quality was found to be contaminated from agricultural run-off, pesticide residues as well as saltwater intrusion from over-extraction. The coastal and marine waters in the Gulf of Thailand are under threat from both land-based and maritime pollutants.

Water pollution causes damage to human health, fisheries, and agriculture, and results in associated health and economic costs. Diseases relating to contaminated water range from diarrhea to birth defects. Preliminary health cost estimates from reported cases of diarrhea, dysentery, and typhoid amounted to US$23 million in 1999. In addition, costs of providing access to clean water and sanitation was estimated to be US$ 686 million, annually.

The Thai Government has put into place policies, plans and water quality standards in an effort to reduce water pollution. Five-year plans -which emphasize the Government's commitment to the rehabilitation of natural resources -have included improving water quality as an important goal. The Office of Environment Policy and Planning's 20 year policy and perspective plan for enhancement and conservation of environmental quality, also recognizes the role of local government authorities and civil society in improving and protecting water quality.

The Thai regulatory system for water resources management and pollution control is both centralized and fragmented. While MoSTE develops national policies, plans, standards, and regulations for water pollution control, implementation authority often rests with other ministries. Furthermore, the enforcement of existing environmental laws is weak due to the lack of political will, inadequate coordination among various agencies, low technical capability for proving violations, and limited access to information.

Over the past 15 years, Thailand has embarked on an ambitious program for the management of water pollution generated from municipal sources. To date, 57 wastewater treatment plants, have been constructed in 50 municipalities at a total cost of almost 19 billion baht. However, budgetary shortfalls, especially at the local level, are affecting the operations and maintenance of these plants and resulting in equipment malfunctions and failures.

Collection efficiency is constrained by the reliance on old drainage systems comprised of canals or open sewers and poorly maintained drainage pipe networks with limited connections. Additional investment needs for new municipal wastewater collection and treatment systems is estimated to be around US$ 2 billion.

Moving ahead, Thailand needs to aggressively implement its articulated position of area-based integrated water resources management that recognizes both: quantity and quality; and demand and supply balance, with the participation of all stakeholders.

hotspot maP

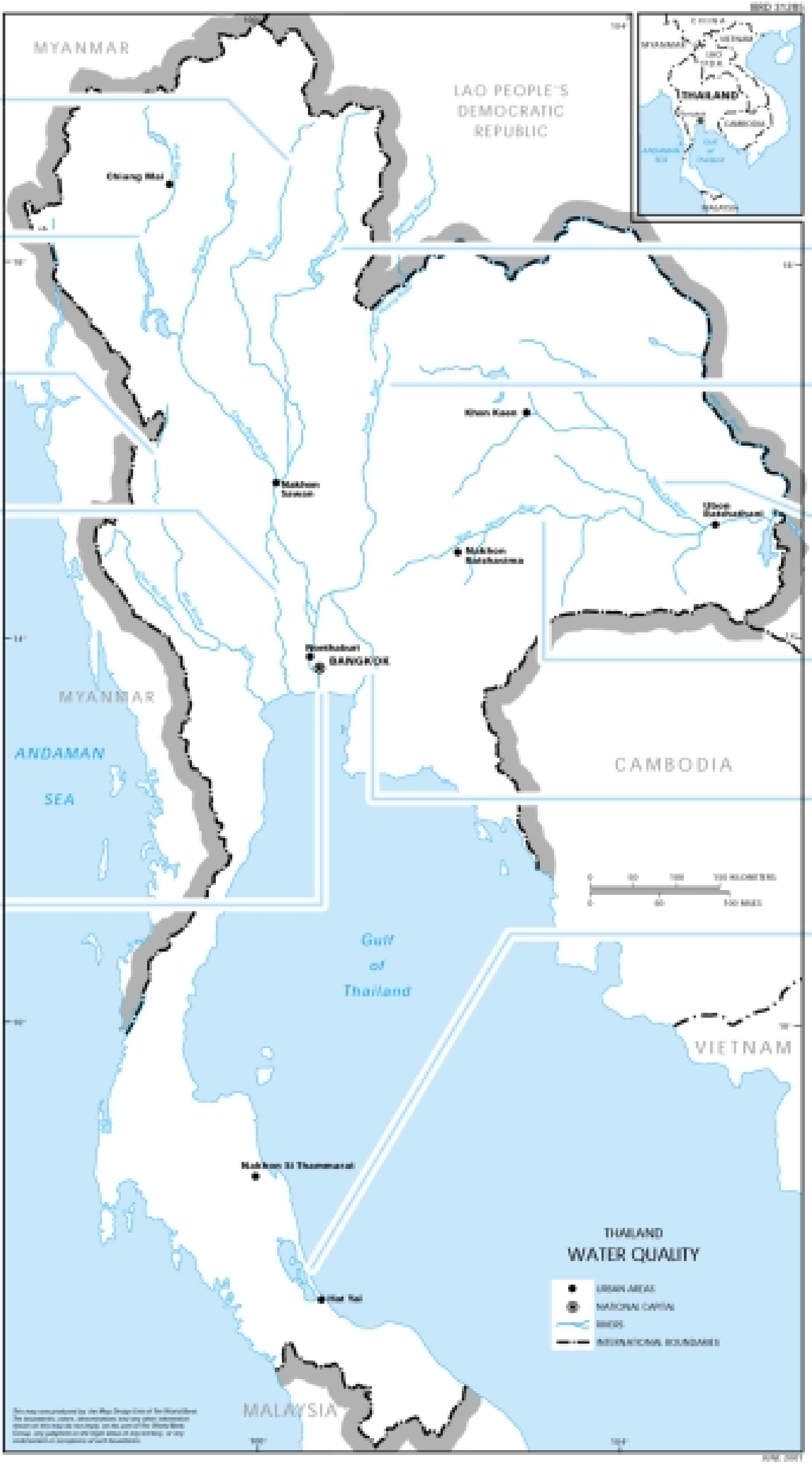
YOM
Class: 2
BOD: 1.5
DO: 5.8
Coliform: 270

PING
Class: 2
BOD: 1.1
DO: 5.6
Coliform: 800

MAE KLONG
Class: 2
BOD: 1
DO: 6
Coliform: 790

THACHIN
Upper
Class: 2
BOD: 1.1
DO: 4.8
Coliform: 1450
Middle
Class: 5
BOD: 1.6
DO: 1.5
Coliform: 10000
Lower
Class: 5
BOD: 2
DO: 1.3
Coliform: 2400

CHAO PRAYA
Upper
Class: 2
BOD: 0.9
DO: 5.7
Coliform: 1300
Middle
Class: 3
BOD: 0.8
DO: 4.5
Coliform: 2700
Lower
Class: 5
BOD: 2.8
DO: 1
Coliform: 14500



NAN
Class: 2
BOD: 1.5
DO: 6.7
Coliform: 215

PASAK
Class: 2
BOD: 1.4
DO: 6
Coliform: 1100

CHI
Class: 2
BOD: 1.4
DO: 6.6
Coliform: 130

MOON
Class: 2
BOD: 1.1
DO: 6.3
Coliform: 70

BANGPAKONG
Class: 3
BOD: 0.9
DO: 4.7
Coliform: 195

SONKHLA LAKE
Class: 3
BOD: 1.8
DO: 5.9
Coliform: 110

BOD: mg/l
DO: mg/l
Coliform: MPN/100ml

Thailand's Surface Wa

Water Basins	Population and Land Area	Sources of Pollution	Quality Indicators	Overall State of Water Quality
I. Chao Phraya	Basin Area (Km^2): 20,125 Population: 11,651,995 m^3 per-person: 1,905	Industry: M Agriculture: H Domestic H	**Upper** Class: ●● BOD: 0.9 mg/l DO: 5.7 mg/l TCB: 1,300 MPN/100 ml	GOOD
		Industry: L Agriculture: M Domestic: M	**Middle** Class: ●●● BOD: 0.8 mg/l DO: 4.5 mg/l TCB: 2,700 MPN/100 ml	MODERATE
		Industry: H Agriculture: L Domestic: H	**Lower** Class: ●●●●● BOD: 2.8 mg/l DO: 1 mg/l TCB: 14,500 MPN/100 ml	VERY POOR
II. Tha Chin	Basin Area (Km^2): 13,682 Population: 2,796,221 m^3 per-person: 1,482	Industry: M Agriculture: H Domestic: H	**Upper** Class: ●● BOD: 1.1 mg/l DO: 4.8 mg/l TCB: 1,450 MPN/100 ml	GOOD
		Industry: M Agriculture: H Domestic: H	**Middle** Class: ●●●●● BOD: 1.6 mg/l DO: 1.5 mg/l TCB: 10,000 MPN/100 ml	VERY POOR
		Industry: M Agriculture: H Domestic: H	**Lower** Class: ●●●●● BOD: 2 mg/l DO: 1.3 mg/l TCB: 2,400 MPN/100 ml	VERY POOR
III. Mae Klong	Basin Area (Km^2): 30,840 Population: 2,387,843 m^3 per-person: 5,109	Industry: M Agriculture: M Domestic H	Class: ●● BOD: 1 mg/l DO: 6 mg/l TCB: 790 MPN/100 ml	GOOD
IV. Bang Pakong	Basin Area (Km^2): 7,978 Population: 956,975 m^3 per-person: 3,879	Industry: M Agriculture: M Domestic H	Class: ●●● BOD: 0.9 mg/l DO: 4.7 mg/l TCB: 195 MPN/100 ml	MODERATE
V. Moon	Basin Area (Km^2): 69,701 Population: 9,533,006 m^3 per-person: 2,796	Industry: L Agriculture: M Domestic H	Class: ●● BOD: 1.1 mg/l DO: 6.3 mg/l TCB: 70 MPN/100 m	GOOD

er Quality Scorecard

Water Basins	Population and Land Area	Sources of Pollution	Quality Indicators	Overall State of Water Quality
VI. Pasak	Basin Area (Km²): 16,292 Population: 1,822,137 m³ per-person: 1,548	Industry: L Agriculture: L Domestic H	Class: ●● BOD: 1.4 mg/l DO: 6.0 mg/l TCB: 1,100 MPN/100 ml	GOOD
VII. Ping	Basin Area (Km²): 33,898 Population: 2,451,503 m³ per-person: 3,249	Industry: L Agriculture: L Domestic H	Class: ●● BOD: 1.1 mg/l DO: 5.6 mg/l TCB: 800 MPN/100 ml	GOOD
VIII. Chi	Basin Area (Km²): 49,477 Population: 6,170,556 m³ per-person: 1,418	Industry: L Agriculture: M Domestic H	Class ●● BOD: 1.4 mg/l DO: 6.6 mg/l TCB: 130 MPN/100 ml	GOOD
IX. Nan	Basin Area (Km²): 34,330 Population: 2,275,273 m³ per-person: 4,025	Industry: L Agriculture: L Domestic H	Class: ●● BOD: 1.5 mg/l DO: 6.7 mg/l TCB: 215 MPN/100 ml	GOOD
X. Yom	Basin Area (Km²): 23,616 Population: 2,355,024 m³ per-person: 1,256	Industry: L Agriculture: L Domestic H	Class: ●● BOD: 1.5 mg/l DO: 5.8 mg/l TCB: 270 MPN/100 ml	GOOD
XI. Songkhla Lake	Basin Area (Km²): 8,945 Population: 841,387 m³ per-person: 5,819	Industry: L Agriculture: H Domestic H	Class: ●●● BOD: 1.8 mg/l DO: 5.9 mg/l TCB: 110 MPN/100 ml	MODERATE

PCD Standard Values for Surface Water Classification

The determination of the overall state of water quality is based on evaluation of the currently available water quality parameters, with the ***worst parameter*** dictating the state.

Water Quality Parameter	Units	Standard Value for Class				
		Class 1 (Very good)	Class 2 (Good)	Class 3 (Moderate)	Class 4 (Poor)	Class 5 (Very poor)
Dissolved Oxygen (DO)	mg/l	Natural	6	4	2	-
Biochemical Oxygen Demand (BOD)	mg/l	Natural	1.5	2	4	-
Total Coliform Bacteria (TCB)	MPN/100 ml	Natural	5,000	20,000	-	-

Thailand Water Quality Overview

In terms of per capita water availability per year, Thailand ranks the lowest in Asia, with only 1,854 cubic meters. This is also lower than the world average. Furthermore, compared to other Asian countries, Thailand also has the lowest volume of surface water per person.[9]

This water shortage problem is further compounded by the fact that Thailand ranks 14th in the world in terms of industrial organic water pollution, discharging nearly 0.4 million kilograms of effluent per day.[10] Almost a third of the country's total available water is unsuitable for human consumption[11], which puts Thailand among countries whose water availability is projected as "under stress" for 2000-2025.[12]

The total inland water area of Thailand is 45,450 square kilometers, comprising of man-made reservoirs, natural lakes, rivers, and other types of freshwater bodies, including groundwater. Distinct hydrological characteristics vary from region to region depending on the geographical and climatic conditions of each region. Recognizing these differences, the country can be divided into 25 water basins and grouped into the following five regions: Central, Eastern, Northern, Northeastern, and Southern regions.

Water Profile

Despite a worldwide trend of declining organic water pollution between 1980 and 1997, Thailand witnessed an increase of more than 60 percent over the same period of time. Furthermore, it has also been estimated that Thailand ranks ninth in the world in terms of BOD effluent per square kilometer of the country's surface area. However, in terms of pollution intensity, organic effluent per worker declined from 0.22 kilograms per day in 1980, to 0.16 kg in 1997 largely as a result of the adoption of cleaner technologies.[13]

[9] State of Environment Report, 2000
[10] Estimates of the Development Research Group, World Bank
[11] 1997 PCD water quality survey
[12] World Resources Report 2000-2001
[13] Estimates of the Development Research Group, World Bank

Annual Renewable Water Resources

Country	**Total Resources** (Km^3)	**1995** (m^3/person)
World	30,712	22,544
Asia	13,207	3,680
Thailand	110	1,854
Cambodia	88	8,195
Indonesia	2,530	12,251
Malaysia	456	21,259
Myanmar	1,082	22,719
Philippines	323	4,476
Vietnam	376	4,827

Source: The State of the Environment in Thailand in Decade of Change, TDRI, 2000.

Water Basins in Thailand

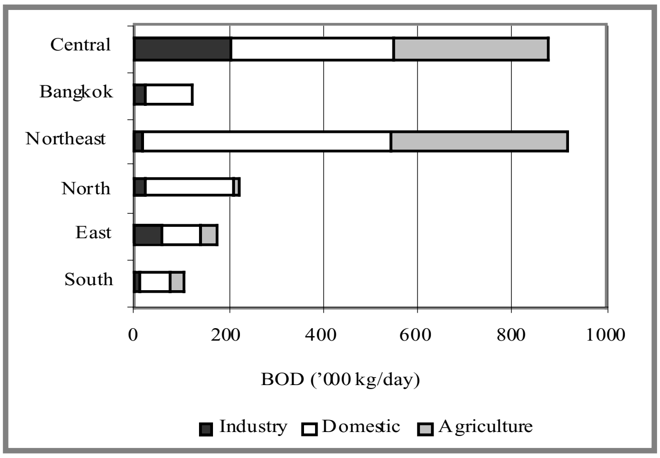
Region/Water Basins	Provinces
Central (4) Chao Phraya Tha Chin Mae Klong Lower Pasak Sakae Krung	Ang Thong, Bangkok, Chainat, Kampaeng Phet, Kanchanaburi, Lopburi, Nakorn Pathom, Nakon Sawan, Nonthaburi, Pathum Thani, Phetchabun, Phetchaburi, Phra Nakhon Si Ayudhya, Prachuapkhirikhan, Ratburi, Samut Prakran, Samut Sakhon, Samut Songkham, Saraburi, Singburi, Suphanburi, Uthaithani
East (4) Prachinburi, East Coast-Gulf, Tonale Sap, Bang Pakong	Chachoengsao, Chanthaburi, Chunburi, Nakorn Nayok, Prachinburi, Rayong, Sakaew, Trad
North (10) Ping, Wang, Yom Nan, Upper Pasak Kok, Ing, Kuang Li	Chiang Mai, Chiang Rai, Kampaeng Phet, Lampang, Lumphun, Mae Hong Son, Nakhon Sawan, Nan, Phayao, Phichit, Phitsanulok, Phrae, Sukhothai, Tak, Uttaradit
Northeast (3) Chi Mun Mekong	Amnat Charoen, Buri Ram, Chaiyaphum, Kalasin, Khon Kaen, Loei, Maha Sarakham, Mukdahan, Nakhon Phanom, Nakhon Ratchasima, Nong Bua Lam Phu, Nong Khai, Roi Et, Sakon Nakhon, Si Sa Ket, Surin, Ubon Ratchthani, Udon Thani, Yasothon
South (7) Songkhla, Tapipum Trang, Pattani, Lanugsuan, Saiburi, Kuiburi, Bangnara Khlongta, Pranburi	Chumphon, Nakhon Si Thammarat, Narathiwat, Pattani, Phangnga, Phattalung, Ranong, Satun, Songkhla, Surat Thani, Trang, Yala

Agricultural runoff, domestic wastewater and industrial effluent are responsible for the poor water quality in Thailand. At the regional level, the bulk of industrial effluent occurs in the Central and Eastern regions, where over 50,000 firms contribute significantly to the country's total organic pollution. Agricultural sources of BOD are highest in the Northeastern and Central regions, accounting for more than 29 percent of the national and 30 percent of each regions' generation. The dominant source for organic pollution, however, is domestic wastewater, which is responsible for 54 percent of total national generation and an average of 60 percent across regions.

At a national level, the top ten water basins in terms of total BOD generation contribute to 79 percent of total organic pollution in Thailand's surface waters. Ranging from the Moon basin (0.4 million kg/day) to the Bang Pakong (0.06 million kg/day), these ten basins are characterized by large populations and agricultural activities, along with industry in the Central region.

Across industrial sector sub-groups, effluent generation is also concentrated in relatively few sectors, with the top ten sectors accounting for 95 and 97 percent of BOD and Total Suspended Solids (TSS), respectively. Sectors such as pulp & paper, industrial chemicals, food & beverages (i.e. sugar, spirits, dairy, fish, fruits & vegetables) are high generators of BOD, while iron & steel, pulp & paper and nonferrous metals tend to be associated with larger contributions to TSS.

Regional contribution of industrial, agricultural and domestic BOD, 1999



Source: Development Research Group, World Bank, 2001

Cumulative contribution of Top 10 water basins to total BOD generation, 1999

Basin	Region	BOD [1] (Kg/Day)	Percent	Cumulative
Moon	Northeast	405,451	16.7	16.7
Chao Phraya	Central	363,705	15.0	31.7
Chi	Northeast	284,467	11.7	43.4
Mekong	Northeast	228,743	9.4	52.8
Tha Chin	Central	208,122	8.6	61.4
Mae Klong	Central	129,935	5.3	66.7
Pasak	Central	115,148	4.7	71.5
East Coast-Gulf	East	65,673	2.7	74.2
Nan	North	57,500	2.4	76.5
Bangpakong	East	56,743	2.3	78.9

1- Includes generation from industry, domestic, and agriculture
Source: Development Research Group, World Bank, 2001

Cumulative contribution of top 10 industrial sectors to total BOD and TSS emissions, 1999

BOD	# firms	%	Cumulative	TSS#	firms	%	Cumulative
Pulp & paper	96	32	32	Iron & steel	479	61	61
Industrial chemicals	305	15	47	Pulp & paper	96	9	70
Sugar factories	137	10	57	Nonferrous metals	674	9	79
Distilled spirits	28	9	66	Jewelry	592	7	86
Dairy products	83	8	74	Drugs & medicines	274	3	89
Nonferrous metals	674	7	81	Athletic goods	99	2	91
Plastics	3940	6	87	Industrial chemicals	305	2	93
Fish products	359	5	92	Fertilizers & pesticides	204	1	94
Preserved fruits & vegetables	488	2	94	Distilled spirits	28	1	96
Spinning & weaving	1597	1	95	Sugar factories	137	1	97

Source: Development Research Group, World Bank, 2001

Surface Waters

In 1999, the Pollution Control Department (PCD) monitored the quality of 50 rivers and lakes in Thailand. Findings revealed that 48 percent of water bodies surveyed were suitable for agriculture and general consumption ("good" and "moderate" quality). Over 50 percent of Thailand's surface waters were found to be "poor" to "very poor" quality. No surface water in the study is categorized as 'very good' quality (extra clean water which is suitable for aquatic animals and human consumption after normal treatment). Water quality appears to be worsening, in terms of BOD, DO and TCB indicators surveyed by the PCD of major rivers and lakes in Thailand.

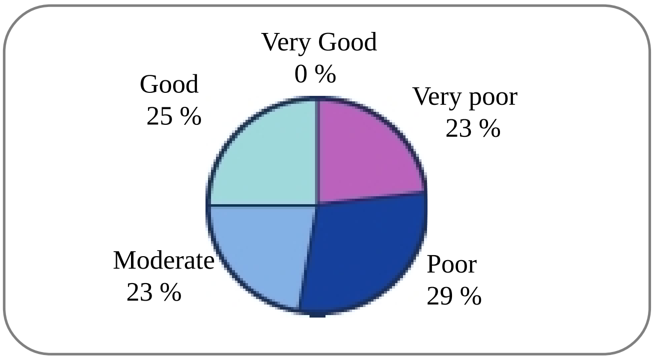
Surface water quality varies widely in the different regions of Thailand. Water quality studies by the PCD revealed that surface water monitored in the Central, Eastern and Southern regions appeared to have poor quality; while water in the Northern region was fair. Compared to the other regions, the rivers and lakes monitored in the Northeastern region had good quality surface water.

In terms of DO, surface waters in the Northern and Northeastern regions rank the best with 6.4 mg/l, followed by the Southern and Eastern regions (with 5.6 mg/l and 5.2 mg/l respectively). The Central region ranks the lowest with 4.6-mg/l average. The highest concentrations of TCB, among surface waters monitored, is found in the Central region (63 percent), followed by the Eastern region (15 percent). Surface waters in the Northern and Northeastern regions have relatively lower TCB levels.

During the dry months between May-July, when water flows are low, many rivers deteriorate to very poor water quality (e.g. the lower Chao Phraya River, the Pasak River and the Petchaburi River). Deteriorated and polluted waters are also periodically found in Mae Klong, Bang Pakong, Pasak, Ping, Wang, Yom, and Nan Rivers.

Coastal water quality is also deteriorating. The main pressures are from domestic discharges (which contribute to 70 percent of total marine pollution in the Gulf of Thailand), industrial waste, and the burgeoning tourism industry. Such pollution is resulting in damage to coral reefs, as well as affecting fish populations which use the waters of the Bay as spawning grounds.

Condition of Water Quality



Source : Pollution Control Department, 1999

PCD has set up 218 monitoring stations along the 2,600 km coastline and important islands. Water quality at most stations were good to fair in 1999. Poor water quality was found near the inner Gulf and river mouths of Pak Panang, Pattani, and Ranong. In 25 percent of the stations, TCB contamination was higher than the standard. High contamination was also found near the mouths of major rivers, such as the Chao Phraya and Tha Chin, as well as the eastern and southern coasts.

Ground water is mainly recharged by rainfall and seepage streams. Aquifers yield a large amount of water throughout Thailand, with the exception of the Eastern region. The largest source of groundwater is found in the Lower Central Plain, particularly in BMR and surrounding provinces, and is being used to meet the growing water demand.[14] Unlike the other regions, some groundwater extraction data is available for the central region.

Agricultural run-off, coastal aquaculture, industrial effluents and domestic sewage are responsible for the pollution of groundwater in Thailand. Also the lack of an appropriate pricing policy is leading to over-exploitation of groundwater beyond sustainable yield levels. There is limited information on groundwater extraction rates, or the extent of contamination at the national-level.

[14] Water demand doubled between 1980 and 1990 to reach a daily amount of about 43,000 million cubic meters, and it is growing at the rate of 10 percent annually. Demand is projected to continue roughly doubling each decade for at least the next twenty years.

costs of Polluted WateR

Water pollution causes damage to human health, fisheries, and agriculture, and results in associated health and economic costs. It also threatens ecosystems through eutrophication, and is responsible for the loss of plant and animal species.

Exposure to polluted water results in numerous diseases including diarrhea, hepatitis, typhoid, trachoma and hookworm infection. More toxic water pollutants may lead to other health effects including skin disease, liver cancer, and birth defects. For many of these health effects, it is often difficult to show the exact cause without large epidemiological surveys carried out over many years. In contrast to fecal-borne diseases such as diarrhea, water pollution related cancers and birth defects are believed to be caused by heavy metals and toxic chemicals that can be removed through cleaner production and waste treatment.

In the past, policy setting and decision making did not fully consider the economic and health costs of water pollution. The estimates in this Monitor represent a first attempt in Thailand to account for the full economic and health costs of water pollution. The analysis is limited to only “reported” cases of three diseases- diarrhea, typhoid and dysentery - and therefore greatly underestimate the true costs of water pollution.[15]

Although about 89 percent of households have access to safe public water supply and sanitation, mortality and morbidity associated with water-borne diseases remains high in the country. In 1999, more than 1.1 million cases of diarrhea were registered, leading to 323 cases of premature death (25 percent of which were children below age four), and 95,000 cases that needed hospitalization. Furthermore, in the same year, there were 7,165 cases of typhoid and 59,064 cases of dysentery, of which more than 4,000 and 7,000, respectively needed hospitalization. The total costs of out-patient hospitalization amounted to US$4.9 million -averaging US$6 per case.

Putting your Money where the River Mouth is:
W illingness to Pay of Bangkok s residents to Clean Up the Chao Phraya River

Bangkok s central Chao Phraya River and many of its 1,145 canals are heavily polluted. Since 1990, the levels of dissolved oxygen in the lower reaches of the Chao Phraya have been close to zero, making it almost impossible for aquatic life to survive.

In 1998, a contingent valuation study was carried out to estimate the willingness of Bangkok residents to pay for improved water quality in the Chao Phraya and its canals. Heads of about 1,100 households (residential, commercial, canal houses and informal settlements) were interviewed in 20 of the city s districts, in addition to consultations with various departments and focus groups.

The survey found that over 60 percent of people interviewed thought that water quality was very poor , with 20 percent rating it as poor . More than two-thirds of the respondents indicated that they were willing to pay for water treatment services should they be made available. Results show that they were willing to pay on average 100 baht/month (approximately US$2.3) to improve water quality from boatable to fishable and 1 15 baht/month (US$2.7) to go from fishable to swimmable . Furthermore, half of the respondents said that they would prefer a separate billing for any such fee charged, so that they would know how much they are contributing to improving the quality of the water near their household.

Following the release of the study, the BMA announced the intention of starting a household wastewater treatment fee of 100 baht/household/month —-the mean willingness to pay revealed in the survey. This fee, however, has not been implemented yet.

Source: Tapvong, C., and Kruavan, J., Water quality improvements: A contingent valuation study of the Chao Phraya river, EEPSEA Research Report, 1999.

Total Patient Hospitalization Costs, 1999

Disease	Out-Patient Cost (million US$)	Out Patient Case Cost per Patient (US$)	In-Patient Cost (million US$)	In Patient Case Cost per Patient (US$)	In-Out Total Patient Cost (million US$)
Diarrhea	4.69	4.5	2.28	24.0	6.97
Typhoid	0.03	9.7	0.14	32.5	0.17
Dysentery	0.24	4.5	0.22	31.5	0.46
Total (million US$)	**4.96**		**2.64**		**7.59**

Source: Supakankunti Siripen, Pirus Pradithavani, and Tanawat Likitkererat, Valuing Health and Economic Costs of Water Pollution in Thailand. May 2001 draft.See also Methodology section.

[15] See Methodology section.

Diarrhea, typhoid and dysentery patients required hospitalization for treatment averaging hospital stays of 2.1, 4.3 and 2.2 days respectively, at a total cost of US$2.6 million. The total out-patient and in-patient hospitalization costs for these three water-borne diseases amounted to US$7.5 million in 1999 alone.[16]

Assuming an average wage of US$ 4 per day, wages lost due to hospitalization and to premature death were estimated at US$0.5 million and US$7 million, respectively. These preliminary estimates show that, in 1999 alone, diarrhea, typhoid and dysentery have cost the Thai economy about US$23 million —0.02 percent of gross domestic product (GDP).[17]

Findings from earlier studies of household spending and water markets indicate that 11 percent of Thailand's total urban population (2.5 million people) and 23 percent of the total rural population (9 million people)[18] have no access to safe water, and spend up to 10 and 3 percent of their annual income for it.[19] This means that about US$ 686 million is spent annually for accessing safe water -which amounts to 0.56 percent of Thailand's GDP.

Improvements in water supply and sanitation can substantially reduce the incidence and severity of these diseases. Under a medium-term investment scenario (examined by the World Bank), annualized costs for implementing urban sanitation and water pollution control measures would amount to US$0.66 billion in 2005 and US$1.76 billion in 2020 -a per capita investment of about $11 and $30 respectively. The health and economic benefits generated under such a scenario is estimated at about US$5.2 billion in 2005 and US$8.9 billion in 2020. This means that for each dollar invested in water and sanitation measures, almost $7 is gained in benefits.[20]

[16] Siripen et al, 2001.
[17] See Methodology section.
[18] World Bank. *The Little Green Data Book 2001*, From the World Development Indicators, 2001.
[19] MOSTE, World Bank. *Thailand Building Partnerships for Environmental and Natural Resources Management.* September 1999.
[20] MoSTE, World Bank, *Thailand Building Partnerships for Environmental and Natural Resources Management*, Washington D.C. September 1999; World Bank, *Can the Environment Wait: Priorities for East Asia*, November 1997.

Summary of Costs for Diarrhea, Typhoid and Dysentery, 1999

Disease	Diarrhea	Typhoid	Dysentery	Total
Total Hospital Costs (million US$)	6.97	0.17	0.46	7.59
Wages Loss Hospitalization	0.45	0.06	0.03	0.53
Wages Loss Premature Death	14.34	0.06	0.54	14.94
Total (million US$)	**21.75**	**0.28**	**1.03**	**23.06**

Source: Supakankunti Siripen, Pirus Pradithavani, and Tanawat Likitkererat, Valuing Health and Economic Costs of Water Pollution in Thailand. May 2001 draft. See also Methodology section.

Estimated Annual Income Spent to Access Water and Sanitation

	Population (Million)	Percent of Population with no access to safe water	Per-capita Income (US$)	Percent of income spent on safe water	Total Costs (US$M)
Urban	23	11	2010	10	506
Rural	39	23	700	3	180
Total	**62**				**686**

Source: Monitor Team Estimates, World Bank, 2001

Contamination of Klity Creek: The Role of the Public in Natural Resources Management

Located near the Thung Yai Wildlife Sanctuary a World Heritage Site in Kanchanaburi Province —Klity Creek has been the primary source of water for many generations of Karen villages that live along the Creek. About 30 years ago, the Department of Mining Resources (DMR) granted a mining concession to Lead Concentrate Thailand Co. The company operated the lead separation plant upstream from the Karen village, and used to discharge contaminated sediment into the river.

Since 1994, many village children have been diagnosed with Down s Syndrome and physical deformities, while the adults suffer from an unidentified illness which caused the body to swell and ache. In addition, the deaths of hundreds of cattle that consumed water from Klity Creek was attributed to lead poisoning. Reacting to this health crisis, the Karen Studies and Development Center requested the PCD in 1998 to test lead concentrations in the surface waters, sediments, aquatic life in the Creek, as well as in the blood of the villagers. The first blood tests in 1999 revealed that the lead concentration was 4-5 times higher than 4.9 ug/dl, the average for Thai adults. Creek water concentrations were tested at 0.55 mg/l (PCD s standard allow 0.05 mg/l), while lead concentrations in the sediment tested 3,000 times higher than the 11 mg/kg safety level set by PCD.

In 1998, DMR ordered closure of the lead separation plant and fined the company 2,000 baht (US$ 48). In 2000, the company dredged the river bed sediment in an effort to remove contaminants. Since then, the water quality has improved, although lead concentrations in the creek waters are still higher than what is considered safe for human consumption. This is particularly worrisome as villagers continue to drink water, catch and consume fish from the creek, despite official warnings.

Source: PCD, Bangkok Post articles from 1998-2001

Central Region

The Central region comprises of 4 larger water basins and seven smaller basins -Chao Phraya, Tha Chin, Mae Klong, the lower Pasak, and Sakae Krung. The Chao Phraya originates at the confluence of the Ping, Wang, Yom and Nan rivers at Nakhon Sawan about 200 km north of Bangkok. From Nakhon Sawan, the river flows down through the central plain, passing Bangkok, to the Gulf of Thailand. Flood plains of the Chao Phraya cover an area of about 1 million hectares.

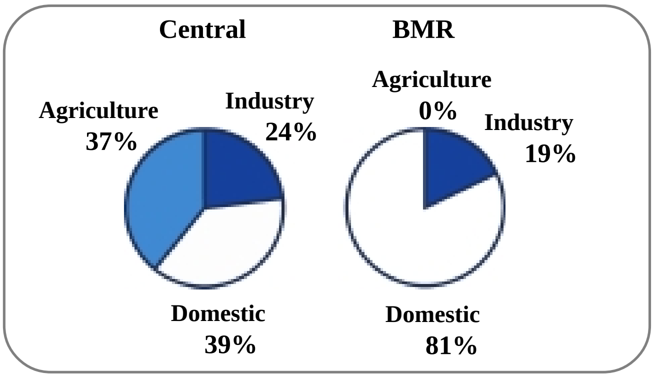
The Central region is the richest and most densely populated region in Thailand. Its economy is extremely well diversified among industry (due in large part to the proximity to the supporting infrastructure of Bangkok), agriculture (the Chao Phraya Basin has rich soils and good water supply), and commerce.

Water Quality Profile. Pollution is most severe in the BMR, especially in the lower reaches of the Chao Phraya and Tha Chin rivers, owing to high industrial and domestic wastewater discharges.

For the region as a whole, domestic and agricultural sources constitute the largest shares in terms of organic pollution (BOD), with industry contributing to 24 percent of overall generation. Within the BMR, due to large population density and limited wastewater treatment capacity, domestic discharges account for 81 percent of total BOD pollution, while industry with over 21,000 plants, contributes 19 percent.

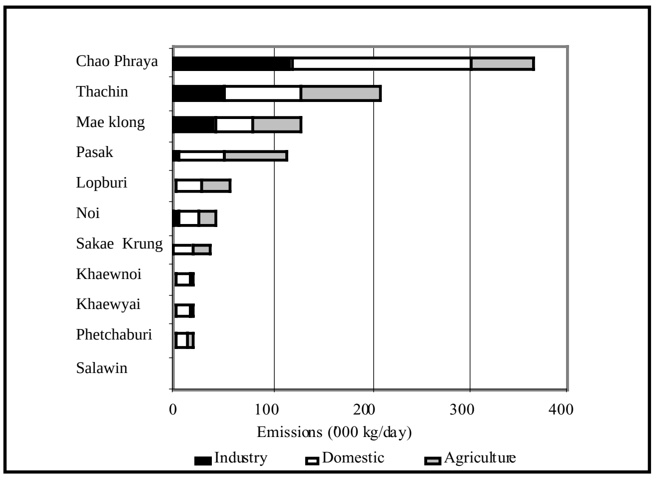
The Chao Phraya basin is the largest and most polluted owing to the diverse nature of economic activities that cater to the area. Along with the BMR, industry in the basin maintains over 32,000 industrial factories, employs 1.5 million people, and as a sector, constitutes 32 percent of the basins' load. Fertile soils in the Chao Phraya delta facilitate the heavy use of land for agriculture, leading to organic runoff which constitutes 17 percent of BOD generation in the basin. The largest contributor however is domestic wastewater, where over 50% of the generated load comes from over 5 million people in the basin.

Sector contribution to total BOD load, 1999



Source: Development Research Group, World Bank, 2001

Contribution of industry, domestic and agriculture to Central region basin , BOD, 1999.



Source: Development Research Group, World Bank, 2001

Of the 46,000 industrial plants that characterize the region, only a selected number of sub-sectors are responsible for BOD and TSS effluents. The most notable sector, pulp & paper is responsible for 37 percent of regional BOD and 9 percent of TSS. Also significant, are the food processing sectors of dairy and spirits contributing to BOD and jewelry and drugs & medicines to TSS.

Industrial sector contribution to BOD and TSS loads, Central region, 1999

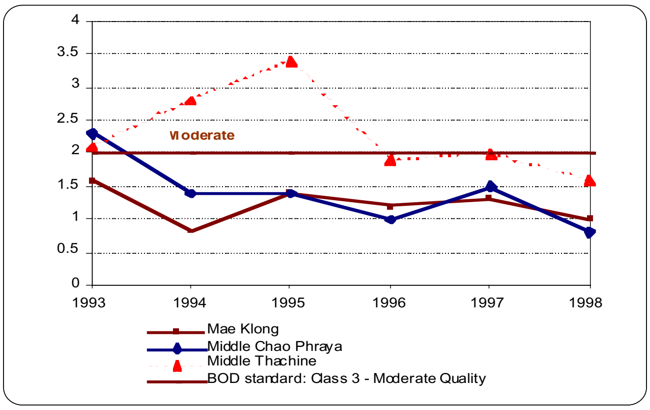
BOD	# firms	%	TSS	# firms	%
Pulp & paper	55	37	Iron & steel	396	61
Industrial chemicals	211	11	Nonferrous metals	575	9
Nonferrous metals	575	9	Pulp & paper	55	9
Dairy products	36	9	Jewelry	536	8
Distilled spirits	12	8	Drugs & medicines	253	4
Total number of firms in the Central region: 45,928					

Source: Development Research Group, World Bank, 2001

Surface Water Indicators

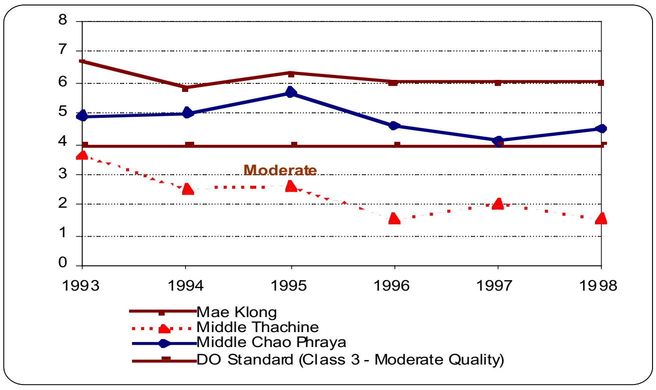
The PCD monitored the quality of three major rivers - the Mae Klong, the middle Chao Phraya and the middle Tha Chin, in terms of three indicators - BOD, DO and TCB. Throughout this period, the middle Tha Chin had the poorest levels of DO, which worsened over the years, while the Mae Klong had the most elevated levels. Similarly, the middle Tha Chin consistently had the worst BOD concentrations throughout this period. However, the study also revealed that BOD levels improved in all three rivers from 1996 to 1998. Overall, TCB remained unchanged during the last three years, with the exception of the Mae Klong. Between 1996 and 1997, the TCB levels in this river peaked, and then dropped back to low levels in 1998.

BOD Levels in the Central region, 1993-98



Source: PCD, 2000

DO Levels in the Central region, 1993-98



Source: PCD, 2000

Groundwater

Nearly 13,000 wells supply over 2.5 million cubic meters of water for variety of uses in BMA and 7 adjoining provinces. Commercial and industrial sector and households account for 65% and 25% of that use.[21] Though government institutions own 32% of the wells, they use a mere 7% of the total groundwater extraction. Reports indicate that extraction is exceeding safe yields, causing land subsidence particularly in the eastern and southern suburban areas of Bangkok. Groundwater quality in this region is also progressively worsening due to the buildup of nitrates from agricultural runoff, toxics from pesticides, and saltwater intrusion.

Groundwater Extraction in BMA plus 7 provinces, 2000

	Wells	%	Extr. M^3/d	%
Household	3246	25	580669	24
Bus/Industry	5204	40	1598398	65
Agriculture	131	1	5869	0
SoE	146	1	122154	5
Govt	4186	32	160570	7
Total	12913		2467660	

Source: DMR, 2001

[21] Department of Mineral Resources, March 2001

eastern RegioN

The Eastern region comprises of four larger water basins and the following river basins —Rayong, Prasae, Pangrat, Chantaburi, Weru, and Trad, located along the coastal areas; the Bang Pakong river basin, located further inland; and the upstream part of the Tonle Sap basin.

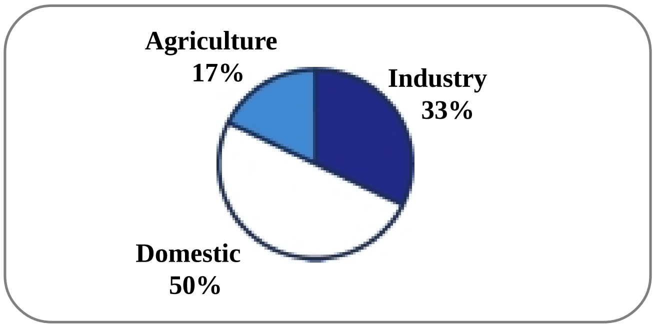
Eight provinces fall under this region, of which the two largest in terms of size are Chonburi and Chanthaburi. Tourism and industry (pulp and paper, pottery, porcelain, food, petrochemicals and agroprocessing) drive economic development in the region, with agriculture and mining contributing significantly.

Water Quality Profile. Regional water quality is broadly classified as poor due to the heavy concentration of industry in the major centers of Chonburi, Prachinburi and Rayong. Dense populations in these areas further contribute to overall generation. Domestic wastewater discharges contribute to 50 percent of the total BOD generated, while industry and agriculture account for 33 and 17 percent respectively.

At the water basin level, the relative contributions from agriculture, industry and domestic sources varies quite substantially. In the East Coast-Gulf basin, for example, industry contributes as much as 46 percent to the total BOD generated in the basin, whereas in Tonle Sap it is less than 1 percent. In the Bang Pakong basin, agriculture runoff accounts for 32 percent of the basins' BOD, whereas in Prachinburi it represents only 6 percent. BOD generated from domestic wastewater is more consistent across the Eastern basins where it represents approximately 50 percent of each basin's total load.

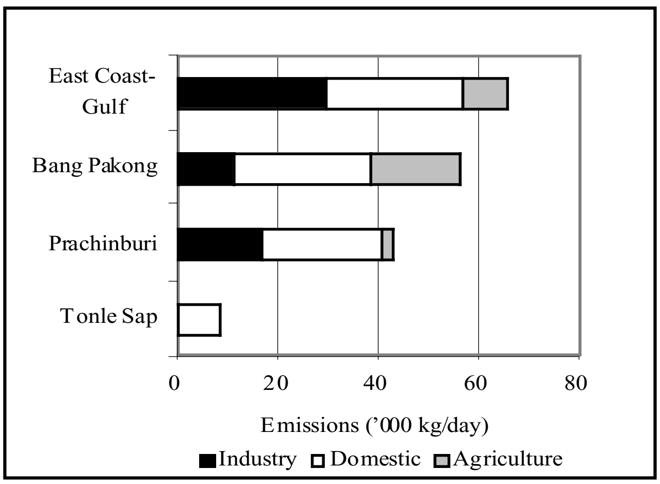
The Eastern region, with over 5,000 firms, has a highly diversified manufacturing structure, however, in terms of BOD and TSS, it is the chemicals, pulp & paper and iron & steel sub-sectors that comprise the bulk of industrial effluent generation. The chemicals and pulp & paper sectors are responsible for 69 percent of BOD, while the iron & steel industry alone contributes to 72 percent of total TSS.

Sector contribution to total BOD generation, 1999



Source: Development Research Group, World Bank, 2001

Contribution of industry, domestic and agriculture to Central region basin BOD, 1999.



Source: Development Research Group, World Bank, 2001

Surface Water Indicators

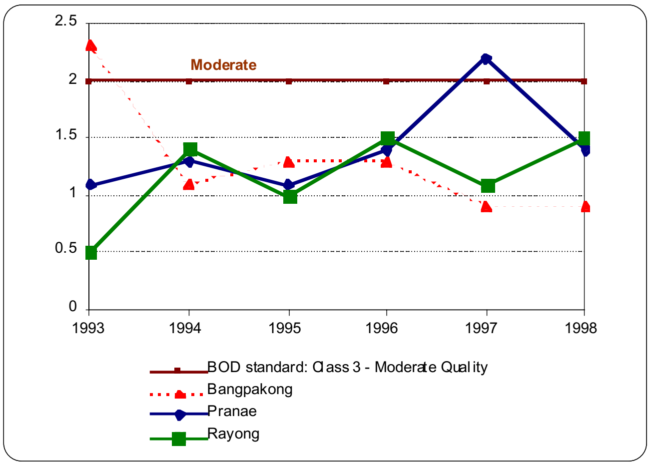
A 1998 survey of eight rivers and lakes revealed that, on average, the Eastern region was the second most polluted in Thailand in terms of TCB count. The worst counts were recorded in the Rayong Basin (2,000 MPN/100ml), followed by the Trad basin (900 MPN/100ml), and the Pranae River.

In the Eastern Region, water samples taken by PCD from the Bang Pakong, Pranae and Rayong rivers, showed improvements in levels of pollution from TCB between 1996 and 1998. Between 1993 and 1998, dissolved oxygen in the Rayong river declined slightly, while DO in the Pranae and Bang Pakong improved marginally. In terms of BOD levels, the Rayong river remained unchanged, while the Bang Pakong showed improvements in water quality.

Coastal Waters. Petrochemical and other industries proliferating along the Eastern Seaboard represent a growing threat to the coral reefs and seagrass in the coastal area. Rapidly expanding hotels in coastal areas, accompanied by ineffective wastewater treatment systems has degraded the water quality in important tourist sites such as Chonburi Bay, Loy Island, Pattaya Beach, and Bangsaen.

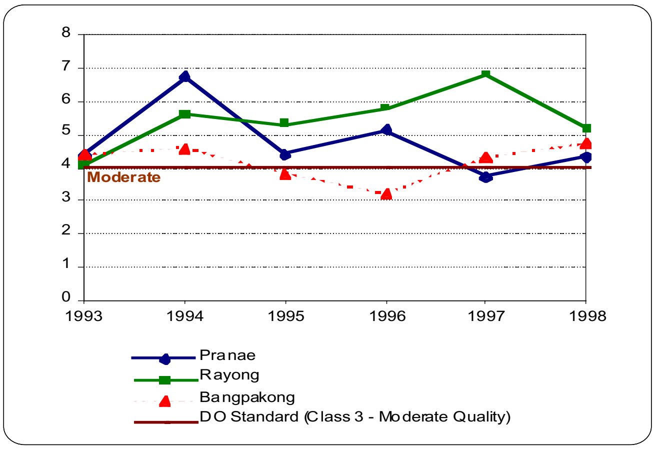
Groundwater. Little information is available about current groundwater quality. But trends are expected to be the same as in the Central Region. Saltwater intrusion, caused in part by intensive pumping of water from the aquifers, contributes greatly to pollution.

BOD Levels in the Eastern region, 1993-98



Source: PCD, 2000

DO Levels in the Eastern region, 1993-98



Source: PCD, 2000

Industrial sector contribution to BOD and TSS loads, Eastern region, 1999

BOD	# firms	%	TSS#	firms	%
Industrial chemicals	85	41	Iron & steel	55	72
Pulp & paper	14	28	Pulp & paper	14	7
Nonferrous metals	58	7	Nonferrous metals	58	7
Sugar factories	28	6	Athletic goods	25	6
Distilled spirits	3	6	Industrial chemicals	85	5
Total number of firms in the Eastern region: 5,374					

Source: Development Research Group, World Bank, 2001

The Northern region comprises the following water basins: Ping, Wang, Yom and Nan basins that conform the Upper Chao Phraya and the Upper Pasak River basin; the Pai and the Khun-Yuam river basins which form a part of the Salawin basin, which Thailand shares with Myanmar; and the Kok and Ing water basins that constitute part of the Mekong basin.

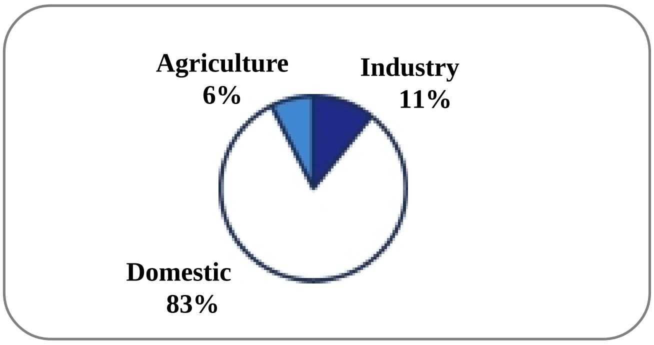
This region accounts for one-third of the country's land area and about 21 percent of the population. There are significant variations in income across areas within the region, with large pockets of poverty among upland hill tribes. Agriculture, dominated by crop production, plays an important role in the region. Despite a low population density, agricultural activities are concentrated in small-montane basins and narrow river plains.

Water Quality Profile. Water quality in this region is fair owing to the poor conditions for agriculture and the relatively low presence of industry. Agriculture and industry together account for 17 percent of total BOD generation while domestic wastewater discharges account for about 83 percent.

The water basins of the Nan, Ping, Yom, and Wang together account for about 77 percent of organic pollution in the Northern region. With the exceptions of the Nan and the Ping, BOD generation from agricultural runoff is low, typically amounting to only one or two percent of each basins' total. Similarly, although the region is home to over 7,600 manufacturing firms, the industrial sector contributes only marginally in the Nan, Ping and Yom water basins with 14, 12, and 9 percent of BOD respectively. In all eight basins, however, domestic sources account for the major portion (over 80 percent on average) of BOD generated.

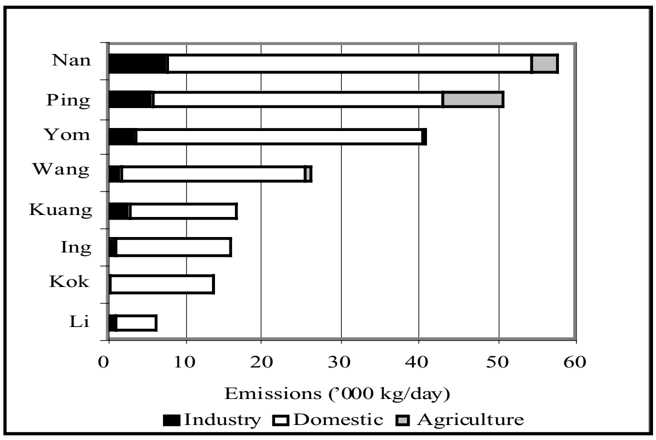
Across industrial sub-sectors, pulp & paper is responsible for 37 percent of BOD and 31 percent of TSS. Sugar and spirits total 42 percent of BOD generation, while nonferrous metals and jewelry account for 33 percent of TSS. From a regulatory

Sector contribution to total BOD generation, 1999



Source: Development Research Group, World Bank, 2001

Contribution of industry, domestic and agriculture to Northern region basin BOD, 1999.



Source: Development Research Group, World Bank, 2001

standpoint, there is much to gain from the relatively small number of firms and composition of industry.

Ninety-one percent of BOD is generated from only five sub-sectors and 228 firms, or only 3 percent of all firms in the region. Similarly for TSS, 81 percent is generated from only 105 firms.

Surface Water Indicators

Between 1995 and 1998, the TCB count in the northern region averaged approximately 825 MPN/100ml, especially in the Ping and Wang rivers. This, however, was still lower than the national average. The Bung Borapeth and the Kwan Payao are among the cleanest rivers, with very low concentrations of TCB (averaging 35 MPN/100ml).

Water samples taken by the PCD from the Ping, Wang, and Yom rivers between 1996 and 1998 showed dramatic improvements in total coliform bacteria concentrations. BOD and DO levels were also within the water quality standards, making the rivers suitable and safe for fisheries and domestic uses. Throughout this period, the Ping was the cleanest river in terms of BOD.

Groundwater

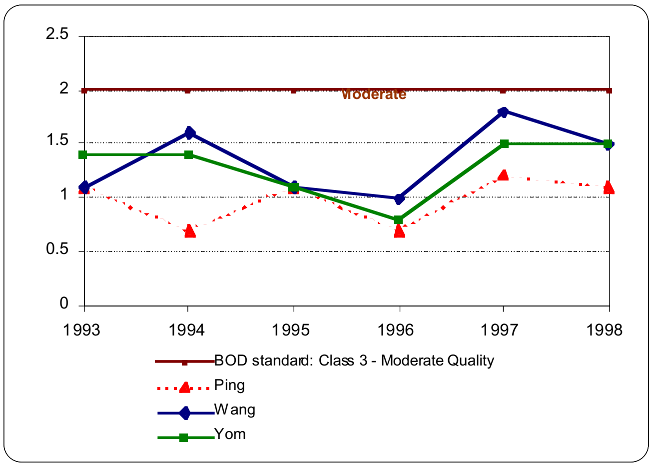
Large amounts of groundwater are found in the North in Chiang Mai and Lampang provinces. There is some evidence of nitrate and fluoride contamination from fertilizers as well as naturally occurring hot springs in the Chiang Mai province.

Industrial sector contribution to BOD and TSS loads, Northern region, 1999

BOD	# firms	%	TSS	# firms	%
Pulp & paper	27	37	Pulp & paper	27	31
Sugar factories	22	22	Nonferrous metals	22	17
Distilled spirits	6	20	Jewelry	42	16
Preserved fruits & vegetables	161	7	Distilled spirits	6	9
Dairy products	12	5	Iron & steel	8	8
Total number of firms in the Northern region: 7,633					

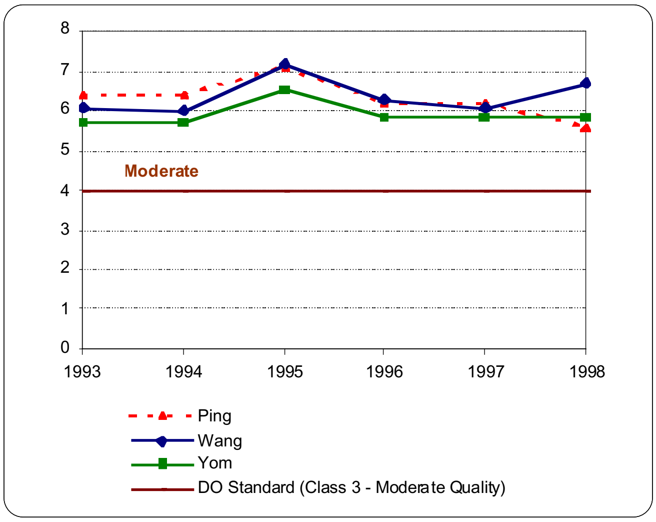
Source: Development Research Group, World Bank, 2001

BOD Levels in the Northern region, 1993-98



Source: PCD, 2000

DO Levels in the Northern region, 1993-98



Source: PCD, 2000

northeastern RegioN

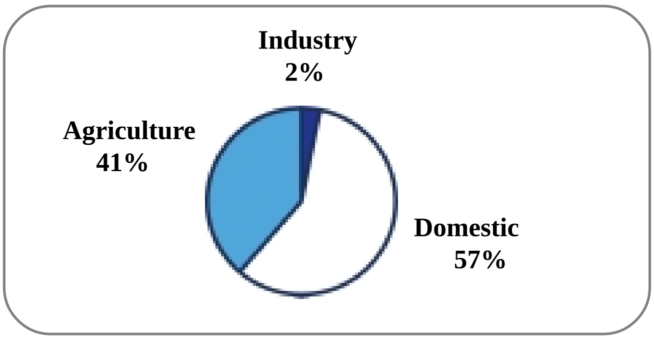
The Northeastern region is mainly dry. A range of hills constitute a number of small watersheds draining into the Chi, Moon and Mekong rivers. The Mekong basin bounds the northern part of the region as well as the plateau in the northeast. The river basins are underlain with impermeable layers of latterite causing intense surface run-off in the rainy season, and short droughts in the dry season.

Covering one-third of the country's land area and 44 percent of the rural population, the Northeast is the most populous and poorest region. The combination of low agricultural productivity and low incomes has spurred massive forest encroachment (for marginal land conversion to agriculture) as well as large scale migration to other regions for employment. While the Northeast accounts for about 40 percent of total agricultural land in Thailand, it contributes less than one-quarter of total agricultural output, reflecting poor soils, erratic rainfall, and seasonal drought and flooding.

Water Quality Profile. The 1998 PCD water quality survey ranked the Northeastern region as having cleanest surface water, despite being the most populous and agrarian region in Thailand. The region is largely characterized by marginal agriculture, which as a sector accounts for 41 percent of total BOD generation. With over one-third of the country's population, domestic sources of wastewater account for 57 percent of the total BOD load. The industrial sector maintains a relatively low presence and is responsible for only 2 percent.

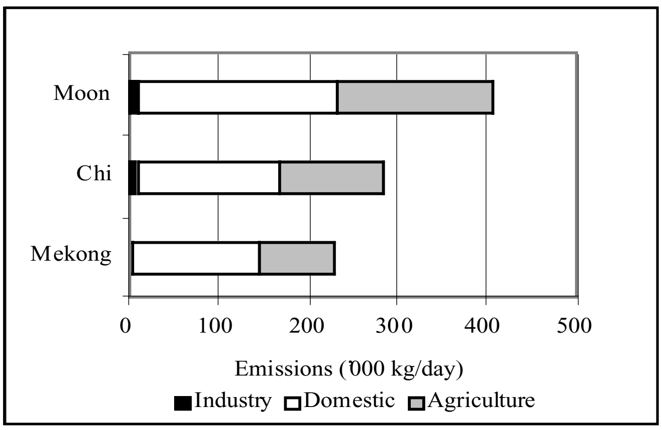
At the water basin level, agricultural activities are responsible for about 40 percent of each basins' organic pollution. Domestic wastewater effluents average 58 percent of the total generated load in each basin and is greatest in the Moon basin. The Moon basin was identified as the largest in terms of absolute BOD generation with over 405,000 kg/day. The manufacturing sector is quite large, with over 7,000 firms and employing over 176,000 people in the region. However, its relative contribution to BOD generation is small with only one to three percent share of each basins' load.

Sector contribution to total BOD generation, 1999



Source: Development Research Group, World Bank, 2001

Contribution of industry, domestic and agriculture to Northeastern region basin BOD, 1999



Source: Development Research Group, World Bank, 2001

Looking closer at the industrial sector, food products such as sugar, dairy, and spirits comprise the top shares of BOD generation, while iron & steel accounts for 70 percent of TSS. As in the Northern region, the relatively small number of firms in each sub-group indicates that there are potential gains in regulation.

Surface Water Indicators

Between 1993 and 1998, water samples taken by the PCD from the Moon, Siew, and Songkram rivers showed improvements in water quality in terms of both TCB, and DO levels. DO levels improved in all three rivers, indicating increases in levels of oxygen which would benefit aquatic life. Although BOD levels improved in the Moon river, BOD loads increased in both the Siew and Songkram rivers, resulting in higher organic pollution.

While rivers have shown good water quality, on average, there have been some severe cases of water pollution in lakes around the region. Rapid eutrophication is resulting in the proliferation of algal species that poses a threat to humans and biota, and hinders water treatment processes. Cases of eutrophication have been reported in the Mae Guang dam, and the Mae Ngad dam reservoirs. In 1995, increased inflow of wastewater from households, restaurants, and agricultural runoff resulted in algal proliferation in the Lake of Lam Ta Khong dam - disrupting Korat's water supply.

Groundwater

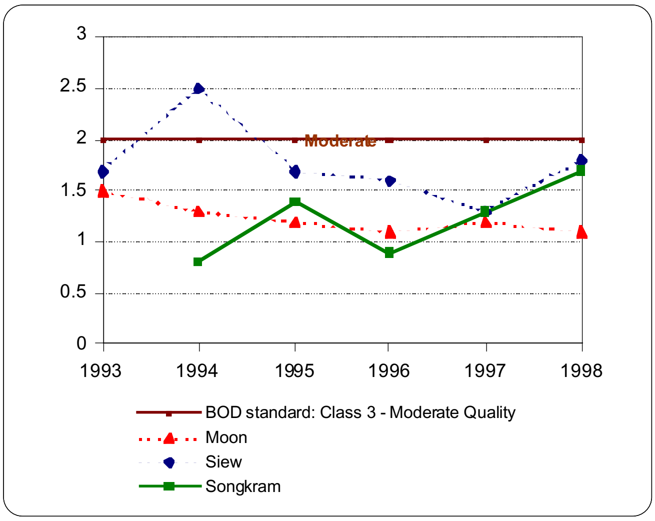
Groundwater is mainly found along the Mekong river, particularly in the Nong Khai and Nakhon Phanom provinces. The little information available on groundwater quality indicated some contamination from fertilizers, as well as from naturally occurring salt, iron, sulfate, and calcium carbonate.

Industrial sector contribution to BOD and TSS loads, Northeastern region, 1999

BOD	# firms	%	TSS	# firms	%
Sugar factories	25	41	Iron & steel	13	70
Dairy products	26	22	Sugar factories	25	9
Distilled spirits	5	20	Distilled spirits	5	6
Plastics	104	5	Jewelry	7	5
Industrial chemicals	5	4	Nonferrous metals	15	5
Total number of firms in the Northeastern region: 7,151					

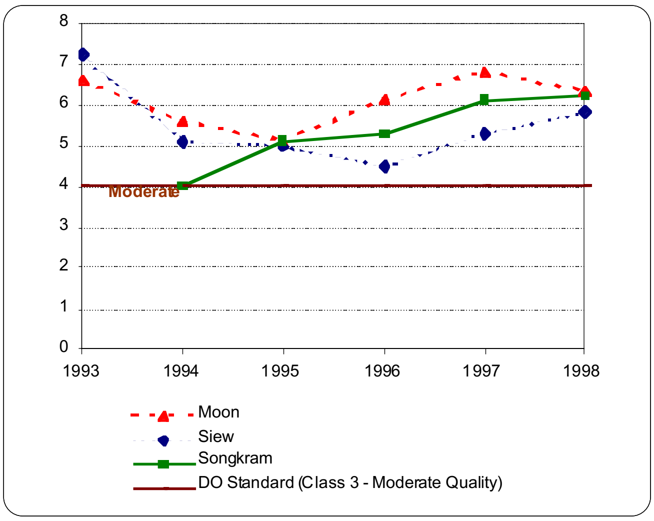
Source: Development Research Group, World Bank, 2001

BOD Levels in the Northeastern region, 1993-98



Source: PCD, 2000

DO Levels in the Northeastern region, 1993-98



Source: PCD, 2000

southern RegioN

The Southern region, which receives heavy rainfall, has the highest water resource availability among all regions. The upper Southern region consists of the Petchaburi and the West Coast Gulf river basins. The lower Southern region can be divided into the East Coast and West Coast river basins, with higher annual run-off from the East coast. The lower Southern region comprises the Peninsular-East Coast, Tapipum, Thale Sap Songkhla and Pattani river basins on the East coast; the Peninsular-West coast river basin; and the Kolok River marking the Southern border with Malaysia.

The Southern region, with about 14 percent of the land area and population, has a well developed economy. Along with the lucrative tourism industry, fishing and agriculture contribute significantly to gross regional product (including large shares from rubber production), reflecting good moisture and humidity in the tropical climate. Mining, aquaculture and natural gas development have also been growing rapidly in the region.

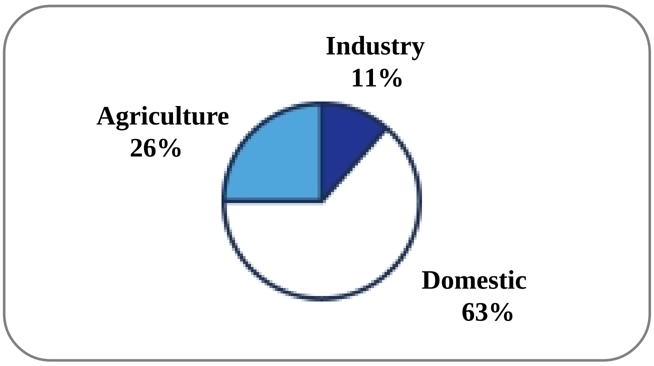
Water Quality Profile

The quality of surface and coastal waters in the Southern region is poor. Domestic wastewater discharges, primarily from the tourism industry, are responsible for nearly two-thirds of total BOD generation, while agriculture accounts for 26 percent and industry for the remaining 11 percent.

Across the 11 major water basins, the Songkhla, Tapipum and Pakphana basins account for 58 percent of total regional BOD generation. Among these top three, agriculture averages 35 percent of each basins' total BOD, while domestic wastewater averages 55 percent. The presence of industry is largest in Songkhla and Tapipum, where the fishing industry is an important source of local income.

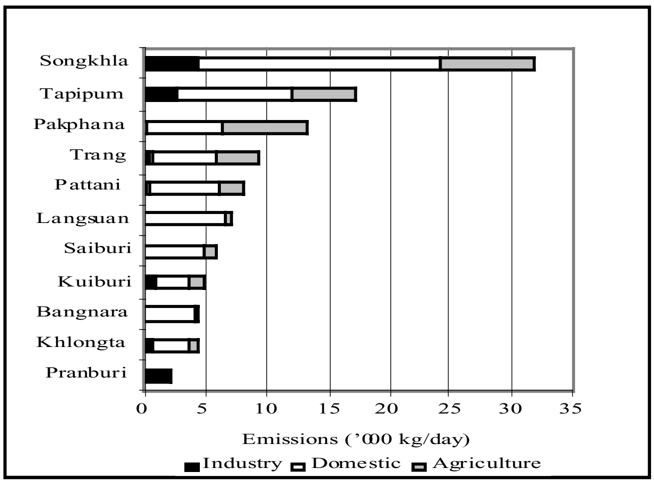
Important industrial activities in the South include food products and rubber production, which employ 50,000 and 29,000 people, respectively. These major economic sectors also have their consequent impact on the environment. In terms of BOD and TSS generation, ninety-three firms in the

Sector contribution to total BOD generation, 1999



Source: Development Research Group, World Bank, 2001

Contribution of industry, domestic and agriculture to Southern region basin BOD, 1999



Source: Development Research Group, World Bank, 2001

fish industry alone account for 43 percent of BOD generation, and 16 percent of TSS. Rubber production accounts for 33 percent of TSS, while the iron & steel industry contributes 25 percent.

Surface Water Indicators

Water quality indicators for the Chumporn river between 1993 and 1998 showed relatively unchanged BOD levels. BOD improved in the Songkhla Lake over this time frame, and worsened slightly in the Langsuan River. Dissolved oxygen levels improved in all three rivers during this period. In general, DO levels are high and suitable for conservation and fisheries.

High TCB counts are found in the Noi Sea and the Songkhla Lake, where pollution is possibly exacerbated by the restricted exchange of water between the lagoon and the open sea.

Coastal Waters

In contrast, along the Andaman coast, water quality ranges from fair to very good, particularly in Ranong, Phang-Nga, Krabi and Phuket provinces where low TCB concentrations were recorded.

Groundwater

The largest source of groundwater is found along the east coast, adjacent to the Gulf of Thailand. A study of groundwater in Hat Yai, southern Thailand, revealed that seepage of urban wastewaters adversely affected the quality of the shallow groundwater directly beneath the city. Further infiltration is also gradually contaminating the deeper aquifers - the source of the city's potable water.[22]

Groundwater is also found to be contaminated by iron and trace metals from mining, as well as arsenic, around Nakhon Si Thammarat. In addition, the wells are also thought to be contaminated by naturally occurring arsenic from the soil as a result of intensive pumping of water.

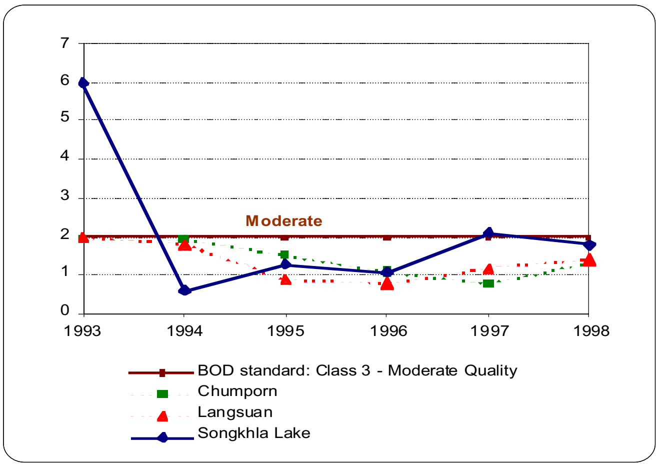
[22] A.R. Lawrence, D.C. Gooddy, P. Kanatharana, W. Meesilp and V. Ramnarong. *Groundwater evolution beneath Hat Yai, a rapidly developing city in Thailand*. Springer-Verlag, 2000

Industrial sector contribution to BOD and TSS loads, Southern region, 1999

BOD	# firms	%	TSS	# firms	%
Fish products	93	43	Rubber products	241	33
Distilled spirits	2	17	Iron & steel	7	25
Preserved fruits & vegetables	35	16	Fish products	93	16
Dairy products	6	9	Distilled spirits	2	6
Sawmills	500	4	Preserved fruits & vegetables	35	6
Total number of firms in the Southern region: 4,138					

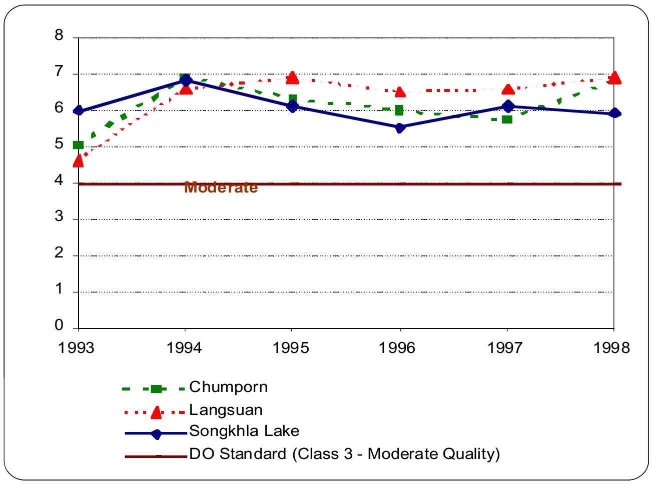
Source: Development Research Group, World Bank, 2001

BOD Levels in the Southern region, 1993-98



Source: PCD, 2000

DO Levels in the Southern region, 1993-98



Source: PCD, 2000

Five-Year Plans

Since 1961, the Royal Thai Government (RTG) has developed five-year National Economic and Social Development plans that establish the overall priorities and policy framework for the country's development. While early plans emphasized economic development through the exploitation of natural resources, the 7th Plan (1992-1996) declared the government's commitment to promoting sustainable economic development that protects the environment. One key objective of the 7th plan was to rehabilitate water quality in the lower reaches of the Chao Phraya and Tha Chin rivers.

The ongoing 8th Plan (1997-2001) continues to emphasize the rehabilitation of natural resources and the environment by strengthening environmental management, and increasing local and community participation. Key principles emphasize good governance through decentralization, public participation in decision-making, increased transparency and accountability, and empowerment of communities. The forthcoming 9th Plan (2002-2006) builds on these foundations.

Twenty-Year Perspective Plan

Developed by OEPP and approved by the Cabinet, the 20 year Policy and Prospective Plan for Enhancement and Conservation of National Environmental Quality (1997-2016) establishes goals, principles, and policies, including sectoral policies and guidelines for environmental quality management. The Prospective Plan also recognizes the role of local government authorities (LGAs) and NGOs in improving and protecting water quality by increasing awareness and monitoring.

Under this plan, policies for water pollution aim to:

- Accelerate the rehabilitation of water quality in important water resources;
- Reduce and control water pollution originating from community activities, agriculture, and industry;
- Apply the polluter pays principle; and
- Promote and support private sector investment in solving water pollution problems.

Legislation

Water pollution control is administered under various laws. Many of the water pollution laws were originally enacted to primarily regulate the use and management of, rather than protection of natural resources and the environment.[23]

In 1992, the Enhancement and Conservation of National Environment Quality Act (NEQA) was enacted. In the same year, a number of environmental laws -including the Factory Act, Public Health Act, Hazardous Substances Act, and the Energy Conservation Promotion Act were amended. In addition, the Decentralization Act of 1999 entitles LGAs to develop local plans to manage and conserve natural resources and the environment as well as gives them the legal authority to construct and operate central treatment facilities for solid waste, and wastewater.

Institutions

The Thai regulatory system for water resources management and pollution control is both centralized and fragmented. Thirty agencies within six Ministries share authority depending on jurisdiction.[24] Each Ministry administers its own laws and

[23] Senate Environmental Committee Report, p. 14, 2000

[24] The six Ministries are: Ministry of Science, Technology and Environment, Ministry of Transport, Ministry of Interior, Ministry of Industry, Ministry of Public Health, and Ministry of Agriculture and Cooperatives.

Water Pollution Legislation and Responsible Ministries

Legislation	Regulated Activities	Responsible Ministries	Remarks
Enhancement and Conservation of National Environment Quality Act (NEQA) of 1992	Regulates specified point sources for wastewater discharges into public water resources, or the environment, based on effluent standards	MoSTE	Amendment to NEQA is being drafted; key environmental legislation to fill gaps; no criminal or civil liability for violation of standards
Factories Act of 1992	Limits level of effluent discharged and restricts concentration levels of chemical and/or metal pollutants	MoInd	MoInd also promotes industrial devel opment activities which creates conflicts of interest. An amendment to the Act is being drafted to require polluters to pay for clean-up costs.
Navigation in Thai Waterways Act (Volume 14) as amended in 1992	Prohibits dumping of any refuse including oil and chemicals into rivers, canals, swamps, reservoirs, lakes or waterways that may pollute the environment or disrupt navigation in Thai waterways	MoTC	Many cases have been successfully brought against polluters
Public Health Act of 1992	Regulates nuisance activities related to water pollution such as odor, chemical fumes, wastewater discharge system of buildings, factories or animal feedlots that cause harmful health effects	MoP	Decentralized implementation to LGAs
Cleanliness and Tidiness of the Country Act of 1992	Prohibits dumping of refuse in waterways	LAOs	Decentralized implementation to LGAs
Canal Maintenance Act of 1983	Prohibits dumping or discharging of wastewater in canals	MoAC	Little used
Building Control Act of 1979	Regulates discharges of water pollution from buildings	MoInt	Decentralized implementation to LGAs
Penal Code of 1956	Prohibits adding harmful substances in water resources reserved for consumption	OAG	Little used
Fisheries Act of 1947	Prohibits dumping or discharging of hazardous chemicals into water resources reserved for fishing	MoAC	Difficult to prove intention for criminal liability
Royal Irrigation Act of 1942	Prohibits dumping of garbage or discharging polluted water or chemicals into irrigation canals	MoAC	Limited jurisdiction

regulations. While MoSTE develops national policies, plans, standards, and regulations for water pollution control, implementation authority often rests with other ministries.

Based on the Decentralization Act, LGAs, provincial administrative organizations, municipalities, tambon (village) administrative organizations, and BMA also play major roles in wastewater treatment and water pollution control through wastewater treatment facilities. Under the NEQA, the PCD has an oversight function to ensure efficient and effective results on the ground.

The Office of the National Water Resources Committee, established in 1996, coordinates water resources management. This Office oversees the drafting of the new Water Law that calls for the establishment of river basin organizations. In 1997, the Government also established the Chao Phraya River Basin Organization to implement the comprehensive Chao Phraya Basin Water Management Strategy.

Enforcement

Enforcement of existing environmental laws is weak due to the lack of political will, inadequate coordination among various agencies, low technical capability for proving violations, and limited access to information. To initiate regulatory reforms and improve firms' compliance with environmental standards, existing command-and-control measures are being complemented by market based instruments and public disclosure tools.

The Thai Administrative Court -recently established under a 1997 Constitutional requirement -provides an opportunity for citizens and civil society to participate in enforcement. Citizen suits can be brought against agencies which fail to perform their non-discretionary duties under the law. The Court is now receiving over fifteen new cases per day, many of which related to the environment. Despite such provisions, access to courts by citizens seeking pollution damage claims remains limited by the traditional standing doctrines of causation, burden of proof, access to information, and litigation costs.

Public Disclosure

Under public disclosure programs, the environmental performance of firms are publicly announced, and subsequent public pressure often results in pollution reduction activities. PCD is currently developing a public disclosure program to improve the environmental performance of industrial polluters.

Economic Instruments

These instruments are intended to provide incentives that will result in a changed behavior of water users and polluters. DIW, OEPP and PCD have undertaken separate studies to design and implement pollution charges program to contain water pollution from industrial enterprises. The challenge before decision makers is to integrate the findings of these studies and develop a coherent program that reduces the cost of compliance and provides incentives for polluters. Application of economic instruments for the abstraction of ground and surface water and appropriate pricing will also spur conservation efforts.

Environmental Law at Work:
The Nam Phong River Cases

The 1992 Case: Establishing Standing to Sue

In 1992, prior to the enactment of NEQA, the Office of the Attorney General (OAG) made a legal determination that clean up costs incurred by the government for a molasses spill on the Phong River could not be recovered, since no one could claim ownership of the river which is public property. Since there were no damages to agencies or citizens, there was no standing to sue.

In 1997, however, the OAG reversed its decision citing that natural resources are the common heritage of mankind. Arguing that NEQA supports public participation and decentralization in environmental protection, OAG recommended that agencies or citizens that have been injured have standing to sue for clean up costs or damages.

The 1993 Case: Recovering Government Clean-Up Costs

In 1993, the Nam Phong River suffered from a series of major wastewater discharge events from a pulp and paper factory located below the Ubonrat Dam. Contamination led to significant fish kills and impacted the livelihood of fishing communities along the river. In an effort to restore acceptable water quality, the Electricity Generating Authority of Thailand released 1.9 million cubic meters of water, which were worth about US$6,735 in electricity production.

In 1999, for the first time since the enactment of NEQA and based on NEQA provisions for the Polluter Pays Principle, EGAT brought a lawsuit against the pulp and paper company to recover costs associated with clean up through lost electricity production. The case is currently pending in the Thai Civil Court.

Source: Office of the Attorney General

Physical Investments in Waste Water

Over the past 15 years, Thailand has embarked on an ambitious program for the management of water pollution generated from urban municipal sources.

Construction of WWTSs in Thailand

Prior to 1990, there was virtually no treatment of municipal wastewater in Thailand. By the end of 1995, 25 WWTS - 2 in the Northern region; 7 in the Northeastern region; 9 in the Central region; 5 in the Eastern region; and 2 in the Southern region - had been constructed with a combined treatment capacity of about 430,000 m^3/day. In spite of such progress, the available total capacity was sufficient to provide service to just over 10 percent of the urban population in 1995.[25]

For the period 1995-1999, the RTG budgeted about $950 million for capital investments in the wastewater sector, for 40 additional facilities to be constructed and/or expanded. However, following a 38 percent reduction in capital investments due to the 1997 economic crisis, the implementation schedule suffered significant delays and in some cases investments were cancelled.

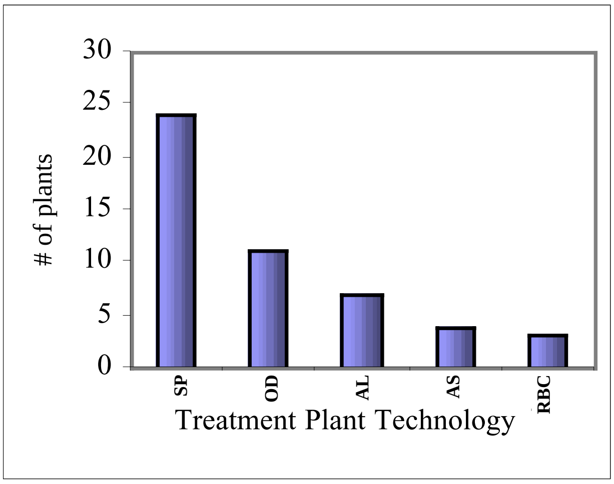
To date, 57 wastewater treatment plants, have been constructed in 50 municipalities at a total cost of almost 19 billion baht.[26] About 75% of the treatment capacity provided by these systems has entered service only over the past four years. Another 28 facilities are presently under construction or undergoing expansion.[27] Although the serviced population is much lower due to problems with operation and collection, it is estimated that there is enough wastewater treatment capacity to cover 29% of municipal population and after the completion of those facilities that are under construction or undergoing expansion this will increase to 65%.[28]

Municipal WWTS Capacity in Thailand

Region	Existing Treatment Plants		Existing Plants + Those under construction	
	Capacity (m^3/day)	% of Municipal Population Covered by Capacity	Total Capacity (m^3/day)	% of Municipal Population Covered by Capacity
North	83,600	22	139,500	37
Northeast	106,650	19	170,710	31
Central	164,350	23	399,850	57
South	102,950	35	233,650	51
East	214,400	85	326,300	85
BMA	270,000	27	992,000	98
Total	**941,950**	**29**	**2,262,010**	**65**

Source: OEPP, 2001; Plant data from PCD August 2000; Population statistics from NSO, 2000.
Note : Capacity in excess of the needs of the municipal population for certain tourist provinces in the East, South and Central regions is not included as this capacity is designed to cover the tourist population.

Types of Technologies in Existing WWTS



Source: PCD, August 2000
SP: Stabilization Pond; OD: Oxidation Ditch; AL: Aerated Lagoon; RBC: Rotating Biological Contactor

Treatment Technologies: Technology choices for WWTS in Thailand took into account the limitations in funding for capital and operational costs, the lack of operational experience, and limited staff. The treatment plants primarily consist of proven and relatively simple technologies, such as oxidation ditches, aerated lagoons and stabilization ponds. These systems have low capital and O&M costs. The activated sludge process is more complex and costly to build and operate, but requires less land.

[25] OEPP, 2001; PCD, August 2000.
[26] PCD, March 2001.
[27] PCD, March 2001.
[28] World Bank Task Team estimates.

This technology is used in some urban areas of the central region or the BMA where land costs or availability limit the application of other technologies.

Condition and Operation of Facilities.

Thailand has been only moderately successful in operating wastewater treatment plants. About a third of the existing plants have major malfunctions or do not operate.[29] The major reason for this is the inadequacy of funds to cover O&M costs. This shortfall in terms of O&M budgets was also revealed in a 1999 survey of 29 facilities, that showed that most facilities suffer from equipment failure or damage, and deficiencies in staff skill levels.[30]

The effectiveness of wastewater systems is also limited by the condition of the collection systems. Typically, wastewater collection systems in Thailand rely on old drainage systems comprised of canals or open sewers and poorly maintained drainage pipe networks with limited connections. Investments have primarily focused on intercepting the flow from these systems with little focus on rehabilitation of the drainage networks. As a result, the collection efficiency of these systems is low. Performance data on 19 plants has shown that these collection systems can, on average, collect only 55% of the wastewater that treatment plants are designed to treat.[31] In addition to making almost half the capacity of these plants redundant, inadequate collection has, in many cases interfered with proper treatment plant operation.[32]

[29] Survey of REOs, April 2001.
[30] PCD, 1999.
[31] Based on performance data from 19 operating plants in Thailand.
[32] Survey of REOs, April 2001.

Key Issues in Wastewater Management

Insufficient Funding. While there has been significant progress over the past decade in constructing new facilities, there remains a large backlog in unmet investment needs. With the large investments necessary, the sector would greatly benefit from additional sources of financing that rely on direct cost recovery, including debt over the shorter term and private sector equity investment over the longer term.

Sustainability of Services. In addition to inadequate collection systems and poor plant design, serious deficiencies also exist in the funding of operations and maintenance. This affects the quality and sustainability of services. This is due primarily to reliance on public sector operations and maintenance; lack of cost recovery options; and inadequate enforcement of existing environmental regulations.

Technical Skill Shortages. Technical skill shortages are a major factor responsible for poor performance in operations and maintenance. The lack of private sector participation and better job incentives in the private sector exacerbate this shortage.

Lack of Cost Recovery. User charges are implemented in only a few municipalities in the country. The adoption of user charges by municipalities has been slow primarily due to the lack of political will and public acceptance. The lack of cost recovery is a major obstacle to private sector participation, which could play a major role in addressing the existing funding and skills shortages in the sector.

Inadequate Enforcement. There is presently no regular program for the monitoring discharges from existing municipal wastewater facilities, or penalizing municipalities with inadequate or no treatment facilities. With environmental awareness within Thailand still low, active enforcement tends to be the primary catalyst in driving environmental improvement programs.

Piloting Innovative Treatment Technologies for the Thai Context

Treatment technologies using natural processes such as constructed wetlands provide an attractive alternative to conventional technologies. They have low O&M costs, provide effective treatment, and often remove heavy metals better. They also can be used to enhance the natural habitats or to grow plants that can be harvested and used for other purposes.

In Petchaburi province, the Laem Phak Bia Environmental Research and Development Project is an ambitious Royal Initiative involving 3 universities and 6 national government entities. The project treats a portion of the waste from the city of Petchaburi using plants —such as wetland grasses, mangroves and rice —that have productive or ecologically value. The project systematically assesses the suitability of the major Thai plant species and the identifies optimal operating conditions for wastewater treatment. In addition, the project increases public awareness and education through publications and tours, and provides assistance to municipalities planning on constructing wastewater treatment facilities.

Source: Laem Phak Bia Environmental Research and Development project.

Costs of Organic Pollution Control :
A Case Study of the Food and Beverage, and Textile Sectors

The food and beverage and textile sectors play a major role in the economy, representing 20 and 23 percent of total industrial production. Together they also contribute to approximately 37 percent of Thailand's industrial BOD load. The total costs of reducing this pollution, however, are largely unknown. Using information from a recent case study[33] of in-plant treatment costs[34] for these two sectors in Samut Prakarn, it is estimated that full treatment ($BOD_5 \leq$ 20 mg/l) of organic effluents in Thailand would total approximately 229 billion baht ($US 5.4 billion) with annual O&M costs of 26 billion baht ($US 0.6 billion) for food & beverage and textile sectors.[35]

At a regional level, these costs vary depending on the location and scale of the two sectors. For the food processing sector, the largest concentration occurs in the Central and Northeastern regions, where together they constitute nearly 56 percent of the total investment cost. In the textiles sector, the Central region along with the BMR comprises 91 percent of total investment cost requirements.

The level of treatment also has different impacts in each sector. In the food processing sector, moving from a pre-treatment level 2 to a level 1 standard would result in a 60 percent reduction in BOD concentrations for a 25 percent increase in cost (58 to 72.6 billion baht). The same 60 percent reduction in the textiles sector would imply an 82 percent increase in investment costs. Overall costs would be significantly reduced if there were centralized treatment of wastewater and rigorous application of cleaner production techniques.

Estimated per plant investment costs of local BOD treatment for the food processing and textile industries (million baht)

Sector/ Scale	*Capacity (m^3/d)*	*Full treatment ($BOD_5 \leq 20$ mg/l)*	*Pre-treatment Level 1 ($BOD_5 \leq 400$ mg/l)*	*Pre-treatment Level 2 ($BOD_5 \leq 1000$ mg/l)*
Food/Beverage				
Large Scale	1000	37.4	21.6	17.2
Medium Scale	100	10.1	6.3	5.1
Small Scale	10	3.7	3.5	3.3
Textiles				
Large Scale	1000	36.9	20.6	11.3
Medium Scale	100	10.0	7.5	5.7
Small Scale	10	3.6	2.4	N/A

Source: Samut Prakarn Wastewater Management Project — Pøject Report on Treatment of Industrial Wastewater from Textiles and Food Processing Industries, July 1998

Total investment costs[1] of in-plant treatment of BOD in the food & beverage sector (billion baht)

Food Proc/ Regions	*# of firms*	*Full treatment [2]*	*Pre-treatment Level 1 [3]*	*Pre-treatment Level 2 [4]*
Central	3045	46.8	27.3	21.8
Bangkok	936	17.1	9.9	7.9
East	1063	16.0	9.3	7.4
North	1134	13.3	7.9	6.4
Northeast	1662	23.0	13.5	10.8
South	622	7.9	4.7	3.7
Sector total	**8462**	**124.2**	**72.6**	**58.0**

Source: Development Research Group, World Bank, 2001

Note: 1. Calculated as the cost per plant times the number of plants in the region and sector; 2. Consists of Sand and Grease Trap, Fine Screening, Equalization, and Conventional Activated Sludge process; 3. Consists of Fine Screening, Equalization, and Dissolved Air Flotation, including chemical precipitation and/or coagulation; 4. Consists of Dissolved Air Flotation, Fine Screening, and Equalization.

Total investment costs[1] of in-plant treatment of BOD in the textile sector (billion baht)

Textiles/ Regions	*# of firms*	*Full Treatment [1]*	*Pre-treatment Level 1 [2]*	*Pre-treatment Level 2 [3]*
Central	1521	26.9	15.1	8.3
Bangkok	3678	67.8	37.8	20.8
East	229	3.8	2.1	1.2
North	180	2.8	1.6	0.9
Northeast	218	3.1	1.8	1.0
South	20	0.1	0.1	0.0
Sector total	**5846**	**104.5**	**58.5**	**32.2**
Total	**14308**	**228.7**	**131.1**	**90.2**

Source: Development Research Group, World Bank, 2001

Note: 1. Consists of Fine Screening, Coarse Screen, Equalization, Conventional Activated Sludge process, Circular Clarifier, and Sludge drying beds; 2. Consists of Fine Screening, Coarse Screen, Equalization, Circular Clarifier, and Sludge drying beds; 3. Consists of Fine Screening, Coarse Screen, and Equalization.

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33 DANCED and Carl Bro International, *Samut Prakarn Wastewater Management Project — Pøject Report on Treatment of Industrial Wastewater from Textile and Food Processing Industries*, July 1998.

34 In 1998, 50-55% of plants had no in-plant treatment, thus investment and O&M costs were estimated based on new designs of local in-plant treatment. Estimates were derived for large-, medium- and small-scale industries for three different treatment levels for 9 textile and 18 food processing plants. Reported costs do not include upgrading and/or retrofitting of existing treatment facilities.

35 Plant-level investment and O&M costs vary with the scale of activity. For example, the cost of treatment for a large-scale food processing plant is 0.03 million baht/m^3 ($US 890), whereas for a small-scale plant the cost is 0.37 million baht/m^3 ($US 8,810). O&M costs are, on average, 10-13 percent of total investment costs.

spending on Water Pollution ControL

Budget allocations for water pollution control and mitigation measures are made at both the national and local levels.

The wastewater sector is heavily dependent on Government budgetary allocations to fund capital investments. MoSTE and PWD have contributed about two thirds of the total capital costs of existing municipal wastewater infrastructure. LGAs typically provide limited contributions, usually in the form of land. One important exception to this is the BMA, which self-funded 33 percent of its wastewater investment program over the 1995 - 2000 period.[36]

While the role of local and regional governments has so far been limited in terms of funding capital investments, they assume the primary responsibility for operations and maintenance. Since the enactment of NEQA in 1992, they are also increasing their role in the planning and implementation of sector investments, though much more remain to be done. Funding for environmental infrastructure is allocated on the basis of Provincial Environmental Action Plans (PEAPs). The funding requirements for the PEAPs are determined by the RTG through the National Environment Board (NEB) and then distributed to the LGAs through MOSTE agency budgets. With the enactment of the new Constitution in 1997 and the supporting Decentralization Act, the process of moving decision making authority to the local and regional levels of government has accelerated.

Existing Government policies and legislation support private sector participation in the wastewater sector. To facilitate this objective, Wastewater Management Authority was established in 1995 to identify, prepare, and participate in public-private partnerships in the sector. However, progress in achieving private sector participation has been slow, largely because of the lack of cost recovery, a supporting regulatory framework and contractual mechanism.

[36] PCD, 2001

Capital Cost of Existing Municipal Wastewater Infrastructure (million baht)

Region	PWD	MoSTE	LGA & other[1]	Total
North	871	296	0	1,167
Northeast	829	64	90	983
Central	2,962	184	215	3,361
South	1,003	1,254	10	2,257
East	3,216	1,982	0	5,198
BMA	0	0	5,886	5,886
Total	8,881	3,780	6,201	18,852

[1]Local government authorities, Department of Local Administration, King s projects, Fisheries Department, Irrigation Department & Tourism Authority of Thailand

Source: PCD, May, 2001.

Impact of ISO 14001 on the manufacturing sector in Thailand

The ISO 14001 certification process was first introduced in Thailand in 1996, and nearly 400 companies have been certified as of June, 2001. A recent survey of 45 certified companies revealed a number of positive findings.

Among the major benefits to the environment, 82% of firms experienced an average reduction of 76% in industrial wastewater, 69% experienced an average decrease in hazardous waste of 60% (to be treated and land filled), and 40% of firms decreased their particulate emissions by an average of 40%.

The highest benefits stated by companies came in the form of better corporate image, improved working environments, and cost savings. Two of the key determinants to implementation were staff awareness and commitment of top management.

The average cost of establishing the system and achieving certification by the 45 firms was just under 3 million baht (US$70,000), with an average cost savings of 4.7 million baht (US$112,000) through water recycling, reduced sludge production, reduced electricity consumption and chemical substitution. The average payback period was 2 years.

The largest cost allocation was for the acquisition of new equipment, infrastructure improvement, and the modification of existing equipment and processes.

Source: How can it benefit business? A survey of ISO 14001 certified companies in Thailand, Thailand Environment Institute, March 1999.

Capital Expenditures in the Wastewater Sector: 1995 — 2000 (million baht)

Source	FY95	FY96	FY97	FY98	FY99	FY00	Total
OEPP	121	503	2,894	2,209	1,994	3,559	11,280
PWD	1,738	1,545	1,613	1,439	832	680	7,848
BMA	1,316	2,448	1,538	291	1,214	929	7,735
Environment Fund	32	351	935	3,091	871	555	5,834
BMA Contributions	322	1,482	537	256	726	551	3,874
Total	**3,529**	**6,328**	**7,517**	**7,285**	**5,638**	**6,274**	**36,571**
% change over previous yr.	N/A	79	19	-3	-23	11	
Total — equivalent $ mill.	**141**	**253**	**240**	**176**	**149**	**156**	**1,115**

Source: BOB, OEPP, PCD, BMA

Trends in wastewater expenditure

Between 1995 and 2000, capital investment in the sector totaled almost 37 billion baht ($1.1 billion). Capital spending on wastewater management accelerated rapidly throughout the early and mid-1990s. Between 1995 and 1997, annual spending more than doubled. However, the recent economic crisis has highlighted the vulnerability of the sector to its heavy reliance on government budgetary allocations. Between 1997 and 1999, total capital expenditures in the sector were cut by 25%.[37]

The Government contributed 82 percent of total capital expenditures, which included 5.8 billion baht from the Environment Fund (EF), mostly in the form of grants. However, only about half of the EF commitments had actually been disbursed as of 2000.[38]

Funding for O&M

O&M costs are to be funded primarily from the budgetary resources of the municipalities. However, the municipalities cannot cover the full cost of O&M from general revenues, and have been reluctant to establish and implement customer tariffs that could cover these costs. Of the 50 municipalities having wastewater treatment facilities, only two - Pattaya and Patong (Phuket) -presently apply a direct user charge. In both cases , however, the full costs of O&M are not recovered. Furthermore, because of budget constraints, BMA is presently spending less than half of the amount estimated to be required for sustainable O&M on the recently commissioned Yannawa WWTP.

Future Investments

Future investments in the sector will need to focus on rehabilitating dysfunctional treatment plants and collection systems as well as constructing new facilities to expand existing treatment plant and collection capacity to cover the urban population. While it is difficult to estimate rehabilitation costs, the costs of new construction necessary to provide treatment and collection to the municipal population is estimated at 87 billion baht with the largest investment needs in the Northeastern Region. Four-fifths of this would go towards funding collection systems.

Additional Investment Needs for New Municipal Wastewater and Collection Systems

Region	Investment Costs Million Baht		
	Treatment	Collection	Total
North	3,285	12,491	15,775
Northeast	5,371	20,091	25,463
Central	3,713	11,139	14,852
Southern	2,038	7,836	9,874
Eastern	416	1,247	1,663
BMA	269	19,556	19,826
Total	**15,092**	**72,360**	**87,453**

Source: Team Estimates, World Bank, 2001
Represents the investment needed to cover the municipal population not including investments for existing WWTSs and those under construction (PCD, August 2000);

[37] PCD, 2001

[38] PCD, 2001

glossary of Environmental TermS

Ambient Measurement: A measurement of the concentration of a substance or pollutant within the immediate environs of an organism; taken to relate it to the amount of possible exposure.

Aquifer: An underground geological formation, or group of formations, which are sources of groundwater.

Biochemical Oxygen Demand (BOD): The amount of oxygen consumed in the biological processes that break down organic matter in water. The greater the BOD, the greater the degree of organic pollution.

Dissolved Oxygen (DO): The oxygen freely available in water, vital to fish and other aquatic life and for the prevention of odors. DO levels are considered a most important indicator of a water body's ability to support desirable aquatic life. Secondary and advanced waste treatments are generally designed to ensure adequate DO in waste-receiving waters.

Effluent: Wastewater - treated or untreated - that flows out of a treatment plant, sewer, or industrial outfall. Generally refers to wastes discharged into surface waters.

Heavy Metals: Metallic elements with high atomic weights (e.g., mercury, chromium, cadmium, arsenic, and lead); can damage living things at low concentrations and tend to accumulate in the food chain.

Most Probable Number (MPN): An estimate of microbial density per unit volume of water sample, based on probability theory.

Organic Pollution: Carbonaceous waste contained in plant or animal matter and originating from domestic or industrial sources.

Pesticide: Substances or mixture thereof intended for preventing, destroying, repelling, or mitigating any pest. Also, any substance or mixture intended for use as a plant regulator, defoliant, or desiccant.

Point Source: A stationary location or fixed facility from which pollutants are discharged; any single identifiable source of pollution; e.g., a pipe, ditch, ship, ore pit, factory smokestack.

Pollutant: Generally, any substance introduced into the environment that adversely affects the usefulness of a resource or the health of humans, animals, or ecosystems.

Red Tide: A proliferation of marine plankton toxic and often fatal to fish, perhaps stimulated by the addition of nutrients. A tide can be red, green, or brown, depending on the coloration of the plankton.

Run-Off: That part of precipitation, snowmelt, or irrigation water that runs off the land into streams or other surface-water. It can carry pollutants from the air and land into receiving waters.

Salinization/ Saline Intrusion: The invasion of fresh surface or ground water by salt water.

Sewage: The waste and wastewater produced by residential and commercial sources and discharged into sewers.

Standards: Norms that impose limits on the amount of pollutants or emissions produced.

Subsidence: Downward movement of the land surface associated with groundwater pumping, especially where such pumping exceeds safe yield and the water table has dropped.

Suspended Solids: Small particles of solid pollutants that float on the surface of, or are suspended in, sewage or other liquids. They resist removal by conventional means.

Total Coliform Bacteria (TCB): A collection of relatively harmless microorganisms that live in large numbers in the intestines of man and warm- and cold-blooded animals. A specific subgroup of this collection is the fecal coliform bacteria - whose presence in aquatic environments indicates that the water has been contaminated with the fecal material of man or other animals.

Total Suspended Solids (TSS): A measure of the suspended solids in wastewater, effluent, or water bodies, determined by tests for "total suspended non-filterable solids." (See: suspended solids.)

Water Quality Standards: The standards prescribe the use of the water body and establish the water quality criteria that must be met to protect designated uses.

Watershed: The land area that drains into a stream; the watershed for a major river may encompass a number of smaller watersheds that ultimately combine at a common point.

Source: This glossary is based on United States Environmental Protection Agency's "Terms of the Environment", revised May 1998.

Thailand's Surface Water Quality Classification and Definitions

Water Classification

Class 1 (Very Good) Extra clean fresh surface water resources used for:

- Conservation not necessary pass through water treatment process require only ordinary process for pathogenic destruction
- Ecosystem conservation where basic organisms can breed naturally
- Conservation of ecosystem for water sources

Class 2 (Good) Very clean fresh surface water resources used for:

- Consumption which requires ordinary water treatment process before use
- Aquatic organism of conservation
- Fisheries
- Recreation

Class 3 (Moderate) Medium clean fresh surface water resources used for:

- Consumption, but passing through an ordinary treatment process before using
- Agriculture

Class 4 (Poor) Fairly clean fresh surface water resources used for:

- Consumption, but requires special water treatment process before using
- Industry

Class 5 (Very Poor) The sources that are not classified in classes 1-4 and used for navigation

Ambient Standards. To date NEB has prescribed three types of water quality standards:

(1) Surface Water Quality Standards for 5 classes;

(2) Coastal Water Quality Standards for 7 classes, Chao Phraya, Tha Chin, Bang Pakong, Nakorn Nayok, Prachinburi, and Mae Klong rivers; and

(3) Drinking Water Quality including Bottled Drinking Water Quality Standards and Ground Water Quality Standards for drinking purposes.

Effluent Standards. Many agencies are authorized to set effluent standards, however, under NEQA, MoSTE has the authority to set the regulatory floor. Agencies that establish less stringent standards must correct their standards to conform to MoSTE. If there is a conflict, the NEB intervenes and makes the final decision.

Although under NEQA MoSTE may prescribe effluent standards based on the quality of the receiving waters, in practice MoSTE does not adjust effluent standards, and effluent standards apply to all receiving waters.[39]

There are three types of effluent standards:

- Building effluents standards;
- Factory and industrial estate; and
- Housing estate effluent standards.

Point Sources. Under NEQA, "point source of pollution" is broadly defined to include "any community, factory, building, structure, vehicle, place of business or activity or any other thing from which pollution is generated". However, only point sources that MoSTE prescribed and published in the Government Gazette are subject to effluent standards. The 15 types of point sources that are regulated are: (i) factories and industrial estates; (ii) housing estates; (iii) condominiums; (iv) hotel dormitories; (v) massage parlors; (vi) hospitals; (vii) school and university buildings; (viii) governmental office buildings; (ix) department stores; (x) fresh food markets; (xi) restaurants; (xii) hog farms; (xiii) solid waste incinerators; (xiv) power plants; and (xv) rock mines.

[39] Environmental Law Handbook DEQP, p. 19 (1999).

thailand at a GlancE

Geography

Area: total: 514,000 sq km
land: 511,770 sq km
water: 2,230 sq km

Land boundaries:
total: 4,863 km
border countries: Myanmar 1,800 km, Cambodia 803 km, Laos 1,754 km, Malaysia 506 km

Coastline: 3,219 km

Maritime claims:
continental shelf: 200-m or to depth of exploitation
exclusive economic zone: 200 nm
territorial sea: 12 nm

Climate:
tropical; rainy, warm, cloudy southwest monsoon (mid-May to September); dry, cool northeast monsoon (November to mid-March); southern isthmus always hot and humid.

Terrain:
central plain; Khorat Plateau in the east; mountains elsewhere.

Elevation extremes:
lowest point: Gulf of Thailand 0 m
highest point: Doi Inthanon 2,576 m

Mineral resources:
tin, natural gas, tungsten, tantalum, timber, lead, fish, gypsum, lignite, fluorite.

Land use:
arable land: 34 percent
permanent crops: 6 percent
permanent pastures: 2 percent
forests and woodland: 26 percent
other: 32 percent (1993 est.)

Irrigated land: 44,000 sq km (1993 est.)

Environment-international agreements:
party to: Climate Change, Endangered Species, Hazardous Wastes, Marine Life Conservation, Nuclear Test Ban, Ozone Layer Protection, Tropical Timber 83, Tropical Timber 94.
signed, but not ratified: Biodiversity, Law of the Sea

Economy/Society

GDP: US$ 121.8 billion (2000)

GDP growth rate: 4.3 percent (2000)

GDP-composition by sector:
agriculture: 11.2 percent
industry: 39.3 percent
services: 49.5 percent (2000)

Inflation rate-consumer price index: 1.5 (2000)
Unemployment rate: 3.7 percent (2000)
Gross Domestic Investment/GDP: 19.9 (1999)
Exports of good and services/GDP: 58.5 (1999)
Gross domestic savings/GDP: 32.6 (1999)
Gross national savings/GDP: 30.1 (1999)

Industrial production growth rate: 2.8 percent (2000)
Agricultural production growth rate: 2.2 percent (2000)
Agriculture-products:
rice, cassava (tapioca), rubber, corn, sugarcane, coconuts, soybeans.
Exports: total value: $67.9 billion (f.o.b., 2000)
Imports: total value: $62.4 billion (c.i.f., 2000)

Population, mid-year: 61.8 million
Population growth rate: 1.1 percent
Urban population (percent of total population): 37
Birth rate: 16.76 births/1,000 population (1998 est.)
Death rate: 7.11 deaths/1,000 population (1998 est.)
Infant mortality: 33 deaths/1,000 live births (1995-96)
Access to safe water (percent of population): 81
Access to sanitation (percent of population): 84
Life expectancy at birth: 69 years
Literacy (at age 15): total population: 93.8 percent
Gross primary enrollment
(percent of school-age population): 87
National capital: Bangkok
Administrative divisions: 76 provinces (changwat)
Independence: 1238
(traditional founding date; never colonized)

Sources:
Thailand Social Monitor *"Poverty after the Crisis: Thailand's new Challenge", March 2001;*
East Asia Quarterly Update, March 2001; *Bank of Thailand Statistics*