delivered to Batangas Coal-fired Power Plant evidencing the very inferior quality control on the part of the coal supplier. A huge amount of money is wasted for the disposition of this situation, and the low quality coal makes a cause of the decrease of output and environmental pollution. Strict request for assurance of the coal quality should be made to the coal supplier.

5. Other Recommended Items

(1) Earlier implementation of the items pointed out by Quality Assurance of the Head Office. (All thermal power plants)

(2) Improvement and reinforcement of communication systems. (All thermal power plants/fuel management department)

(3) Inspection and repair of bottom plates of oil storage tanks and water storage tanks. (All thermal power plants/oil depots)

(4) Improvement and reinforcement or installation of waste water treatment equipment and sedimentation pond (dredging). (All thermal power plants)

(5) Inspection and dredging of cooling water intake. (All thermal power plants, especially Batangas Power Plant with higher priority)

(6) Maintenance of the analyzing equipment and tools in chemical laboratory. (All thermal power plants)

6. Requests to Other Organizations

(1) The coal supplier should be requested to assure the coal quality.

(2) The coal supplier should be requested to use larger coal carriers.

7. Special Remark

In 1989, the JICA Afforestation Project Study Report was submitted to the Department of Environment and Material Resources of the Philippine Government. The report forecasted the danger of avalanche of sand and stone with Malaya Power Plant located near Lake Laguna, and proposed the countermeasure.

Detailed investigation should be carried out at an early date and the countermeasure should be taken in consultation with the Government.

7.3 Geothermal Power Plants

7.3.1 Present Status and Problems of Operation and Maintenance

1. Operation and Maintenance Organization

The organizations for the operation and maintenance of geothermal power plants have been reformed in parallel with the reorganization of SLRC which controls the geothermal power plants. One of the targets of the reorganization is to increase the efficiency of the operation and maintenance works, incorporating the items pointed out by the QA Division of the Head Office. For this purpose, the organizations have been reformed functionally and simplified.

The future problems would be,

1) to establish the new procedures for efficient operation of the works, with the features of the new organization taken into account, and

2) to secure the necessary personnel and assign them strategically.

(1) Southern Luzon Regional Center (SLRC)

There are now 2 geothermal power plants in operation in Luzon Island. Both Tiwi and Mak-Ban Power Plants are under the control of SLRC. The new organization of SLRC is shown in Tables 7-3-1 and 7-3-2.

a. Major change

The major change related with the geothermal power plant is as follows.

(a) Discontinuation of CM/TS in SLRC.

b. Features of the change

The geothermal power plants used to carry out the maintenance and periodical overhaul for themselves and, if necessary, got the cooperation of CM/TS. And there would be no problem posed by the discontinuation of CM/TS by the recent reorganization. The maintenance and periodical overhaul will be made by the reorganized maintenance division with the assistance of MEC as before.

(2) Geothermal Power Plants

The organization of the geothermal power plants have also been reorganized. The new organizations are shown in Tables 7-3-3 and 7-3-4.

a. Major changes

(a) The four sections in the old organization have been reorganized as follows.

Each division is headed by the manager who assumes the full responsibility of the division. The organization is basically similar to that of the thermal power plant.

Old Organization		New Organization
. Operation (1 section) (incl. chemical)	→	. Operation (1 division)
. Maintenance (1 section)	→	. Maintenance (1 division) (Including planning & scheduling group (newly organized))
. Engineering & Chemical (1 section) (incl. environmental)	→	. Efficiency & Environmental Control Group (1 group) (newly organized)
. Support Services (1 section)	→	. Support Services (1 section) . Watershed Area Team (1 team)
Total 4 sections		2 divisions + 1 section + 1 group + 1 team

(b) The Efficiency and Environmental Control Group has been created under the Complex Manager.

(c) The Planning & Scheduling Group has been created in the Maintenance Division.

b. Features of the changes

The remarks similar to those on the thermal power plants apply generally to the geothermal power plants.

(a) The organization has been reformed functionally and simplified.

(b) In the new organization, the line of direction and command and the divisions of responsibility have been defined more clearly.

(c) The intent to reorganize and strengthen the Maintenance Division is observed in the new organization.

c. Problems and effects of reorganization

(a) The problems under the old organization (as described in the section of thermal power plants) have been given consideration to, and the new organization is esteemed as having incorporated the corrective measures. The difference from the thermal power plant organization is in the fact that the environmental analyst (chemical) has been assigned since the time of the old organization.

(b) Future problems

- To establish the operating procedures under the new organization speedily.

- To secure the necessary personnel and assign them strategically.

2. Performance of Operation and Maintenance

(1) Operation

Same as for the thermal power plant.

(2) Maintenance

Same as for the thermal power plant.

3. Training and Education

Same as for the thermal power plant.

4. Procurement and Management of Equipment and Materials

Same as for the thermal power plant.

5. Performance and Efficiency Management

Same as for the thermal power plant.

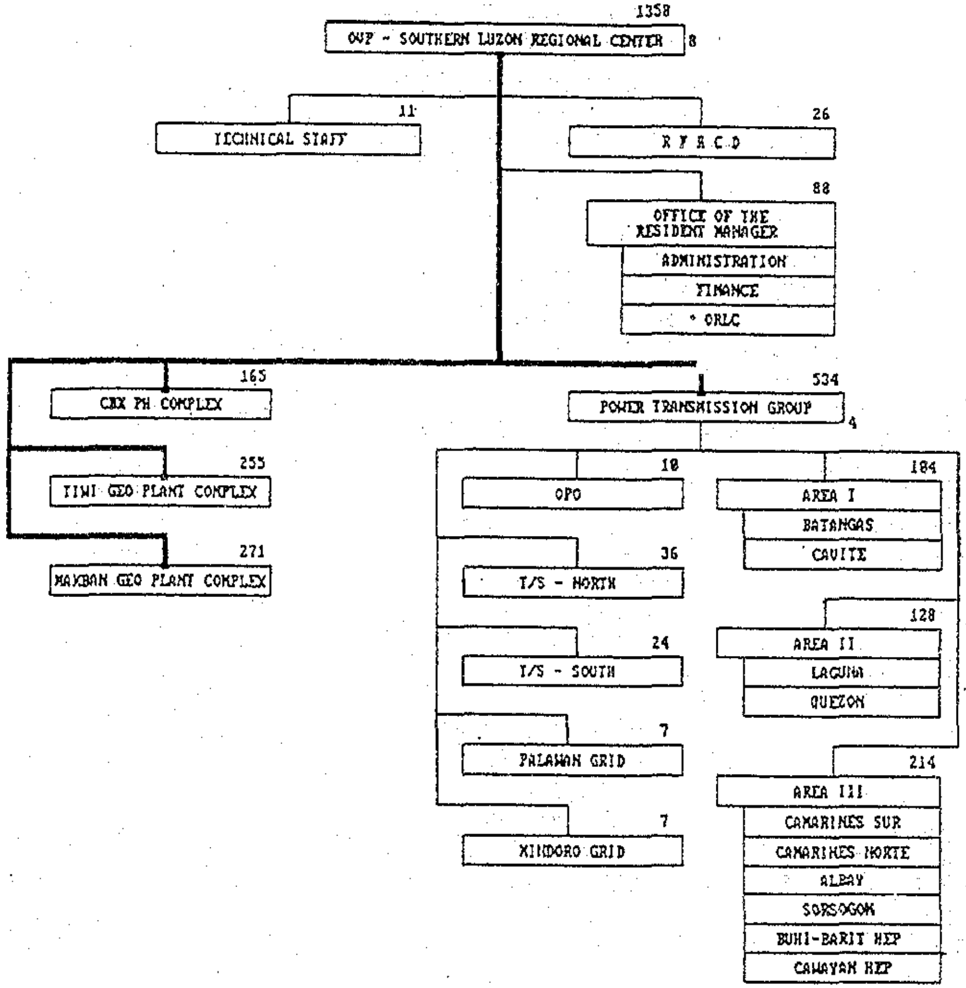
SUMMARY:

OVP	- 8
TECHNICAL STAFF	- 11
RFRCD	- 26
ORM	- 88
PLANTS	- 691
POWER TRANSMISSION GROUP	- 534
TOTAL	1358

Table 7-3-1

SOUTHERN LUZON REGIONAL CENTER

TABLE OF ORGANIZATION



SUMMARY:

OVP	- 8
TECHNICAL STAFF	-11
RFRCD	-26
ORM	-88
Total............	133

Table 7-3-2

OFFICE OF THE VICE-PRESIDENT

TABLE OF ORGANIZATION

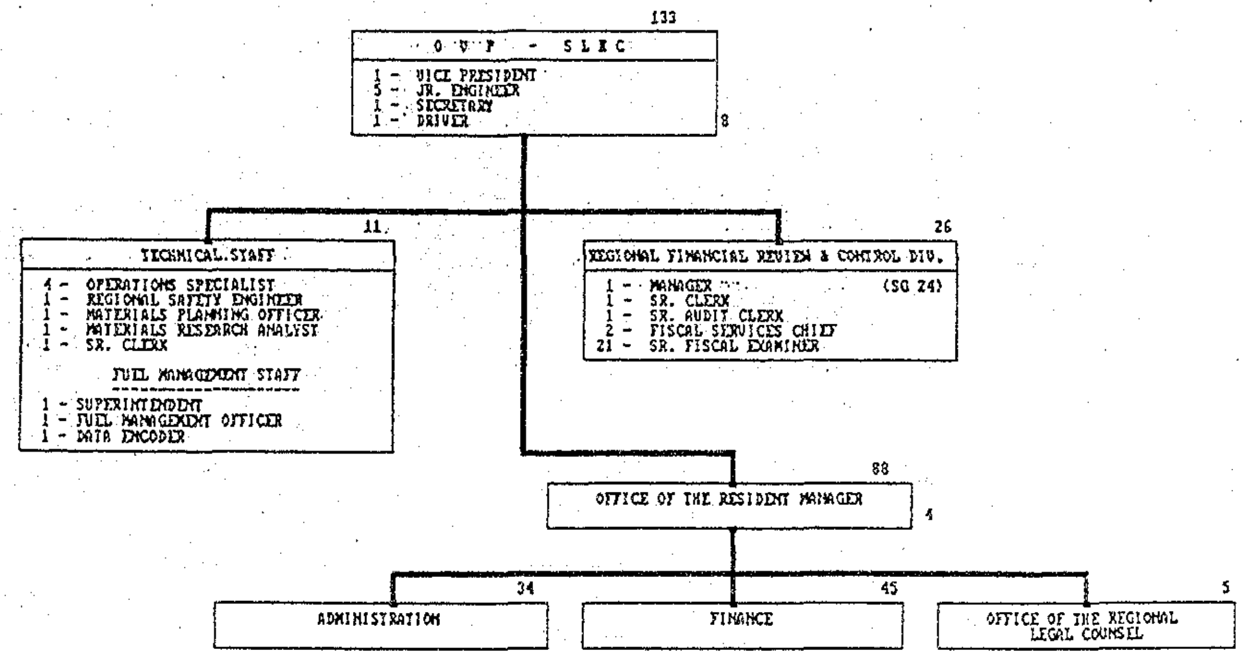
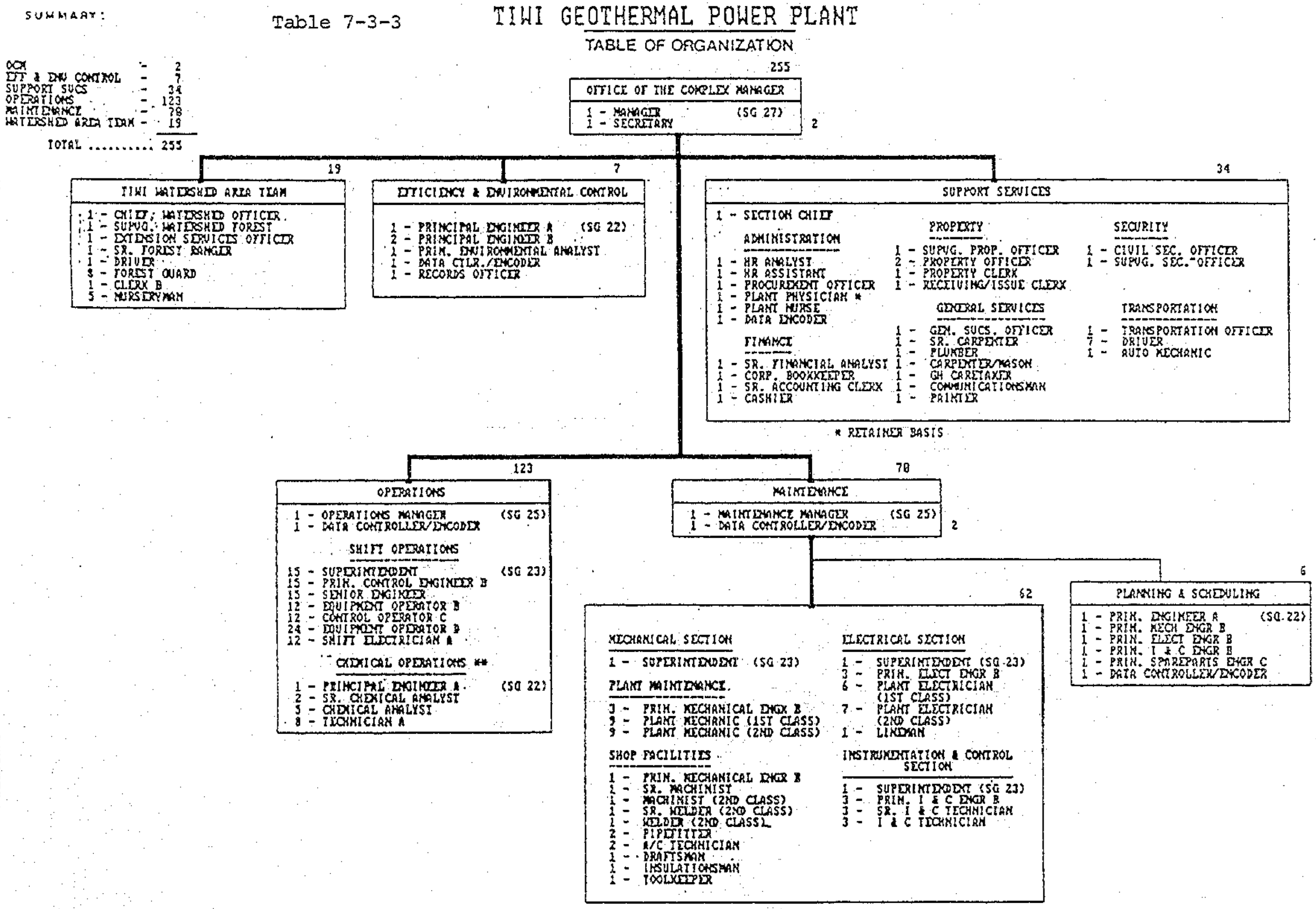


Table 7-3-3

TIWI GEOTHERMAL POWER PLANT

TABLE OF ORGANIZATION



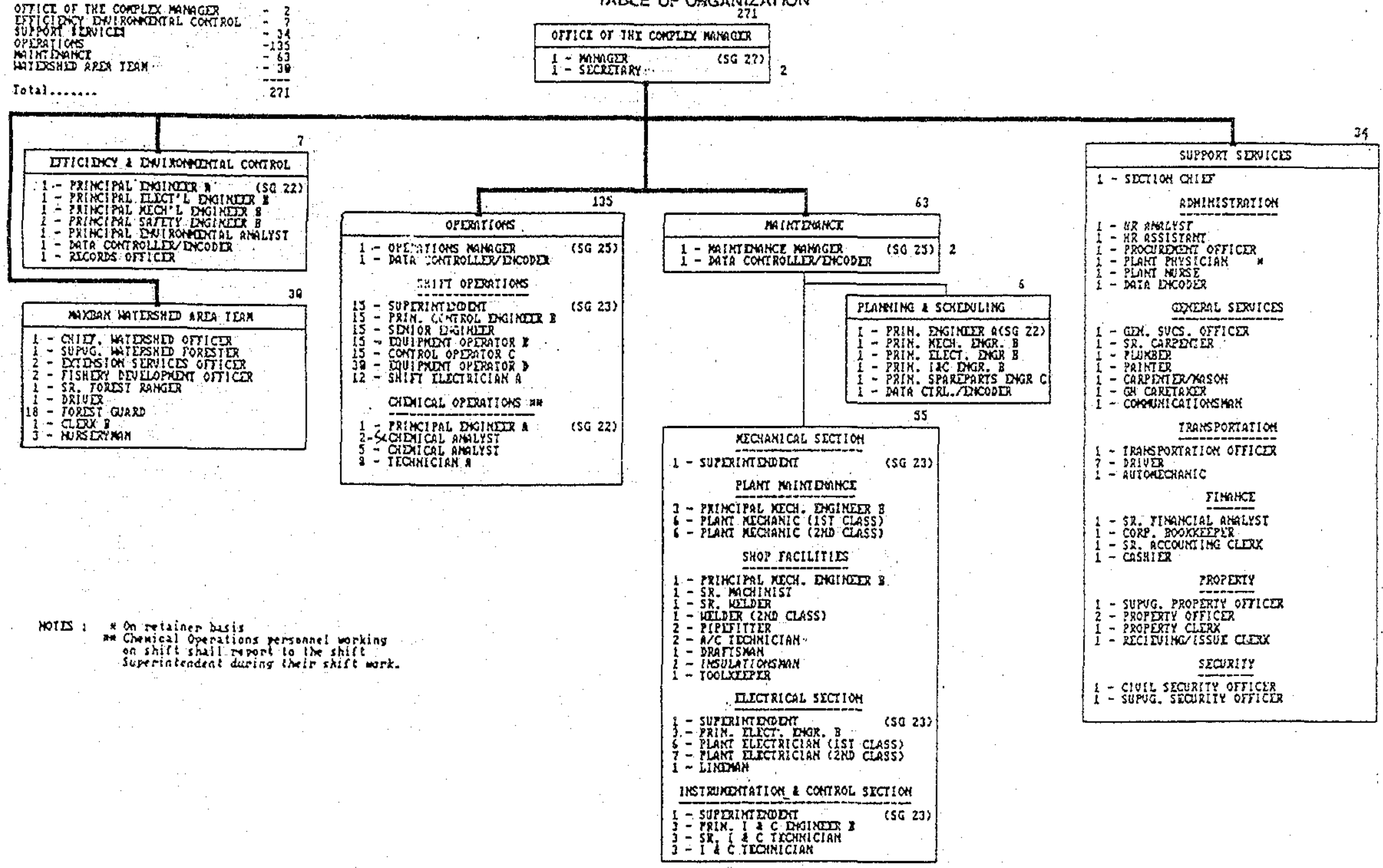
SUMMARY:

OFFICE OF THE COMPLEX MANAGER	- 2
EFFICIENCY ENVIRONMENTAL CONTROL	- 7
SUPPORT SERVICES	- 34
OPERATIONS	-135
MAINTENANCE	- 63
WATERSHED AREA TEAM	- 30
Total.......	271

Table 7-3-4

MAKBAN GEOTHERMAL POWER PLANT

TABLE OF ORGANIZATION



NOTES : * On retainer basis
** Chemical Operations personnel working on shift shall report to the shift Superintendent during their shift work.

7.3.2 Recommendation of Maintenance Management and Operation and Maintenance Improvement Program

With a view to solving the foregoing problems and effecting improvement, the Study Team recommends the following.

1. Operation and Maintenance Management System

(1) Review of Jurisdiction

Since the geothermal power plant is quite similar to the thermal power plant in the scale of unit, system, operation management system, and the procedures of maintenance and periodical overhaul, the transfer of jurisdiction to MMRC, as with the case of Batangas Thermal Power Plant which is located in the SLRC area, was considered.

However, as the special geothermal maintenance forces have been established, there is no technical reason to transfer the jurisdiction to MMRC now. And it would be more advantageous to leave the geothermal power plants under the jurisdiction of SLRC.

(2) Reinforcement of Organization

There are already 12 geothermal power generating units, and assuming that the periodical overhaul of the units will be carried out once a year, it would be necessary to continue periodical overhauls one after another all through the year.

In consideration of the expansion project of Mak-Ban Power Plant and other expansion projects in the future on top of the above situation, it is imperative to reinforce the maintenance organization and the staff of the power plants and provide additional maintenance equipment, tools and vehicles.

Switching of the present direct working system into the contract working system should be taken up as a subject of study.

2. Performance of Operation and Maintenance

(1) Improvement of Daily Operation Management

Same as for the thermal power plant.

(2) Improvement of Daily Maintenance Management

Same as for the thermal power plant.

(3) Improvement of Management of Periodical Overhaul

Same as for the thermal power plant.

(4) Operation and Maintenance Manuals

Same as for the thermal power plant.

3. Training and Safety Education

Same as for the thermal power plant.

4. Procurement and Management of Equipment and Materials

Same as for the thermal power plant.

7.4 Hydro Power Plants

7.4.1 Present Status and Problems of Operation and Maintenance

1. Operation and Maintenance System

(1) In the Luzon Grid, the Northern Luzon Regional Center (NLRC) and the Southern Luzon Regional Center (SLRC) take charge of operation and maintenance of hydro power plants, geothermal power plants, transmission lines, and substations. The area under their responsibility can be roughly divided into the north and the south of Metro Manila.

(2) The present organization and staffing of NLRC and SLRC are as illustrated in Tables 7-4-1 and 7-4-2. Both organizations were reorganized in November 1991, during the course of the study.

In NLRC, the organization for operation and maintenance is largely divided into the Power Generation Group (PGG) and the Power Transmission Group (PTG). PGG controls and manages the power plants, while PTG does the Operations Project Office, Technical Services, and area offices. Both PGG and PTG were established by the reorganization, but, there are no PGG and PTG in SLRC. In addition, the Vice-President is supported by the technical staff.

The administrative organizations consist of the Regional Financial Review & Control Division (RFRCD) and the Office of the Resident Manager (ORM). ORM supervises Administration, Finance and Office of the Regional Legal Counsel. By the reorganization, ORM was established and RFRCD was transferred from the Head Office to the regional centers. Administration and Finance, which are responsible for procurement and control of materials, budgeting, etc., were reinforced by the reorganization.

(3) Regional Centers

In the regional centers, operation and maintenance of the hydro power plants, transmission lines and substations are generally controlled by PGG, PTG and technical staff. However, the engineers involved number as few as 10, and no civil engineers are assigned. In order to substantiate and improve upon the facility management, maintenance planning, and maintenance implementation management for the hydro power plants, transmission lines and substations in the future, the present structure is not enough, and it will be necessary to set up the organizational units to take charge of maintenance in the regional centers.

The management span of NLRC is excessively large, with almost twice the size of SLRC in terms of the covered area, the number of power plants, the number of area offices, and the scale of the facilities. In addition, Baguio, where NLRC office is located, is unfavorable for office location as the roads are often closed due to typhoons. It is recommended that NLRC be divided into two regional centers and the office relocated.

The Operations Project Office (OPO) is another office set up by the reorganization, and is responsible for engineering task for the transmission and substation facilities. OPO is staffed by 17 in NLRC and by 10 in SLRC, including electrical, mechanical, civil and geological engineers. OPO will be useful for maintenance planning and implementation in the future.

(4) Technical Services

Technical Services (TS) has the respective sections of Relay, Meter, Test, Communication, Mechanical Test (only in NLRC), and Satellite (only in TS-North-NLRC), and makes the rounds of power plants and substations to conduct preventive maintenance (test, calibration, repair, trouble shooting) of protective relays, meters (including billing meters), power equipment, and communication equipment. The Mechanical Test Section took over the tests which used to be conducted by Central Maintenance (CM), and the Satellite Section was set up to carry out tests in the Cagayan Region.

TS is divided into the north and the south, and in the case of NLRC, offices are located in Bauang and Bulacan, while the SLRC TS offices are located in Calamba and Legazpi. The staff numbers 116 for NLRC and 60 for SLRC, totaling 176.

(5) Hydro Power Plants

The organization of the hydro power plants consists of Operation Section, Maintenance Section, Watershed Area Team, Efficiency Control & Planning & Scheduling Group (ECPS), and Support Services Section, under the control of a manager and an assistant manager. The organization of Kalayaan, Caliraya and Botocan Power Plants is called the Caliraya-Botocan-Kalayaan Plant Complex, and these power plants are controlled by a plant manager, an operation manager, and a maintenance manager. Masiway Power Plant is under the jurisdiction of Pantabangan Power Plant, while Barit and Cawayan Power Plants are under the Area 3 Office in SLRC.

The Operation Section consists of four groups, and the Maintenance Section comprises Electrical, Mechanical, Instrumentation and Control, and General Services Groups.

The following are the major changes made by the reorganization.

- CM staff were transferred to power plants.

- ECPS was set up to improve upon the maintenance planning, spare parts planning, and operational efficiency of power plants.

- The Watershed Area Teams were transferred from the Head Office to the power plants.

- *The Property Unit was reinforced for improving the* management of materials and assets.

By the above changes, improvements of maintenance planning, maintenance implementation, and spare parts management are expected.

2. Operation and Maintenance Procedures

(1) Operation

Operation of hydro power plants is carried out by the 4-group 3-shift system with 5 to 8 operators in each shift. Operators perform the operation in accordance with the instruction of the Power Management Center and the established operation manual.

The operation log is made up of several sheets on which each operator records hourly data for many items. The frequency of recording is considered reducible. It is especially desired that the night shift work be simplified as much as possible.

(2) Maintenance

The maintenance sections of hydro power plants take charge of the maintenance of power plants, and TS's carry out the preventive maintenance of protective relays, meters, power equipment, and communication equipment. The preventive maintenance performed by TS is explained in Item 2 of Sub-clause 7.5.1 because the procedure is identical with that for substations.

In the hydro power plants, operators perform patrol checks. The frequency of checks is divided into each shift, daily, semi-weekly, weekly, semi-monthly, monthly, quarterly, semi-annual, and annual checks. It will be necessary to review the necessity of the said patrol checks and reduce the frequency of checks.

The maintenance sections perform the maintenance works pursuant to the annual preventive maintenance program and the trouble reports issued by the operation sections. The work results are reported by the turnover reports with descriptions of the works done, materials used, etc.

As for the maintenance planning, the power plants prepare the annual preventive maintenance program upon consultation with TS and submit the budget to the Head Office through the regional centers.

As shown in Table 6-3-3, the same kinds of faults are recurring in the power plants. These are, for example, the breakdown of breaking elements in Binga Power Plant, the burnt excitation transformers, and total shutdown due to failure of one unit in Magat Power Plant. These presumably occurred through lack of adequate pursuit of causes of past troubles and inappropriate improvements. Defective relay setting may be the cause of the total shutdown in Magat Power Plant. Future maintenance should simplify the recording of operation logs and the routine inspections, and emphasize the investigation of the causes of faults, arrangement of the various data on faults, and study of proper improvement measures, so as to facilitate effective maintenance of the facilities.

Regarding the civil structures, though routine maintenance is performed by the power plants, no periodical inspection is carried out. It is necessary to carry out the periodical measurement of deposits in the reservoirs and wall thickness of the penstocks, and the periodical inspection of the races.

3. Operation and Maintenance Manuals

(1) Operation Manual

For operation of the power plants, the corporation-wide standardized manual, "Start-up/Shutdown Procedure", has been established. Each power plant has the operation manual that is applicable to its own plants, but since the scope of some of these manuals is so wide, covering the history of the plant through its daily operations, it would be desirable to limit the content to the items related to daily operations only.

Specifications and manuals prepared by the manufacturers are used for the operation and maintenance of the major equipment.

(2) Maintenance Manual

a. Preventive Maintenance Guide

Items, descriptions, and frequency of checks for each equipment, as well as the form of patrol checklist, are specified in the guide. As mentioned in the previous Item 2, it will be necessary to review the frequency of checks. In addition, the check items for switchyard equipment are different from those for patrol checks at substations as mentioned in Item 3 of Sub-clause 7.5.1. It would be desirable to standardize these check items.

b. Civil Structures Inspection Manual

It is necessary to prepare the inspection manual for the measurement of deposits in the reservoirs and wall thickness of the penstocks as well as for the inspection of the races.

4. Operation and Maintenance Records, Reports, and Reporting System

(1) Operation Records

Various data covering generated energy, water turbines and generators including auxiliaries, oil pressure, water pressure, switchyard equipment, transmission lines, etc., are recorded every hour. The operation log is made up of several sheets.

(2) Forced Outage Reports

The hydro power plants submit daily and monthly reports to the regional centers and the Head Office. These reports contain the name of equipment, date and time of occurrences, duration of outages, operation of protective devices, causes, etc.

For the causes, the names of failed parts are often recorded instead. Primary causes should be investigated and reflected on the maintenance of the equipment. Though the monthly reports are enumerated in sequence of date, these should be summarized by units and by causes. Also, annual reports which are summarized by units and by causes should be prepared and utilized as the management data for maintenance of the equipment.

(3) Trouble Report, Maintenance Order, and Turnover Report

The trouble report is issued by the operation section, while the maintenance order and the turnover report are issued by the maintenance section. Since the turnover report contains work descriptions, working hours, used materials, etc., these data should be summarized and utilized as the management data for maintenance works.

5. Spare Parts Inventory Level and Management System

The hydro plant spare parts, which are numerous in both variety and quantity, are classified and managed by parts in the power plants. Some power plants have prepared long-term plans. However, some parts have been stored for a long time and some fall short of the standard requirement levels. And also, insufficient specifications, inadequate lead time, time-consuming bidding procedures, etc. are causing delay in the delivery of parts.

Now that the spare parts management system has been strengthened by reorganization, the following study should be promoted hereafter.

- Arrangement of statistics of parts used in the past
- Arrangement of equipment fault statistics
- Review of the availability of parts
- Review of the standard inventory level of spare parts
- Standardization of specifications
- Adequate lead time and ordering points
- Simplification of procurement procedures such as bidding procedures, delegation of procurement authorities to lower organizations, etc.
- Strengthening of the spare parts management system in the Head Office and the regional centers

It is recommended that the above study is made first and, thereafter, the introduction of the computerized management system is considered.

6. Custody of Technical Documents and Drawings

Specifications and drawings at the time of plant construction are not kept in old power plants. Drawings needed for overhaul of water turbines and generators, and equipment specifications, drawings, manuals, etc. prepared by the manufacturers are kept for the purpose of operation and maintenance.

Though the single line diagrams have been prepared, the contents differ at each power plant, and the diagrams have not been updated periodically.

7. Test Instruments, Workshop Facilities, and Repair Tools

The test instruments are maintained at TS, and the power plants are provided with oscilloscopes, frequency generators, frequency counters, capacitance testers, ground resistance testers, oil testers, infrared testers, meggers, multi-testers, clamp-meters and others which are needed for maintenance of the equipment.

Each power plant has a workshop and is provided with repair tools such as lathe machines, boring machines, power saws, shapers, grinders, drilling machines, welding machines, soldering guns, hydraulic presses, pipe threaders/cutters, lubricating oil pumps, mechanical gas pumps, etc.

In recent years, parts for the hydro power plants have been Cpartially repaired at the MEC (Maintenance Engineering Center), and it will be necessary in the future to fully utilize the MEC for efficient repairing of parts.

8. Training of Operation and Maintenance Staff for Hydro Power Plants, Transmission Lines, and Substations

Technical training has been provided through seminars and OJT. Since NAPOCOR has no training center, facilities such as guest houses are used for the seminars. Because there are no appropriate training facilities, the training quality is not sufficient and the frequency is also not enough. Table 7-4-3 shows the number of attendants in the operation and maintenance training courses for hydro power plants, transmission lines, and substations. Some courses have not actually been carried out, and most are not given continuously. The details of the respective courses are given in Table 7-4-4.

As described in Clause 5.3, it will be necessary to strengthen the technical training system and promote effective training.

- To increase the staff of Technical Training Division to improve the training quality, enrich the curriculum, and increase the frequency of training courses.

- To promote the early implementation of the Training Center Project to enrich and improve the quality of training.

7.4.2 Recommendations on the Operation/Maintenance Improvement Plan

The study and implementation of the following improvement plan is recommended for solving the problems of operation and maintenance mentioned in Sub-clause 7.4.1.

1. Operation and Maintenance System

(1) Division of NLRC into Two Regional Centers and Relocation of Office

To divide NLRC, which has an overly large management span, into NLRC (Area Offices 1 - 4) and CLRC (Central Luzon Regional Center, Area Offices 5 - 7), and relocate NLRC office to plain areas.

(2) Establishment of Organizational Units in Charge of Maintenance in Regional Centers

To establish the maintenance units in the regional centers to take charge of the facilities management, maintenance planning, and maintenance implementation management for hydro power plants (including civil structures), substations, and transmission lines.

2. Operation and Maintenance Procedures

(1) Preventive Maintenance by TS

Described in Item 2 of Sub-clause 7.5.2.

(2) Operation Log

To review the necessity of various data that have been recorded hourly with the water turbines and generators including auxiliaries, oil pressure, water pressure, switchyard equipment, transmission lines, etc., and reduce the recording frequency.

(3) Frequency of Patrol Checks

To review the necessity of the patrol checks that have been performed in every shift, daily, semi-weekly, weekly, semi-monthly, monthly, quarterly, semi-annually and annually, and reduce the frequency of checks.

(4) Periodic Inspection of Civil Structures

a. Measurement of Deposits in the Reservoirs

To measure the deposits in the reservoirs periodically to estimate the future deposits and to take effective countermeasures. Adequate frequency of measurement will be once a year for Ambuklao and Binga reservoirs, and once every three years for other reservoirs. The proper measuring devices should be provided.

b. Measurement of Wall Thickness of Penstocks

In order to predict the replacement timing, to measure the wall thickness of penstocks, which have exceeded 30 years of service, about once every 5 years. The proper measuring devices should be provided.

c. Inspection of Races

To inspect the races roughly once every two years in order to check on the concrete cracks, water leakage, and deposits in the races.

(5) Promotion of Fault Reduction Countermeasures

To prepare the fault reduction program based on the fault statistics described in Item 4 of this Sub-clause, and effectively push forward the fault reduction countermeasures by setting the priority of respective countermeasures.

3. Operation and Maintenance Manuals

(1) Preventive Maintenance Guide

To review the frequency of checks and revise the guide.

(2) Civil Structure Inspection Manual

To prepare the manual for the measurement of deposits in the reservoirs and wall thickness of the penstocks, and for the inspection of the races.

4. Operation and Maintenance Records, Reports, and Reporting System

(1) Forced Outage Reports

a. To standardize the classification of causes on the corporation-wide level.

b. To investigate the primary causes as much as possible to utilize the results in planning the preventive measures.

c. To record damaged equipment in the reports separately from the causes.

d. To prepare monthly and annual reports classified by units, causes, and damaged equipment, and submit them to the regional centers and the Head Office.

(2) Maintenance Work Reports

To summarize the work descriptions, working hours, and materials used from the current turnover reports, prepare monthly and annual reports, and submit them to the regional centers and the Head Office.

(3) Periodic Inspection Report of Civil Structures

To summarize the results of measurement of deposits in the reservoirs and wall thickness of the penstocks, and the results of inspection of the races into an annual report and submit it to the regional centers and the Head Office.

5. Spare Parts Inventory Level and Management System

As explained in Item 5 of Sub-clause 7.4.1, the following study should be pushed forward.

- Arrangement of statistics of parts used in the past
- Arrangement of equipment fault statistics
- Review of the availability of parts
- Review of standard inventory level of spare parts
- Standardization of specifications
- Adequate lead time and ordering points
- Simplification of procurement procedures such as bidding procedures, delegation of procurement authorities to lower organizations, etc.
- Strengthening of the spare parts management system in the Head Office and the regional centers

Subsequent to the above, to study the adoption of the computerized management system.

6. Custody of Technical Documents and Drawings

(1) To establish the rule for keeping the specifications and drawings at the time of construction. For the existing power plants, to prepare these documents and drawings and distribute them to the regional centers and respective power plants.

(2) To standardize the single line diagram and establish the rule for periodic updating.

7. Test Instruments, Workshop Facilities, and Repair Tools

(1) To provide the devices for measuring deposits in the reservoirs and wall thickness of the penstocks.

(2) To make the best use of the Maintenance Engineering Center (MEC) to execute repair works efficiently.

8. Training of Operation and Maintenance Staff for Hydro Power Plants, Transmission Lines and Substations

As explained in Item 8 of Sub-clause 7.4.1, to strengthen the technical training system and promote effective training.

(1) To increase the staff of Technical Training Division to improve the training quality, enrich the curriculum, and increase the frequency of training courses.

(2) To promote the early implementation of the Training Center Project to enrich and improve the quality of training.

Table 7-4-1 ORGANIZATION STRUCTURE OF NLRC (1)

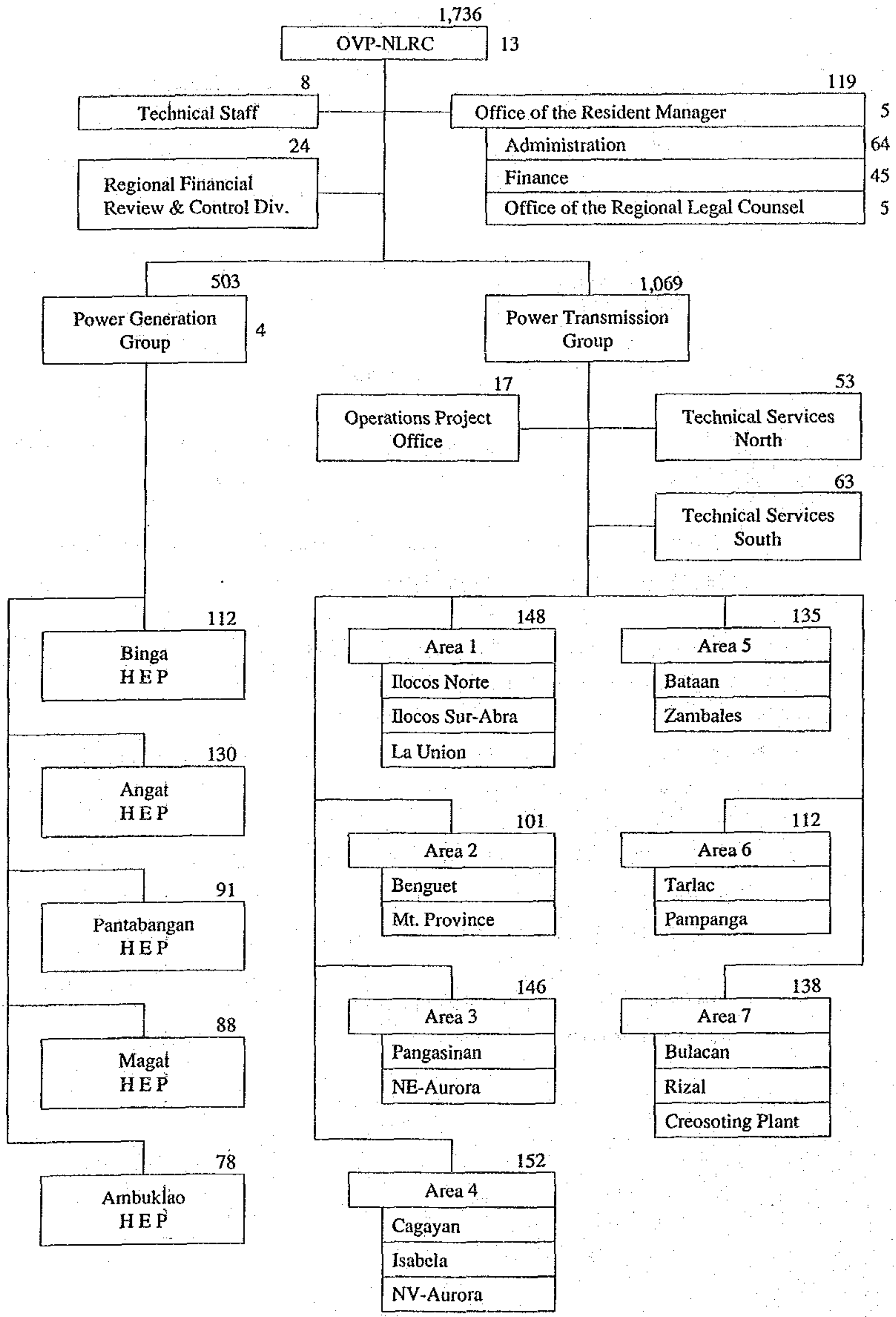


Table 7-4-1 ORGANIZATION STRUCTURE OF NLRC (2)

Technical Services		Manager Office		Relay Section	Meter Section	Test Section	Communication Section	Mechanical Test	Satelite Section
		Manager	Staff						
North	53	1	1	9	9	9	9	9	6
South	63	1	1	17	13	13	9	9	—

Area Offices		Manager Office		Substation			Transmission Line		Support Services	Creosoting Plant
		Manager	Staff	Manager	Operation	Maintenance	Manager	Maintenance		
Area 1	148	1	2	1	32	13	1	70	28	—
Area 2	101	1	2	1	19	13	1	44	20	—
Area 3	146	1	2	1	35	13	1	68	25	—
Area 4	152	1	2	1	35	15	1	70	27	—
Area 5	135	1	2	1	35	13	1	60	22	—
Area 6	112	1	2	1	22	11	1	52	22	—
Area 7	138	1	2	1	20	13	1	60	22	18
Total	932	7	14	7	198	91	7	424	166	18

Power Plants		Manager Office			Operation	Maintenance	ECPS	Watershed	Support Services
		Manager	Asst. Mgr.	Staff					
Binga	112	1	1	1	30	35	4	21	19
Angat	130	1	1	1	34	41	4	29	19
Pantabangan	91	1	1	1	34	32	4	—	18
Magat	88	1	1	1	26	38	4	—	17
Ambuklao	78	1	—	1	13	19	—	33	11
Total	499	5	4	5	137	165	16	83	84

ECPS : Efficiency Control & Planning & Scheduling

Table 7-4-2 ORGANIZATION STRUCTURE OF SLRC (1)

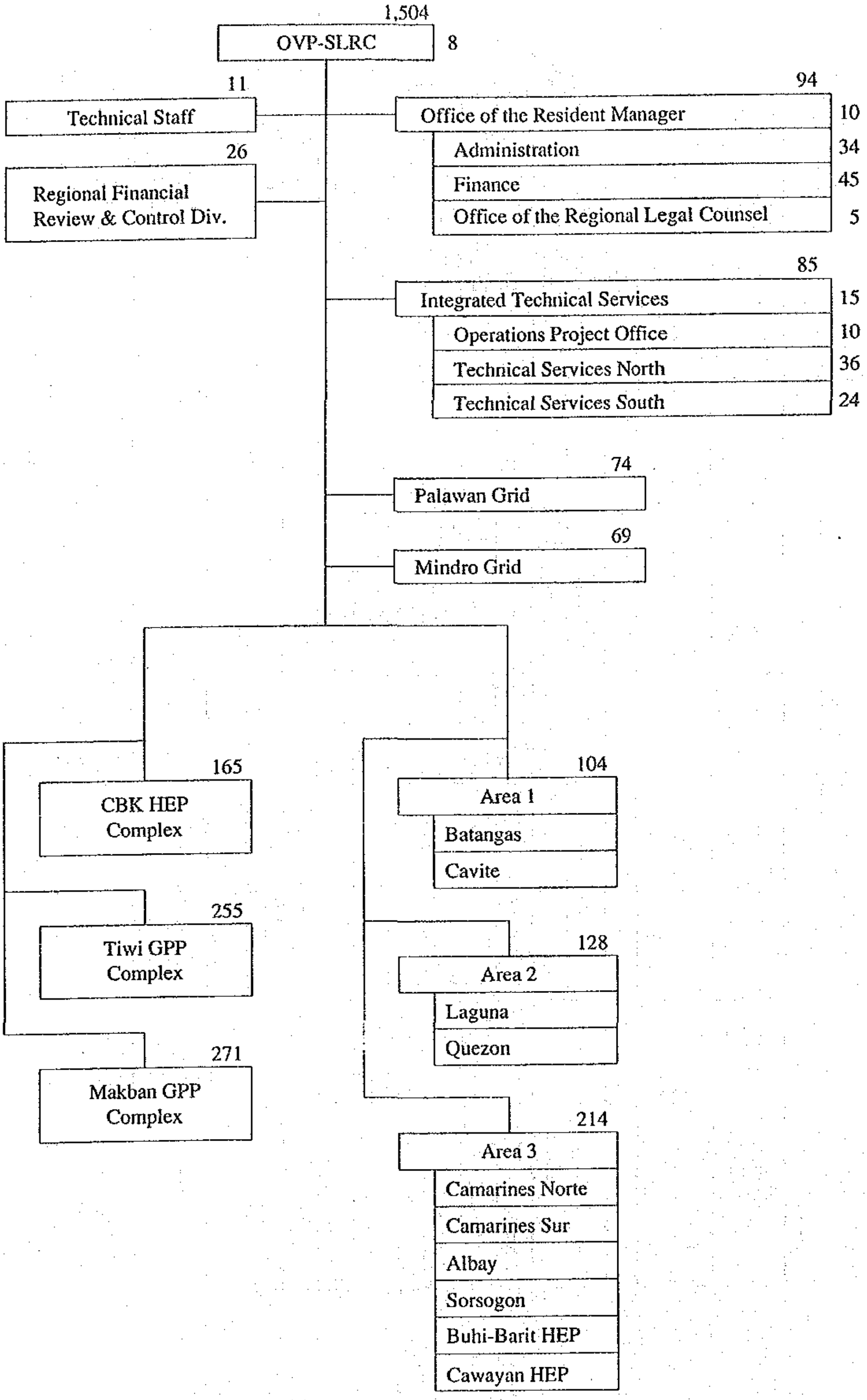


Table 7-4-2 ORGANIZATION STRUCTURE OF SLRC (2)

Technical Services		Manager Office		Relay Section	Meter Section	Test Section	Communication Section
		Manager	Staff				
North	36	1	3	9	9	9	5
South	24	1	3	5	5	5	5

Area Offices		Manager Office		Substation			Transmission Line		Barit & Cawayan HEP			Support Services
		Manager	Staff	Manager	Operation	Maintenance	Manager	Maintenance	Operation	Maintenance	Watershed	
Area 1	104	1	2	1	26	15	1	34	—	—	—	24
Area 2	128	1	2	1	18	13	1	68	—	—	—	24
Area 3	214	1	2	1	31	14	2	95	9	10	12	37
Total	446	3	6	3	75	42	4	197	9	10	12	85

Power Plants		Manager Office		Operation		Maintenance		ECPS	EEC	Watershed	Support Services
		Manager	Staff	Manager	Staff	Manager	Staff				
CBK	165	1	1	1	55	1	49	4	—	20	33
Tiwi	255	1	1	1	122	1	69	—	7	19	34
Makban	271	1	1	1	134	1	62	—	7	30	34
Total	691	3	3	3	311	3	180	4	14	69	101

ECPS : Efficiency Control & Planning & Scheduling
EEC : Efficiency & Environmental Control

Table 7-4-3 NUMBER OF PARTICIPANTS IN OPERATION AND MAINTENANCE TRAINING COURSES (HEP, TL, SS)

	Course Title	No. of Participants					
		1986	1987	1988	1989	1990	Total
HEP	1. Refresher Course on Hydro Power Plant Operations	30			115		145
P P	2. Maintenance Training Series Program	140	233	619	140	23	1,155
	3. Instrumentation and Control Course		24				24
	4. Electrical Maintenance Course						0
	5. Mechanical Maintenance Course						0
	6. Welding technology Course					13	13
	7. Maintenance Planning and control Course	31		23			54
	8. Managed Maintenance Program			58			58
TL& SS	9. Basic Lineman's Course	57	84	58	27	87	313
	10. Hotline Maintenance Course			58	57		115
	11. Substation operations and Maintenance Course	11	47	78			136
	12. Operation and Maintenance Course on High Voltage Circuit Breakers	61					61
	13. Schematic and Troubleshooting Techniques			24	144		168
	14. Woodpole Maintenance					34	34
	15. Protective Relaying and Transformer, Switchgear, Motors and Generators Testing and Maintenance					5	5

Table 7-4-4 OPERATION AND MAINTENANCE TRAINING COURSES (1) (HEP,TL,SS)

Couse Title	Course Content	Participants	Duration
1. Refresher Course on Hydro Power Plant Operations	Introduction to Hydro Power Generation Process Hydraulic Structures Hydro Plant System Major Hydro Plant Equipment Operating Procedures/Parameters Tending of Major/Minor Plant Equipment Plant Troubles and Remedial Measures Plant Safety Rules & Regulation	Hydro Plant Personnel	15 Days
2. Maintenance Training Series Program	Plant Operation and Induction Safety Training Quality Assurance Maintenance - Mechanical - Electrical - Instrumentation & Control New Equipment Demonstration	Technician/Maintenance Personnel	35 Days
3. Instrumentation and Control Course	Calibration Procedures of Measuring Instruments Pneumatic Controls Trouble-Shooting Repair Servicing and Fine Tuning Plant Interlocking Systems Close Loop Control System	Instrument Engineers/ Technicians	21 Days
4. Electrical Maintenance Course	Electrical Fundamentals Testing Devices Electrical Diagram Motor Circuit Protection & Control Cables,Conductors & Conduits Generator,Excitation & Electrical Systems and Load Distributions Maintenance Procedures Troubleshooting & Emergency Repair Rewinding Procedures	Electrical Maintenance Personnel	21 Days

Table 7-4-4 OPERATION AND MAINTENANCE TRAINING COURSES (2) (HEP,TL,SS)

Couse Title	Course Content	Participants	Duration
4. Electrical Maintenance Course	Storage Battery & Charger Metering & Relaying Basic Electronics Emergency Systems Miscellaneous Electrical Equipment		
5. Mechanical Maintenance Course	Blueprints Machine Shop Equipment & Tools Maintenance Processes & Materials Repair/Preventive Maintenance of Bearings Common Equipment Troubles:their Repair & Preventive Maintenance Inspection/Repair/Maintenance of Mechanical Equipment & Auxiliaries Industrial Safety	Mechanical Maintenance personnel	21 Days
6. Welding Technology Course	Weldind and Cutting Processes - Oxy-Acetylene Cutting - Air Carbon Cutting - Plasma Cutting - Shielded Metal Arc Welding - Plasma Welding - GTAW & GMAW - Submerged Arc Welding and PGW Welding Design and Economics Welding Procedure Welding Metallurgy Inspection and Testing Codes and Standards Quality Assurance and Quality Control	Welders and Maintenance personnel	20 Days

Table 7-4-4 OPERATION AND MAINTENANCE TRAINING COURSES (3) (HEP,TL,SS)

Couse Title	Course Content	Participants	Duration
7. Maintenance Planning and Control Course	Work Breakdown Structure Logic/Time Planning Networking, Bar Charts Time-scaled Network Resource Allocation/Levelling Program Schedule/Cost Time Value of Money Time/Trade-off Crashing	Maintenance Personnel	5 Days
8. Managed Maintenane Program	Corporate Policies Maintenance Program Plan Administrative Procedures - Orgn. & Responsibilities - Plant Procedures - Documents & Records - Program Administration - Deficiency Reporting - Maint. Work Order System - Safety & Tagging - Measuring & Test Equip. - Control of Modification - Welding & Special Process - Plant Equipment - Personnel Qualification - Work Permit - Inspection Program - Cleanliness	Plant Personnel	3 Days

Table 7-4-4 OPERATION AND MAINTENANCE TRAINING COURSES (4) (HEP,TL,SS)

Couse Title	Course Content	Participants	Duration
9. Basic Lineman's Course	Theoretical Input - Lineman Role/Responsibility in the NPC Organization - First Aid Treatment - Tools/Equipment Identification,Uses and Handling - Guys,Installation, Tensioning Clearances - Pole Loading and Hauling - Conductors - Line Maintenance - Construction of Dummy Line Practicum - Preparation of Line Materials - Working on Actual Transformer - Making Splices/Joints/Sleeves - Construction/Dismantling Types A-E Lines - Erecting Poles - Climbing/Descending Poles - Conductor Riding - Replacement or Crossarms and Insulators	Lineman A Other members of the line gang	30 Days
10. Hotline Maintenance Course	Live Line Tool Identification and Uses Live Line Job Planning and Safety Selection,Use, and Care of live Line Tools Routine Line Maintenance Pole/crossarm Replacement Replacement of Insulators Testing of Hotsticks	Transmission Line Maintenance Personnel	33 Days

Table 7-4-4 OPERATION AND MAINTENANCE TRAINING COURSES (5) (HEP,TL,SS)

Couse Title	Course Content	Participants	Duration
11.Substation Operations and Maintenance Course	Schematics and Diagram Reading High Voltage Equipment Circuit Breakers,Transformers Metering and Protective Relaying Standard Switching Procedures 2-day *Troubleshooting*	Engineers of Power Plants & Substation	23 Days
12.Operation and Maintenance Course on High Voltage Circuit Breakers	Review on Schematics/Power Systems Design and Applications Principle of Operation Maintenance Requirments Oil/Air Blast Circuit Breakers *SF6* Troubleshooting	Engineers of Power Plants & Substation	10 Days
13.Schematic and Troubleshooting Techniques	Single Line Diagram *AC/DC Circuits* Design,Wiring,and Operational Testing of Circuits Troubleshooting	Engineers of Power Plants & Substation	6 Days
14. Woodpole Maintenance	*Introduction to Woodpole Maintenance* Classification of Woodpole Identification of Defects/Decay *Techniques of Treatment* Practicum	T/L Superintendents, Prin.Engrs. Foremen and Linemen	3 Days
15.Protective Relaying and Transformer,Switchgear,Motors and Generators Testing and Maintenance	Protective Relaying Transformer Testing & Maint. Switchgear Testing & Maint. Motors & Generators Testing & Maintenance	Electrical Engineer involved in Planning, designing and operations of power systm	4 Days

7.5 Transmission Lines and Substations

7.5.1 Present Status and Problems of Operation and Maintenance

1. Operation and Maintenance System

(1) Regional Centers and TS

As explained in Sub-clause 7.4.1.

(2) Area Offices

The area offices are responsible for the operation and maintenance of substations and transmission lines. The organizational structure is divided into the Substation Operation and Maintenance Section, the Transmission Line Maintenance Section, and the Support Services Section, under the control of the respective area manager, substation manager, and transmission manager. In NLRC and SLRC, 10 area offices, 7 in NLRC and 3 in SLRC, cover 26 provinces (refer to Tables 7-4-1 and 7-4-2).

The major changes effected by the reorganization are:

- 6 area offices and 24 sub-area offices in the former structure were integrated into 10 area offices. This integration has facilitated efficient execution of maintenance works.
- The posts of substation manager and transmission manager were established, and the management system of these two sections has been reinforced.
- The number of the substation operators was reduced and the Substation Maintenance Section and the Transmission Line Maintenance Section have been reinforced.

By the above changes, maintenance planning and implementation are expected to be improved hereafter.

2. Operation and Maintenance Procedures

(1) Operation of Substations

Operation of the major substations (230 kV and 115 kV) is performed by the 4-group 3-shift system, with 2 operators at the 230 kV substation and 1 operator at the 115 kV substation for each shift. Operators perform the operation in accordance with the instruction from the load dispatching office and the established operation manual. Some of the 69kV load-end substations are unmanned. Many 69 kV load-end substations are owned by the cooperatives and those still owned by NAPOCOR will be gradually transferred to cooperative ownership.

The operation log is recorded with hourly data every day, but the frequency of recording is considered reducible.

(2) Maintenance of Substations

Maintenance of the substations is taken care of by the substation maintenance sections of the area offices, and preventive maintenance of major equipment by TS.

TS makes the rounds of substations and performs preventive maintenance (test, calibration, repair, and trouble shooting) of protective relays, meters, power equipment, and communication equipment.

In the substations, the operators conduct patrol checks and the maintenance staff perform maintenance works. Patrol checks are conducted in each shift. The results are recorded into the patrol checklist and kept.

All maintenance works are performed by in-house work forces. For the maintenance works, work schedules and accomplishment reports are prepared. For the works carried out by TS, TS submits the reports to the area offices.

As for the maintenance planning, the area offices prepare the annual preventive maintenance program upon consultation with TS, and submit the budget including the TS portion to the Head Office through the regional centers.

Frequency of preventive maintenance conducted by TS is as follows.

. Grid relays (for 230kV and 115kV lines)	Twice a year
. Other relays	Once a year
. Billing meters	Twice a year
. Indicating meters	Once every 2 years
. Integrating meters	Once a year
. Power equipment	Once a year
. Communication equipment	Twice a year

Since the above frequency is considered generally higher than needed, it is necessary to check the test results and review the frequency. Once every 3 years would be sufficient for the power equipment and once every 6 years or so for the GCB. Also, since there are some items which do not require periodic tests, such as turn ratio, winding resistance, exciting current tests of the transformer, an overall review will be necessary.

On the other hand, some meters were found inaccurate, requiring thorough testing or replacement. Also, defective circuit breakers and disconnecting switches were found in some substations. It is necessary to conduct periodic operation tests for these equipment and take immediate countermeasures whenever any defects are discovered.

As for the patrol checks at the substations, there are a large number of items requiring daily checks and, moreover, these checks are carried out in each shift. In view of the present conditions of facilities, weekly check during the day shift seems to be sufficient.

(3) Maintenance of Transmission Lines

Maintenance of the transmission lines is taken care of by the transmission line maintenance sections of the area offices. These sections are divided into 1 to 3 groups, respectively consisting of 2 to 5 maintenance crews. In general, each province is provided with one group. Each maintenance crew is staffed by 8 members, namely, 1 foreman, 6 linemen and 1 driver. In NLRC and SLRC, there are 11 transmission line maintenance sections, 22 groups and 72 maintenance crews. Each maintenance crew is provided with a working vehicle and each group a truck with crane.

The maintenance crews perform patrol checks and maintenance works of transmission lines. For the patrol checks, patrol and inspection are usually performed at the same time, and some area offices conduct right of way (ROW) clearing at the same time as well. The results of each patrol check are recorded into the patrol checklist and kept.

All maintenance works are performed by in-house work forces. For patrol checks and maintenance works, work schedules and accomplishment reports are prepared on a weekly basis. Major maintenance works are ROW clearing and replacement of wooden poles and insulators.

For the maintenance planning, the area offices prepare the annual preventive maintenance program and submit the budget to the Head Office through the regional centers.

An effective way to perform patrol checks of transmission lines would be to divide the works into the patrol for visual observation of ROW and facilities, and the inspection of steel towers, wooden poles, insulators, conductors, etc. As for the frequency, 2 or 3 times a year for the patrol and once every 2 or 3 years for the inspection would be adequate.

Since many faults have occurred in the transmission system, it is necessary to investigate the causes of the faults and push forward the countermeasures for fault reduction. One cause is the large IKL but other causes such as frequent occurrence of back flashover due to defective grounding of steel towers, decrease in clearance due to swinging of suspension insulator strings, flashover due to the contamination of insulators, etc. can be thought of.

Also, for the steel tower failures, misapplication of suspension towers and strain towers, and the influence of missing parts recorded on the transmission line patrol checklists can be considered as causes, not to mention insufficient design strength.

Since there are many faults due to wooden poles breakdown, it will be necessary to strengthen the preventive maintenance of wooden poles. Also, hot-line detection of defective insulators should be conducted to reduce the faults caused by defective insulators.

ROW clearing accounts for a large portion of the maintenance works. Such simple works as ROW clearing should be delegated to common laborers, and the maintenance crews should devote themselves to the maintenance of facilities.

3. Operation and Maintenance Manuals

(1) Operation Manual

For the operation of substations, the corporation-wide standardized manual, "Lines and Substation Energizing/Shutdown Procedure", has been established. In addition, each substation has its own operation manual that is applicable to the substation.

For the equipment such as transformers, circuit breakers, reactors, etc., specifications and operation manuals prepared by the manufacturers are used for operation and maintenance.

(2) Maintenance Manual

a. Substation Patrol Checklist Guideline

Check items and checking frequency for each equipment in the substations and the form of the patrol checklist have been specified. Review of checking frequency is necessary as mentioned in Item 2 above. Since the battery check item (4.1.b of substation patrol checklist guideline) contains technical problem, this item should be reviewed.

b. Transmission Line Patrol Checklist Guideline

Though the check items for the steel towers, wooden poles, etc. and the form of the patrol checklist are defined, the checking frequency is not specified. It is necessary to review the patrol check procedures, check items, and checking frequency as mentioned in Item 2 above.

4. Operation and Maintenance Records, Reports, and Reporting System

(1) Substation Operation Log

Voltage, power, reactive power, and phase current, etc. by lines are recorded every hour.

(2) Forced Outage Report

The area offices submit daily reports to the regional centers and monthly reports to the regional centers and TS. These reports contain the name of the lines, date, duration, lost energy, causes, etc.

The forced outage report contains the following problems:

a. There are many "unknown" and "transient" recorded in the cause column. Primary causes such as lightning, wind, rain, etc. should be recorded.

b. In some cases, the damaged facilities themselves are inadvertently recorded in the cause column.

c. Classification of causes differs by area offices.

d. Forced outage, scheduled outage, and unscheduled outage are enumerated in the monthly report in sequence of date. The report should be classified by the kind of outage, by lines, and by causes.

(3) Maintenance Work Schedule and Accomplishment Reports

These reports are prepared on a weekly basis. The reports contain the date, structure No., work descriptions, name of linemen, etc. The accomplishment reports should be utilized as the management data for the maintenance works by summarizing the work descriptions and man-months.

5. Spare Parts Inventory Level and Management System

(1) Transmission Lines

The major materials used for the maintenance of transmission lines are wooden poles, wooden crossarms, insulators and conductors, and these materials are requested according to the annual preventive maintenance program. The used quantity is relatively small, and though some cases were observed where conductors or others were left exposed outdoors, the quantity control is generally adequate. In the area offices, the property custodians perform material management.

However, since there were some cases of prolonged outage caused by typhoons and others, it will be necessary to estimate the quantity of unplanned materials based on the past records of materials and store the spare materials in the regional centers or the area offices.

(2) Substations

The major spare parts at substations are the parts of transformers and circuit breakers. As with the case of transmission lines, the quantity used is small and quantity control is adequately conducted. However, there are some cases of lacking spare parts for the following reasons.

- A variety of equipment have been purchased from various manufacturers of different countries.

- Parts for old equipment are no longer manufactured.

- Procurement of parts requires considerable time.

- Insufficient specifications, inadequate lead time, time-consuming bidding procedures, etc. have caused delay in the delivery of parts.

On the other hand, repairs requiring high-skilled technique, such as overhauls of GCBs, are likely to increase in the future.

Spare parts should be stored in the future, and in addition, the spare equipment of standard specifications should also be stored for the above-stated reasons.

For the spare parts management, the following study should be pushed forward.

- Arrangement of statistics of parts used in the past.
- Arrangement of equipment fault statistics
- Review of the availability of parts
- Review of the standard inventory level of spare parts
- Standardization of specifications
- Adequate lead time and ordering points
- Simplification of procurement procedures such as bidding procedures, delegation of procurement authorities to lower organizations, etc.
- Strengthening of the spare parts management system in the Head Office and the regional centers

As for the storing condition of spare parts, there was a case where parts were exposed to rain alongside scrap materials. Also, among the materials stored in the warehouse, some became useless because of damage from leaking rain or absorption of moisture.

In one area office, a warehouse with the roof but no wall was under construction. Since some materials are to be kept for a considerably long period, more attention should be paid to the storing condition of materials.

6. Custody of Technical Documents and Drawings

Specifications and drawings at the time of construction are not kept in the area offices, but kept by the engineering department of the Head Office. Some of them for old facilities are missing.

In the substations, specifications, drawings and operation manuals prepared by manufacturers are kept. Though the single line diagrams have been prepared, the forms and recorded items differ at each substation, and the diagrams have not been updated periodically.

As for the transmission lines, the route plans and sectional profile drawings, steel tower drawings, clearance diagrams, etc. are rarely maintained in the area offices. In some area offices, technical data containing details of structures, span length, etc. for wooden pole lines have been prepared.

7. Test Instruments, Workshop Facilities, and Repair Tools

The test instruments are maintained by TS, and the area offices are provided with instruments necessary for routine maintenance such as meggers, multi testers, clamp ammeters, hydrometers, oil testers, etc.

In the workshops of the area offices, only repair tools such as grinders, welding machines, soldering guns, hand drills, wrenches, power saws, etc. are provided, but this poses no problem for the time being.

8. Training of Operation and Maintenance Staff

As described in Item 8 of Sub-clause 7.4.1.

9. Load Dispatching System and Communication System

(1) Load Dispatching System

Operation of power plants, transmission lines and substations is conducted by instruction from the Power Management Center. Information from each station concerning the system operation is, in part, automatically transmitted through telemeters. However, most of the information is collected by telephone. Also, all load dispatching instruction for system operation is issued through telephone.

Though computers are provided for supporting the load dispatching task, 70% of the information is inputted manually due to the incomplete communication system. Accordingly, instantaneous information collection from each station is insufficient and the computer system is far from functioning satisfactorily.

Frequency fluctuation is quite large, and further improvement seems to be impossible with the present power system capacity and regulating capability of NAPOCOR. At present, NAPOCOR is planning to adopt AFC, but satisfactory functioning cannot be expected because the regulating capacity of power plants is insufficient. It will be necessary to fully investigate the conditions of load fluctuation, review the regulating capacity of generators, and study the optimal method.

As for the voltage regulation, due to the insufficient capacity of the reactive power control equipment, the voltage in the metropolitan area drops drastically during thermal power plants shutdowns. And also, the voltage in the northern system similarly drops when hydro power plants in the northern system are stopped. It will be necessary to study and implement the installation of power capacitors as quickly as possible. Also, since there is no agreement with MERALCO on reactive power, the share of responsibility for voltage maintenance is not clear. For maintaining the voltage in the metropolitan area, the extent of responsibility should be clarified with MERALCO and phase modifying equipment should be installed, as needed by both parties.

As for the emergency procedures in case of faults, it seems impossible to adequately handle complicated faults with any reasonable speed by the use of the existing communication system. Therefore, the establishment of effective system operation procedures in case of faults and the improvement of the communication system are strongly urged.

(2) Communication System

The existing communication system for load dispatching consists mainly of micro-wave and power line carrier systems. Since both are equipped with small capacity equipment, the number of channels is insufficient and satisfactory load dispatching is impossible.

The RTU's (Remote Terminal Unit) for collection of site information for load dispatching are also insufficient, and the reinforcement of the RTU's as well as the communication system is necessary.

In addition, since the load dispatching has priority in the use of communication channels, the channels available for other business are insufficient. It will be necessary in the future to further strengthen the communication system to realize computerization and rationalization of business activities.

7.5.2 Recommendations on the Operation/Maintenance Improvement Plan

The study and implementation of the following improvement plan is recommended for solving the problems of operation and maintenance mentioned in Sub-clause 7.5.1.

1. Operation and Maintenance System

As described in Item 1 of Sub-clause 7.4.2.

2. Operation and Maintenance Procedures

(1) Preventive Maintenance by TS

To reexamine the past test results and review the frequency of preventive maintenance and the test items for each equipment. The adequate frequency of the preventive maintenance will be roughly once every three years with the power equipment, once every six years with GCB's, once a year with the billing meters, once every two years with the integrating meters, and as the necessity arises with the indicating meters. Among the test items, the turn ratio, winding resistance, and exciting current tests are considered unnecessary.

(2) Recording of Substation Operation Log

To reexamine the necessity of data that have been recorded hourly with each line, such as voltage, power, reactive power and phase current, and review the recording frequency. It will be sufficient to record every hour during the peak load duration and two to three times for the rest of the day.

(3) Frequency of Substation Patrol Checks

To reexamine the necessity of the patrol checks that have been conducted in each shift every day, and review the frequency. In view of the current conditions of the equipment, once a week during the day shift will be sufficient.

(4) Patrol Check Procedures of Transmission Lines

a. To divide the transmission line patrol checks into the patrol for visual observation of ROW and facilities, and the inspection of steel towers, wooden poles, insulators, conductors, etc. It is advisable to perform minor maintenance works during the patrol and conduct the inspection separately. The standard frequency could be 2 or 3 times a year for the patrol and once every 2 or 3 years for the inspection.

b. To adopt the hot-line detection of defective insulators so as to minimize the faults caused by defective insulators.

(5) Contracting out of Simple Works

To contract out the simple works like ROW clearing to common laborers, enabling maintenance crews to concentrate on the maintenance of facilities.

(6) Promotion of Fault Reduction Countermeasures

To prepare the fault reduction program based on the fault statistics described in Item 4 of this Sub-clause, and effectively push forward the fault reduction countermeasures by setting the priority of respective countermeasures.

3. Operation and Maintenance Manuals

(1) Substation Patrol Checklist Guideline

To review the checking frequency and check items, and revise the guideline.

(2) Transmission Line Patrol Checklist Guideline

To review the patrol check procedures, checking frequency and check items, and revise the guideline.

4. Operation and Maintenance Records, Reports, and Reporting System

(1) Forced Outage Reports

a. To standardize the classification of causes on the corporation-wide level. The following shows one example of the cause classifications.

  - Defective manufacture, defective installation, defective maintenance, natural deterioration, wind and rain, lightning, flood, salt/dust contamination, intentional acts or errors, contact with other objects, influence of other faults, others, unknown

b. To investigate primary causes as much as possible to utilize the reports in planning the preventive measures.

c. To record damaged facilities separately from the causes.

d. To prepare monthly and annual reports classified by lines, by causes, and by damaged facilities, and submit them to the regional centers and the Head Office.

(2) Maintenance Work Reports

To summarize the work descriptions and man-months from the present maintenance work accomplishment reports, prepare monthly and annual reports, and submit them to the regional centers and the Head Office.

5. Spare Parts Inventory Level and Management System

(1) Transmission Lines

a. To divide the materials used for the transmission lines into planned and unplanned materials and record them.

b. To study the spare materials storing system at the regional center or the area office level by estimating the required quantity of unplanned materials.

(2) Substations

As explained in Item 5 of Sub-clause 7.5.1, the following study should be pushed forward.

- Arrangement of statistics of parts used in the past
- Arrangement of equipment fault statistics
- Review of the availability of parts
- Review of the standard inventory level of spare parts and spare equipment
- Standardization of specifications
- Adequate lead time and ordering points
- Simplification of procurement procedures such as bidding procedures, delegation of procurement authorities to lower organizations, etc.
- Strengthening of the spare parts management system in the Head Office and the regional centers

6. Custody of Technical Documents and Drawings

(1) Transmission Lines

a. For the steel tower lines, to establish the rule for maintaining the route plans and sectional profile drawings, steel tower drawings (including foundation), clearance diagrams, etc. at the time of construction. For the existing lines, to prepare the above documents and drawings and distribute them to the regional centers and the area offices.

b. For the wooden pole lines, to maintain the technical data containing the wooden pole construction/replacement years, structures, span length, etc., and the route maps in all area offices.

(2) Substations

a. To establish the rule for maintaining the specifications and drawings at the time of construction. For the existing substations, to prepare the above documents and drawings and distribute them to the regional centers and the area offices.

b. To standardize the single line diagram and establish the rule for periodic updating.

7. *Test Instruments, Workshop Facilities, and Repair Tools*

At the substations, the maintenance requiring highly skilled technique, such as the overhaul of GCB, will increase in the future. In preparation for this, it will be necessary to study the methods of execution of inspection and repair, and improvement of the workshops. Maintenance Engineering Center (MEC) should be utilized for the overhaul of GCB.

8. Training of Operation and Maintenance Staff

As described in Item 8 of Sub-clause 7.4.2.

CHAPTER 8

ENVIRONMENTAL MANAGEMENT

CHAPTER 8 ENVIRONMENTAL MANAGEMENT

8.1 Environmental Management in the Republic of the Philippines

8.1.1 Environmental Administration in the Philippines

In 1977, the administration of environmental affairs was handled individually by various Ministries and Bureaus of the government, but the National Environmental Protection Council (NEPC) was established in 1977 as the united organization by Presidential Decree PD-1121, and the Minister of Human Settlement was appointed as chairman of the Council.

The following four basic matters were decided by Presidential Decree PD-1151.

(1) National Environmental Policy
(2) National Environmental Goal
(3) Right to a Healthy Environment
(4) Environmental Impact Statement (EIS) System

And the National Pollution Control Commission (NPCC) was established as the organization to enforce the environmental regulations.

In 1978, NPCC promulgated the Rules and Regulations of the National Pollution Control Commission (1978).

Pursuant to the provisions of Section 6 of the Presidential Decree PD 984, known as the National Pollution Control Decree of 1976, NPCC promulgated the rules and regulations for the prevention of environmental pollution on June 5, 1978.

In 1979, by Presidential Decree PD-1586, the application of the Environmental Impact Statement (EIS) was promulgated against the projects in Environmentally Critical Areas.

In 1984, the application of the control and regulations by the Laguna Lake Development Authority (L.L.D.A.) was promulgated against the projects along the shores of Laguna Lake by Executive Order - 927.

In 1987, as the Aquino Regime started, the Ministry of Human Settlement was replaced by the Department of Environment and Natural Resources (DENR) and NEPC, and NPCC was reorganized under DENR. NEPC was abolished and the Environmental Management Bureau (EMB) was created, and NPCC was absorbed by DENR.

In 1990, the Water Quality Criteria and Effluent Regulations for the prevention of water pollution were revised.

Chapter III, Sections 68 and 69 of NPCC Rules and Regulations (1978) were replaced by DENR Administrative Order (A.O.) No. 34 and No. 35.

DENR AO: No. 34 (Water Quality Criteria)

Revised water usage and classification, Water Quality Criteria Amending Section Nos. 68 and 69, Chapter III of the 1978 NPCC Rules and Regulations.

DENR AO: No. 35 (Effluent Regulations)

Revised Effluent Regulations of 1990, Revising and Amending The Effluent Regulations of 1982.

The rules and criteria relating to the air and water quality and noises are described in 8.1.3 Present Status of Environmental Management at Power Plants.

8.1.2 Present State of the Environment

Metro Manila now has many problems accompanying its industrialization and population growth. Refer to Table 8-1-1.

Table 8-1-1 Population of the Philippines

	The Philippines	Metro Manila
1960	27,087,685	2,462,488
1980	48,098,460	5,925,884
1995 (estimate)	68,424,000	8,971,000

1. Solid Waste

The present amount of solid waste discharge is 3,600 t/day. However, it is estimated that, in the year 2000, the amount will reach 5,000 t/day. Therefore, disposal of waste along with the treatment of toxic and harmful matters is now being studied.

2. Air Pollution

Sixty percent of the air pollution is believed to be caused by the transport facilities while the other 40% is caused by the factories. The SO_2 concentration within Metro Manila is 0.05 ppm, which is less than the NPCC's control value of 0.14 ppm. The exhaust from diesel engine automobiles is considered as a major pollution source.

3. Sewage Disposal

Only about 12% of the Manila population uses the sewage collection system. As a large amount of waste and sewage is disposed of in rivers and canals, the contamination of the river water has been aggravated.

4. Nature Conservation

For the conservation of the natural environment, the Philippine Government is striving to conserve the national parks by preventing illegal settlement of people and felling of trees.

Also, the preservation of animals indigenous to the Philippines, such as flying lemurs, Philippine eagles and Philippine crocodiles, is also a consideration.

8.1.3 Present State of Environmental Management at Power Plants and Recommendation

Since the energy crisis in 1973--1974, in the energy utilization in the Philippines, the stress has been placed on the development of domestic coal, hydro-electric power and geothermal sources in place of heavy oil.

Now, in the Medium-term Development Plan of 1988--1992, the targets are set for upholding of environmental measures and safety measures for the projects, along with rationalization and reduction of the cost of power generation/transmission and improvement of efficiency of power generation.

The following is the present state of the environmental management at the NAPOCOR power plants, along with recommendations.

1. Air Quality

(1) Exhaust gas from stack

a. Standards

Pursuant to the provision of Section 58 of Rules and Regulations of the National Pollution Control Commission (1978), Maximum Permissible Emission Standard for Specific Air Pollution from Stationary Sources is as follows.

Total Sulfur Oxides	250 milligrams/scm as SO_2, or where limit cannot be met, control to be by stack height
Oxides of Nitrogen	2 grams/scm as NO_2
Note:	If the emission standard cannot be met due to economic and technical limitations, then the ambient air quality standard should prevail.

b. Findings

As the oil-fired thermal power plants (Sucat, Malaya, Manila and Bataan) use heavy oil with the sulfur content of 2.5--4.0%, the SO_2 discharged from the stack is 1,500--2,500 ppm (refer to Table 8-1-2), far exceeding the control value of 250 mg/scm (SO_2 = 87.5 ppm).

[Reference]

In accordance with the present standard for fuel oil (Bureau of Product Standard, Department of Trade and Industry), the maximum sulfur content is 4%. The following table indicates the SO_2 concentration in exhaust gas calculated from the sulfur content in fuel used by NAPOCOR.

Table 8-1-2 SO_2 Concentration in Exhaust Gas at Power Plants (Calculated Value)

Plant	Fuel Oil	Sulfur Content (%)	SO_2 (ppm)
Sucat	Banker C	2.68	1,550--1,590
Malaya	PPC residue +Bunker C	3.63	1,953--2,175
Manila	Bunker KC	3.12	1,573
Bataan	Hi-viscosity	4.07	2,440

In order to meet the emission standard of 250 mg/scm (87.5 ppm as SO_2), a heavy oil with low sulfur content of 0.16% must be used.

c. Present Conditions of Management

Currently, the sampling of stack exhaust gas is possible at all the oil-fired thermal power plants except for Sucat No.1 and No. 2 Units. However, the measurement of exhaust gas (SO_2, SO_3, NOx and dust) is not being conducted on a regular basis. Only at the Batangas Coal-fired Thermal Power Plant, the SO_2 analyzer is installed on the stack for continuous measurement.

d. Recommendation

An exhaust gas sampling port should be installed on each boiler outlet or flue so that the SO_2, SO_3, NOx and dust may be measured regularly. The recommended measuring methods by Japanese Industrial Standard (JIS) are as follows:

JIS K-0103 Methods for Determination of Sulfur Oxides in Flue Gas

JIS K-0104 Methods for Determination of Oxides of Nitrogen ($NO+NO_2$) in Exhaust Gas

JIS 2-8808 Methods of Measuring Dust Content in Flue Gas

The flue gas measuring instrument to be permanently installed on the flue in the future is detailed in 8.2.2.

(2) Ambient Sulfur Dioxide (SO_2) Concentration

a. Standard

For the purpose of protecting public health and welfare as well as providing an air quality management control for emission limitation from mobile and stationary sources, National Ambient Air Quality Standards is established by Section 62 of the 1978 NPCC Rules and Regulations. Refer to Table 8-1-3.

Table 8-1-3 National Ambient Air Quality Standards

	Concentration (Micrograms/scm)	(ppm)	Exposure Time (Hours)
Sulfur Dioxide (as SO_2)	369	0.14	24
	850	0.30	1
Nitrogen Dioxide (as NO_2)	190	0.10	1
Suspended Particulate Matter	180	-	24
	250	-	1

b. Findings

The recent record of measurements shows that the above control values have not been exceeded.

c. Recommendations

In the measurement of SO_2, the wind direction and wind speed measured with the operating conditions (load, etc.) of the plant, the distance from the stack should be taken into consideration. The wind direction and wind speed at the measuring points should be recorded along with the measured values.

The NPCC's limit values of SO_2 concentration of 369 micrograms/scm (0.14 ppm) (24 hours) and 850 micrograms/scm (0.3 ppm) (1 hour) control the aggregate SO_2 concentration emitted from a number of plants. For example, if each of Plants A, B and C simultaneously emits exhaust gas equivalent to 0.05 ppm ground concentration of SO_2, the aggregate value becomes 0.15 ppm, which exceeds the limit value. In such a case the plants would have to lower their production or load to meet the limit value of 0.14 ppm.

(3) Suspended Particulate Matter

a. Standard

The NPCC ambient air quality standard for suspended particulate matter is 250 micrograms/scm (1 hour).

b. Findings

The measurement using a high volume air sampler is made once a month at Batangas Coal-fired Thermal Power Plant. The actual measured data indicate that, at some points, the value was high due to the effect of dust on the road.

c. Recommendation

It would be desirable to conduct measurements at some measuring stations downwind from the plant and not affected by outside conditions.

(4) Meteorological Observation

a. Present status

There is a meteorological observation tower at Batangas Coal-fired Thermal Power Plant, where the wind direction, wind speed, air temperature and relative humidity at 10 m and 100 m heights used to be measured. However, the instruments for 100 m have been out of order since 1989, and only those for 10 m are operational as of November 1991. The repair of the instruments is programed at present.

Meteorology is not observed at the oil-fired thermal power plants (Sucat, Malaya, Manila and Bataan).

b. Recommendation

As stated in h. Meteorology in the Environmental Investigation Items concerning Thermal Power Plants in 8.3.1 Matrix Investigation on Each Power Plant's Environmental Impact Factors, the meteorological observation should comprise the ground level measurement (10 m from surface, one year or longer observation period) and the upper air measurement (up to 1,500 m from the surface) at the power plant or the development site. Additionally, past 15--30 years meteorological data from the nearest meteorological observatory must be used for reference.

The first procedure for the surface meteorological observation is to select observation points representative of the district. The observation items are wind direction, wind speed, air temperature and relative humidity, and the atmospheric stability index should be found by measuring the insolation or, cloud cover.

[Reference]

Table 8-1-4 Pasquill Stability Classes Related to Wind Speed and Insolation

Surface Wind Speed (m/s)	Day Time			Day & Night	Night Time		
	Insolation (Cal/cm2.h)			Cloud	Upper Cloud	Middle and Low Cloud	Cloud
	> 50	49 - 25	< 24	8 - 10	5-10	5-7	0-4
< 2	A	A - B	B	D	-	-	-
2 - 3	A - B	B	C	D	E	E	F
3 - 4	C	B - C	C	D	D	D	E
4 - 6	C	C - D	D	D	D	D	D
> 6	C	D	D	D	D	D	D

Note: A: Extremely Unstable

B: Moderately Unstable

C: Slightly Unstable

D: Neutral

E: Slightly Stable

F: Moderately Stable

The insolation should be continuously recorded by the recording equipment and the values during the daytime should be summed up.

The following tables should be produced with the observation results.

(i) Occurrence frequency table of wind directions classified by wind speed classes (by the month, annual average)

(ii) Wind rose classified by wind speed classes

(iii) Occurrence frequency table of atmospheric stability

(iv) Table and chart of occurrence frequency of wind direction classified into daytime and nighttime.

It is recommended that first the surface meteorological observation be conducted at each power plant and, then the environmental impact investigation for the exhaust gas diffusion be implemented.

The continuous monitoring will be discussed later in 8.2.2.

2. Water Quality

(1) Standard

Water Usage and Classification and Water Quality Criteria of the 1978 NPCC Rules and Regulations was revised by DENR Administrative Order No. 34 in 1990.

Effluent Regulations of 1982 was revised by DENR Administrative Order No. 35 in 1990. Refer to Table 8-1-5 Water Quality Criteria and Table 8-1-6 Effluent Standard.

(2) Status

The condenser cooling water used for the Sucat and Malaya Thermal Power Plants is taken from Laguna Lake. The Laguna Lake Development Authority (L.L.D.A.) and Department of Environmental Natural Resources (D.E.N.R.) are in charge of the supervision of water quality.

(3) Recommendation

Thermal power plants discharge a great volume of acid and alkaline waste water that are regeneration waste water from the demineralizing plant and the condensate polisher (Ammonex), air heater wash waste water, etc.

Each power plant should be equipped with the waste water neutralization equipment to satisfy the Effluent Standard of DENR Administrative Order No. 35.

Table 8-1-5 Water Quality Criteria

	Unit	Fresh Surface Water (rivers, lakes, reservoirs) Class C	Class D	Coastal and Marine Waters Class SC	Class SD
Color		(C)	(C)	(C)	(C)
Temperature (max. rise in degree Celsius)	°C rise	3	3	3	3
pH	-	6.5 - 8.5	6.0 - 9.0	6.5 - 8.5	6.0 - 9.0
Dissolved Oxygen	% satn	60	40	70	50
(minimum)	mg/l	5.0	3.0	5.0	2.0
5-Day 20°C BOD	mg/l	7	10	7	-
Total Suspended Solids	mg/l	30 increase	60 increase	30 increase	60 increase
Total Dissolved Solids	mg/l	-	1000	-	-
Surfactants (MBAS)	mg/l	0.5	-	0.5	-
Oil/Grease	mg/l	2	5	3	5
NO_3	mg/l as N	10	-	-	-
PO_4	mg/l as P	0.4	-	-	-
Phenolic Substance	mg/l	0.02	-	(1)	-
Total Coliforms	MPN/100ml	5,000	-	5,000	-
Chloride	mg/l as cl	350	-	-	-
Copper (Cu)	mg/l	0.05	-	0.05	-
Arsenic (As)	mg/l	0.05	0.1	0.05	-
Cadmium (Cd)	mg/l	0.01	0.05	0.01	-
Hexavalent Chromium (Cr Vl)	mg/l	0.05	0.1	0.1	-
Cyanide (CN)	mg/l	0.5	-	0.05	-
Lead (Pb)	mg/l	0.05	0.5	0.05	-
Total Mercury (Hg)	mg/l	0.02	0.002	0.002	-
Organophosphate	mg/l	nil	nil	nil	-

Note:

Class C : Fishery Water/Industrial Water Supply Class I

Class D : Industrial Water Supply Class II (e.g. cooling, etc.)

Class SC: Fishery Water Class II

Class SD: Industrial Water Supply Class II (e.g. cooling, etc.)

(C) : No abnormal discoloration from unnatural causes

(1) : Not present in concentrations to affect fish flavor/taste

Table 8-1-6 Effluent Standard

		Inland Waters Class C	Coastal Waters Class SC	Coastal Waters Class SD & Other Not Classified
		OEI	OEI	OEI
Color		200	(C)	(C)
Temperature (max. rise in degree Celsius)	°C rise	3	3	3
pH	-	6.0 - 9.0	6.0 - 9.0	6.0 - 9.0
COD	mg/l	150	250	300
Settleable Solids (1 hour)	mg/l	0.5	-	-
5-Day 20°C BOD	mg/l	80	120	150
Total Suspended Solids	mg/l	90	200	(g)
Surfactants (MBAS)	mg/l	7.0	15	-
Oil/Grease	mg/l	10	15	15
Phenolic Substances as phenols	mg/l	0.5	1.0	5.0
Total Coliforms	MPN/100ml	15,000	-	-

Note:

OEI: Old or Existing Industry

(C): Dischange shall not cause abnormal discoloration in the receiving waters outside of the mixing zone.

(g): Not more than 60 mg/l increase (dry season)

3. Noise

(1) Standard

The limit values set by NPCC for class D are 75 dB for the daytime, 70 dB for the morning and evening, and 65 dB for the night.

Class D: A section which is primarily reserved as a heavy industrial area.

(2) Status

According to recorded measurements at the thermal and geothermal power plants, the noise at the plant boundary does not exceed the limit values.

(3) Recommendations

a. In accordance with the NPCC standards, the noise levels at plant boundary should be measured and recorded for each time period - daytime, morning, evening, and night.

b. The noise levels of the major noise sources at the power plant should be measured and recorded, and the decreasing rates as they reach the plant boundary should be determined.

c. An isopleth of noise levels inside the plant yard should be prepared.

UDC 662.992:546.22-31:543.2

JIS

Japanese Industrial Standard

Methods for Determination of Sulfur Oxides in Flue Gas

JIS K 0103-1977

Translated and Published

by

Japanese Standards Association

UDC 662.613.5:543.27:546.17-31

JIS

This standard was revised in 7, 1984

JAPANESE INDUSTRIAL STANDARD

Methods for Determination of Oxides of Nitrogen in Exhaust Gases

JIS K 0104-1979

Translated and Published

by

Japanese Standards Association

UDC 543.275.3:628.511.1:
662.613.13

JAPANESE INDUSTRIAL STANDARD

Methods of Measuring Dust Content in Flue Gas

JIS Z 8808 -1977

Translated and Published

by

Japanese Standards Association

8.2 Recommendations on Improvement of Environmental Measures

8.2.1 Control Technology and Removal Methods of PCB

1. Present Status of PCB Control

Polychlorinated biphenyl (PCB) is a homolog of compounds containing chlorine, and usually oily liquid compound. As PCB has superior characteristics in stability, electric insulation, cooling performance and flame resistance, it has been used for electrical equipment including transformers. However, since its toxicity was confirmed, the Ministry of International Trade and Industry of Japan has enforced stringent storage control regulations on the handling of electrical equipment using PCB since 1984. Meanwhile, a high-temperature thermal decomposition test was carried out for the removal of PCB.

The Environmental Service Department (ESD) of NAPOCOR drew up the "Progress Report on the Survey of PCB", describing health damages and handling and control methods, and includes a list of electrical equipment containing PCB. This is an indication of their serious effort in solving the PCB problem.

However, the present conditions of PCB control at the power plants are not always satisfactory. At one power plant, PCB containing oil was left outside in drum cans and new operator did not understand the toxicity of PCB. Also, there were no labels pasted on the drum cans containing PCB.

2. Recommendations for PCB Control

In consideration of the conditions in NAPOCOR, the following are proposed. (Refer to ANNEX 1-4.)

(1) Storage Control

a. Storage Site

A warehouse should be specified to collectively store the small equipment and oil (in drum cans) containing PCB. The large equipment should be stored in the power plant.

b. Storage Control Ledger

The history of the equipment, etc. should be recorded in a control ledger.

c. The PCB containing equipment in use and in storage should be labeled. The labels should be made collectively at the head office and distributed to each power plant.

(2) Person in Charge of Control

In order to prevent oil leakage accidents, a person in charge of the control should be appointed to attend to transfer and removal of the equipment and oil containing PCB, as well as to conduct regular inspections.

(3) PCB Detection Methods

a. Gas Chromatograph

Refer to JIS K 0093, attached in a separate paper. The measuring method should be studied with the gas chromatograph owned by TSD of MMRC.

b. The presence of PCB can be detected by the method using the screening kit.

c. Handling

PCB should be handled with special attention paid to prevention of leakage, and also to its potential harm to the living things.

It should be handled in specified work clothes and gloves.

3. Other Reference Items

(1) Methods of Treatment of Waste Oil Containing PCB

Tests have been conducted throughout the world, and some countries have already established the method of treatment.

For the treatment of PCB, there are the saponification method with the use of caustic alkali, the biological treatment method and the high-temperature thermal decomposition method. However, not all PCBs can be treated by the same method. PCB's containing a large amount of chlorine can not be treated sufficiently by the saponification method or the biological treatment method, but the thermal decomposition method is advisable.

In Japan, a fair result has been obtained with the "thermal decomposition test." However, the present storage control will be continued until the government gives further instruction.

The toxicity of PCB increases with the amount of chlorine contained. Currently, special attention is required for the treatment of polychlorinated dibenzofuran (PCDF) and polychlorinated dibenzodioxin (PCDD) emitted from transformer fires in the U.S.A. PCDF is generated at 500-550°C, and animal tests proved that its toxicity is 1,000 times that of PCB. Although toxicity in the animal tests can not necessarily be translated into human toxicity, precautions should be taken.

(2) Thermal Decomposition Test Results in Japan

The Atmospheric Protection Bureau of the Environment Agency in Japan drew up the "Plan for High-temperature Thermal Decomposition Test of Liquid PCB Waste", and conducted a test open to the local public at the Kanegafuchi Chemical Industry Co., Ltd., Takasago Plant. The results are as follows.

a. Test Target and Control Standard

Table 8-2-1 Test Target and Control Standard for High-temperature Thermal Decomposition Test of Liquid PCB Waste

Item	Content
(1) PCDD PCDF	No generation of PCDD or PCDF during high-temperature thermal decomposition (0.1 ng/liter or lower)
(2) Combustion efficiency	Combustion efficiency ≥ 99.9%
(3) PCB thermal decomposition efficiency	99.9999% or higher
(4) Environmental impact	PCB environmental concentration in the air should be lower than the limit of determination (0.05 microgram/scm).
(5) Safety of exhaust gas	PCB concentration in the exhaust gas should be PCB≤0.01 mg/Nm^3. In addition, the amount of HCl, NOx and dust must conform with the standard of the statute.
(6) Safety of waste water	PCB concentration in the waste water should be lower than the limit of determination (0.05 microgram/l).
(7) Performance of high-temperature thermal decomposition	The thermal decomposition furnace should be operated under the conditions below: High-temp. thermal decomposition temperature 1,400°C ± 75°C Retention time 1.5 sec. or longer Oxygen concentration in exhaust gas 3% or more

b. Test Procedure

The thermal decomposition furnace is heated to 1,400°C with kerosene, into which the liquid PCB waste at 70°C is sprayed and decomposed thermally. The heat of combustion gas is recovered in the waste heat recovery boiler and the gas is cooled down to approx. 300°C, and cooled further to 70°C in the cooling tower. Then, in the absorption detoxification tower, the hydrogen chloride and free chlorine are neutralized, absorbed and removed with the caustic soda.

After leaving the detoxification tower, the gas is cooled to approx. 30°C in the cooling tower and the entrained splash is removed by the mist catcher. Subsequently, the traces of PCB and other harmful substances are removed completely in the activated charcoal absorption tower. Then, the gas is heated to roughly 100°C to prevent white smoking and exhausted through the stack into the air.

c. Test Results

The liquid PCB waste was decomposed and treated precisely. The harmful substances, PCDD and PCDF generated were below detection limit. PCB emission of 10 microgram/Nm^3 was detected in some portions of exhaust gas, but the amount of PCB in the atmosphere was below the limit of determination. The PCB in both the waste water and the sea water was below the detection limit.

From the above results, it can be considered that this test had no impact on the environment. Although no problems were met in the test, it was felt that the material of the piping for the temporarily sampling unit needed improvement.

ANNEX 1. Recommendation for Control of PCB Equipment

Polychlorinated biphenyl (PCB) is a homolog of chemical compounds containing chlorine, usually in oily liquid form, that is well known for their stability, excellent dielectric and cooling properties, and fire resistance.

PCB can exist in more than 200 chemical structures, but only a few of them are actually produced and used.

Because of the superb properties, PCB has been used widely in many electrical equipment, including transformers, large and small capacitors, fluorescent lights, motors, and appliances.

Although capacitors and transformers use a considerable amount of PCB, PCB has been used also in hydraulic heat transfer systems, pigment manufacture, rubber and resin plasticizer, carbonless copy paper, dedusting agent and adhesive.

ANNEX 2. Evaluation of Effects of PCB on Health

The scientific literature concerning PCBs is voluminous. As for information relevant to risk assessment, it includes human clinical and epidemiologic studies, animal studies of dose-response relationships, animal studies of long-term and low-level exposure, and animal studies comparing the biological effect of various PCB mixtures. Animal studies, unlike the studies of human exposure to PCB, have revealed a wide range of toxic effects.

One reason for this is that, in general, animal toxicologic work is conducted at PCB levels well above those experienced by humans; the relevance of such studies to the low-level exposure of humans is a controversial topic.

Among the adverse effects observed in animal studies were skin lesions (including chloracne-like lesions), decline of the immunity, reproductive disorders and off-spring malformations, and some forms of liver toxicity.

Animal studies reveal that the degree of toxic effects is not the same with all types of PCB; those types containing more chlorine are more toxic than those with less chlorine, and some act like the much more toxic polychlorinated dibenzodioxins or dibenzofurans.

In addition, considerable differences in toxicity were observed among animal species.

In general, PCB levels in the blood of the object population in the studies are much higher than those of the general public, which implies an exposure to much higher levels of PCB and, most likely, for longer periods of time.

Nonetheless, the no adverse effect was detected clinically in the population and no overt relationship with diseases was proved.

Exceptions are sporadic contact dermatitis and chloracne. Also, changes in the parameter of blood serum chemistry consistent with liver changes have been observed.

In some studies, clinical disorders suggesting effects on cardio-vascular, respiratory, or nervous systems are reported.

Evidence from these populations that PCB causes cancer is inconsistent and weak at best.

There have been some reports indicating that the ingestion of a high level of PCBs by pregnant women results in shortened gestation periods and reduced birth weights.

ANNEX 3. Detection of PCB in Transformer Oil

Detection of PCB should be made by the gas chromatography test. The test will be made in the following procedure.

Sample - Extraction by N-hexan - Decomposition by alkali - Removal of interfering matters by silica gel column - Gas chromatograph measurement - Confirmation of existence of PCB.

The limit of determination is larger than 0.001mg/liter, and the standard deviation of the reputability is less than 40%.

Here, the polychlorinated biphenyl means the mix compound of monomer to deca-chlorinated biphenyl. Refer to Japanese Industrial Standard, JIS K 0093 Method for Determination of PCB.

Another most desirable direct measuring method is the use of the MESA-200 analyzer using X-ray fluorescene. The MESA-200 analyzer utilizes a low energy X-ray source to determine the sulfur and chlorine content of each sample. Since no radioactive source material is used in the analyzer, no special licensing or maintenance procedures are required. The analyzer has a total measuring range of 0-0.1 wt% Cl, and 0-0.3 wt% S.

The clor-N-Oil PCB screening kit, is a smaller detector which is designed to determine if the chlorine content in the oil sample is less than 20ppm.

The reagent is added to the sample, and the presence or absence of chlorine is judged by the color (blue or yellow).

ANNEX 4. Polychlorinated Dibenzofuran (PCDF) in Utility Equipment

In recent fires involving PCB transformers, (e.g. in Binghamton and San Francisco), PCDF, partial oxidation product of PCB, was found in the combustion products of fire involving PCB.

In a series of animal tests, PCDF (there are 135 different types, called congeners) showed toxicity as much as 1,000 times that of PCB.

Although the hazard of human exposure has not been directly related to the animal tests, the general public are increasingly concerned. (Gilbert Addis)

UDC 547.62'113.1-126:628.
54+631.879

JIS

JAPANESE INDUSTRIAL STANDARD

Method for Determination of Polychlorinated Biphenyl in Industrial Waste Water

JIS K 0093-1974

Translated and Published
by
Japanese Standards Association

8.2.2 Air Pollution Monitoring Method at Thermal Power Plants

1. Present Status of Air Pollution Monitoring

At the four oil-fired thermal power plants of Sucat, Malaya, Manila and Bataan, the concentrations of SO_2, SO_3 and NOx in exhaust gas at the stack entrance are not measured. Air pollution monitoring for SO_2, NOx and dust in the vicinity of the power plants is not regularly conducted, either.

2. Prediction of Exhaust Gas Diffusion

Predictive calculation of the diffusion of exhaust gas was made with the sulfur content in the fuel oil in 1989 and technical information from the boiler manufacturers.

(1) Predictive Calculation of Exhaust Gas Diffusion

Table 8-2-2 Predictive Calculation of Exhaust Gas Diffusion

Plant	Unit	Max. SO_2 ground concentration C max. (ppm)	Distance Xmax. (m)
Sucat	No.1 & 2 No.3 & 4 Total	0.0389 0.0424 0.0805	11,703 13,609 approx. 13 km
Malaya	No.1 No.2 Total	0.068 0.064 0.1315	9,308 10,515 approx. 10 km
Manila	No.1 No.2 Total	0.047 0.047 0.094	5,817 5,817 approx. 6 km
Bataan	No.1 No.2 Total	0.0576 0.0745 0.1285	4,879 6,261 approx. 6 km
Batangas	No.1	0.00451	8 km

(2) Predictive Calculation Formula for Exhaust Gas Diffusion

The predictive calculation of the short-term diffusion of sulfur oxides was made by the Bosanquet and Sutton's diffusion formulas.

The long-term prediction, was made for only Batangas Power Plant where the data of plant weather observatory was available.

As no measured value of solar radiation is available in the meteorological observatory data, the stability cannot be obtained, hence, the neutral D was used for calculation.

a. Calculation by Bosanquet-1 Formula

$$He = Ho + \alpha(Hm + Ht)$$

$$Hm = \frac{4.77}{1 + 0.43\frac{U}{V}} \cdot \frac{\sqrt{Q \cdot V}}{U}$$

$$Ht = 6.37g\frac{Q(T - T_1)}{U^3 \cdot T_1}\left(\log e J^2 + \frac{2}{J} - 2\right)$$

$$J = \frac{U^2}{\sqrt{Q \cdot V}} \cdot \left(0.43\sqrt{\frac{T_1}{g \cdot G}} - 0.28\frac{V}{g} \cdot \frac{T_1}{T - T_1}\right) + 1$$

Where,

He:	Effective stack height	(m)
Ho:	Actual stack height	(m)
α :	Exhaust gas rising coefficient	(= 0.65)
U :	Wind Speed	(= 6m/s)
V :	Speed of exhaust gas	(m/s)
Q :	Exhaust gas volume corrected to atmospheric temperature	(m^3/s, coverted to 15°C)
T1:	Temperature at which density of exhaust gas equals air density	(°K)
T :	Exhaust gas temperature	(°K)
G :	Temperature gradient	(0.0033°C/m)
g :	Acceleration of gravity	(9.8 m/S^2)

b. Sutton's Diffusion Formula

$$C(X) = \frac{2q \cdot \eta}{\pi \cdot Cy \cdot C_Z \cdot U \cdot X^{2-n}} \exp\left[-\frac{1}{X^{2-n}} \cdot \frac{He^2}{Cz^2}\right]$$

$$C_{max} = 0.234 \frac{Cz}{Cy} \cdot \frac{q}{U \cdot He^2} \cdot \eta$$

$$X_{max} = \left(\frac{He}{Cz}\right)^{\frac{2}{2-n}}$$

Where,

C(X)	:	Ground level concentration at downwind axial distance X	(ppm)
X	:	Downwind distance from smoke source	(m)
Cmax	:	Maximum ground concentration	(ppm)
Xmax	:	Distance to maximum ground concentration point	(m)
q	:	Exhaust volume of pollutant	(m^3/s, 288°K)
Cy	:	Horizontal diffusion parameter	(0.07)
Cz	:	Vertical diffusion parameter	(0.07)
U	:	Wind speed	(= 6m/s)
n	:	Coefficient of atmospheric turbulence	(0.25)
He	:	Effective stack height	(m)
η	:	Time correction coefficient one-hour value: 0.15 24-hour value : one-hour value x 0.59	

(3) Calculation Data

Table 8-2-3 Sucat Power Plant

Boiler		No.1	No.2	No.3	No.4
Load	MW	150	200	200	300
Exhaust gas volume	Nm^3/h	388,462	535,385	535,385	789,231
Gas temperature	°C	150	150	150	150
Sulfur content in fuel	wt%	2.68	2.68	2.68	2.68
Fuel consumption	kg/h	32,924	45,246	45,246	65,553
SO_2 emission	Nm^3/h	618	849	849	1,230
SO_2	ppm	1,590	1,585	1,585	1,558
Stack height	m	122		122	
Stack inner diameter	m	5.18		5.18	

Meteorology (assumed)

Wind speed 6 m/s

Stability Neutral value (D)

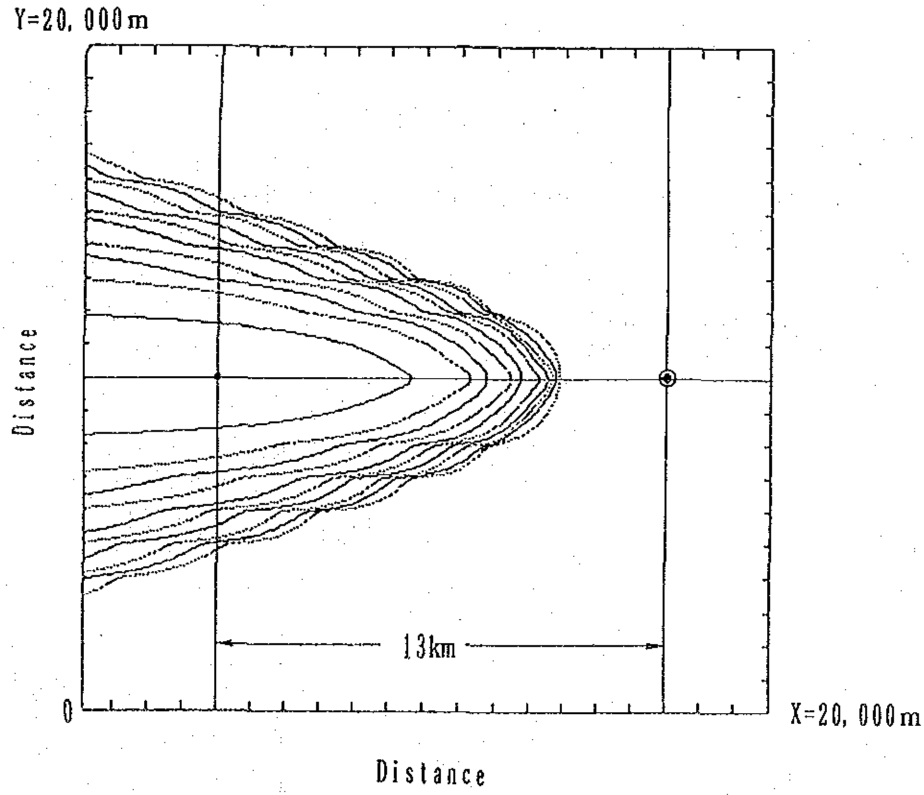
Predictive results of short-term diffusion

Unit	Max. ground concentration Cmax	Distance Xmax
No.1 & No.2	0.0389 ppm	11,703.1 m
No.3 & No.4	0.0424 ppm	13,609.6 m
Total	0.0805 ppm	Approx. 13 km

Fig. 8-2-1 Predictive Results in Sucat District

Sucat District

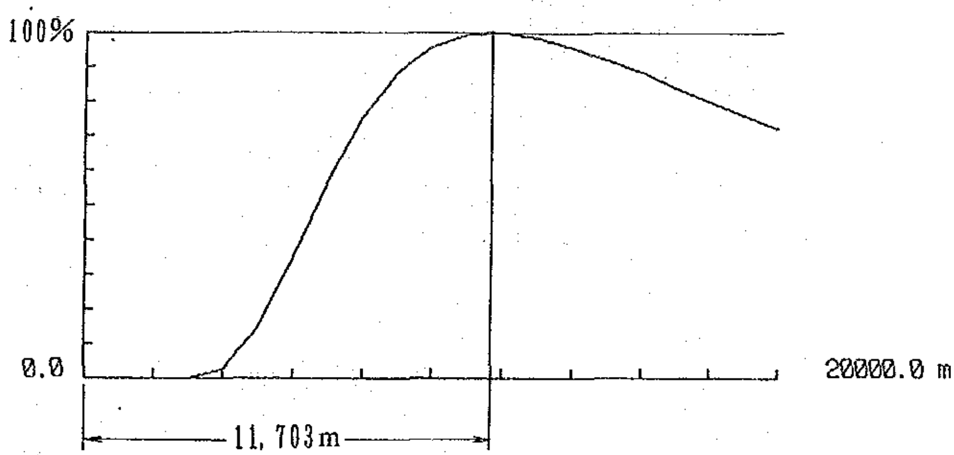
```
Cmax = 0.080521 ppm
i = 4        j = 10
Wind direction             90.0 deg.
Wind speed                 6.0 m/s
Temperature gradient       0.00330°C/m
Exhaust gas rise formula   Bosanquet-1
Diffusion formula          Sutton
Number of stacks           2
Mean time  min             3.00
Cy = 0.467  Cz = 0.070  n = 0.250
Concentration ratio against Cmax
            -- 5.00E-01 -- 2.00E-01
            -- 1.00E-01 -- 5.00E-02
            -- 2.00E-02 -- 1.00E-02
            -- 5.00E-03 -- 2.00E-03
            -- 1.00E-03 -- 5.00E-04
```



Sucat District

Stack No.1

Rise formula by Bosanquet-1, Diffusion formula by Sutton	
Wind direction	90.0 deg
Wind speed	6.0 m/s
Temperature gradient	0.00330°C/m
Effective stack height	254.0 m
Max. ground concentration	0.03898 ppm
Distance of occurrence	11,703.1 m



Stack No.2

Rise formula by Bosanquet-1, Diffusion formula by Sutton	
Wind direction	90.0 deg
Wind speed	6.0 m/s
Temperature gradient	0.00330°C/m
Effective stack height	289.9 m
Max. ground concentration	0.042422 ppm
Distance of occurrence	13,609.6 m

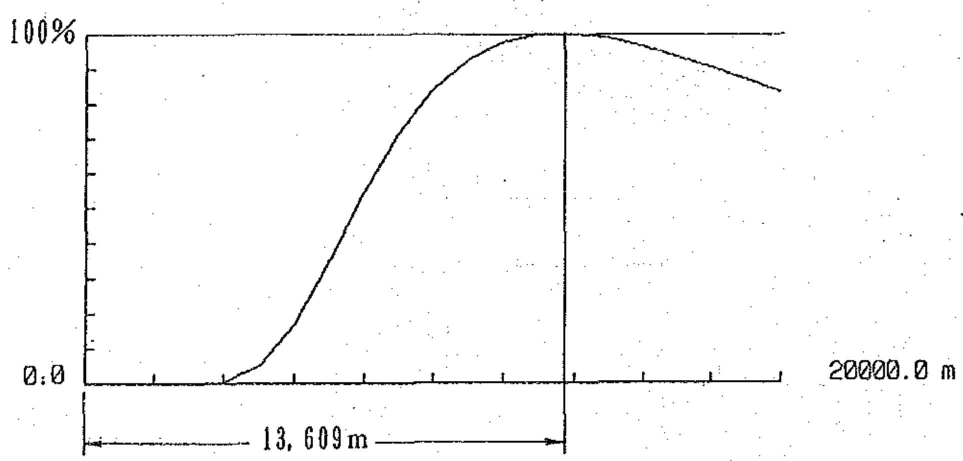


Table 8-2-4 Malaya Power Plant

Boiler		No.1	No.2
Load	MW	300	350
Exhaust gas volume	Nm^3/h	789,231	1,024,615
Gas temperature	°C	150	150
Sulfur content in fuel	wt%	3.63	3.63
Fuel consumption	kg/h	67,559	78,818
SO_2 emission	Nm^3/h	1,717	2,002
SO_2	ppm	2,175	1,953
Stack height	m	90	90
Stack inner diameter	m	4.57	4.57

Meteorology (assumed)

Wind speed	6 m/s
Stability	Neutral (D)

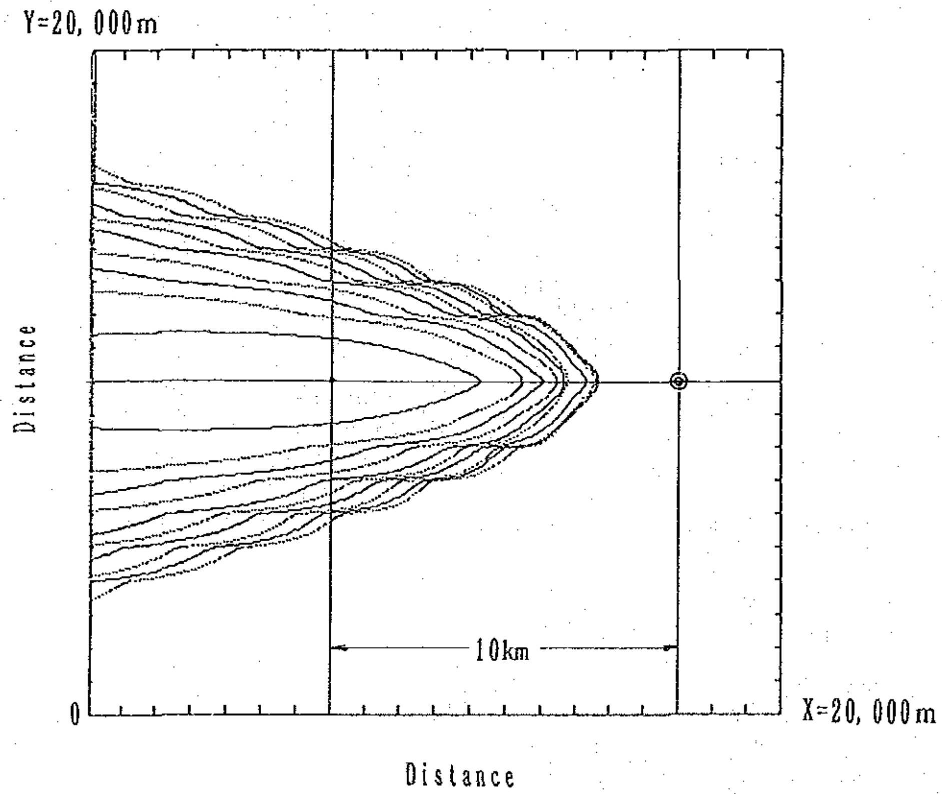
Predictive results of short-term diffusion

Unit	Max. ground concentration Cmax	Distance Xmax
No.1	0.068 ppm	9,308.8 m
No.2	0.064 ppm	10,515.6 m
No. 1 + No. 2	0.1315 ppm	10 km point

Fig. 8-2-2 Predictive Results in Malaya District

Malaya District

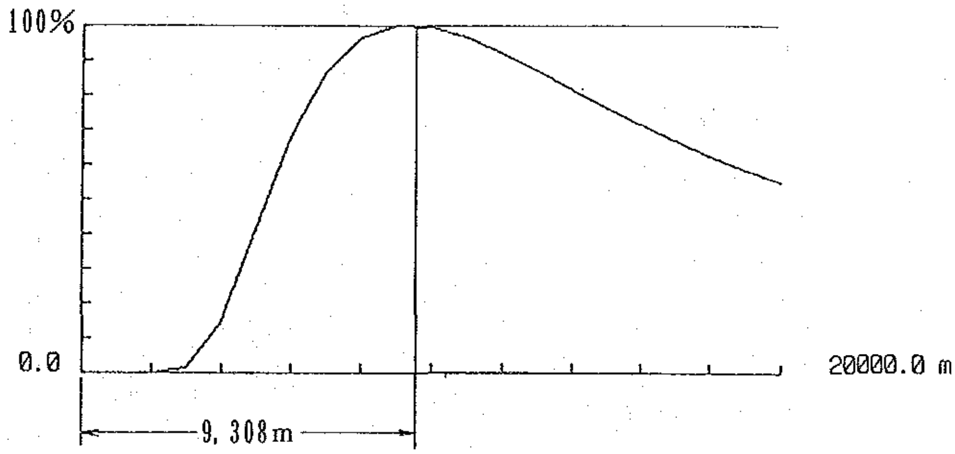
```
Cmax = 0.13153 ppm
i = 7        j = 10
Wind direction            90.0 deg.
Wind speed                6.0 m/s
Temperature gradient      0.00330°C/m
Exhaust gas rise formula   Bosanquet-1
Diffusion formula         Sutton
Number of stacks          2
Mean time   min           3.00
Cy = 0.467  Cz = 0.070    n = 0.250
Concentration ratio against Cmax
            -- 5.00E-01 -- 2.00E-01
            -- 1.00E-01 -- 5.00E-02
            -- 2.00E-02 -- 1.00E-02
            -- 5.00E-03 -- 2.00E-03
            -- 1.00E-03 -- 5.00E-04
```



Malaya District

Stack No.1

Rise formula by Bosanquet-1, Diffusion formula	by Sutton
Wind direction	90.0 deg
Wind speed	6.0 m/s
Temperature gradient	0.00330°C/m
Effective stack height	207.9 m
Max. ground concentration	0.0681 ppm
Distance of occurrence	9,308.8 m



Stack No.2

Rise formula by Bosanquet-1, Diffusion formula	by Sutton
Wind direction	90.0 deg
Wind speed	6.0 m/s
Temperature gradient	0.00330°C/m
Effective stack height	231.3 m
Max. ground concentration	0.06415 ppm
Distance of occurrence	10,515.6 m

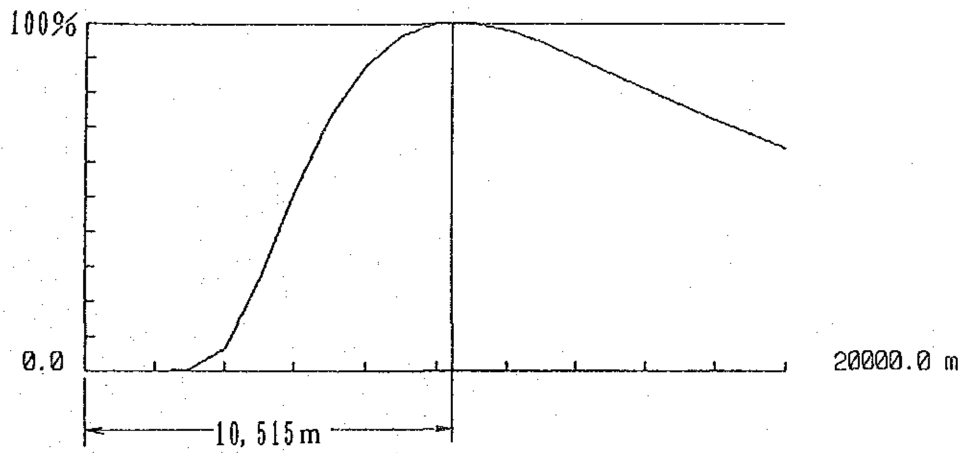


Table 8-2-5 Manila Power Plant

Boiler		No.1	No.2
Load	MW	100	100
Exhaust gas volume	Nm^3/h	332,308	332,308
Gas temperature	°C	136	150
Sulfur content in fuel	wt%	3.12	3.12
Fuel consumption	kg/h	23,935	23,935
SO_2 emission	Nm^3/h	523	523
SO_2	ppm	1,573	1,573
Stack height	m	76	76
Stack inner diameter	m	2.36	2.36

Meteorology (assumed)

Wind direction & speed 6 m/s

Stability Neutral (D)

Predictive results of short-term diffusion

Unit	Max. ground concentration Cmax	Distance Xmax
No.1	0.0472 ppm	5,817.8 m
No.2	0.0472 ppm	5,817.8 m
No. 1 + No. 2	0.0943 ppm	6 km point

Fig. 8-2-3 Predictive Results in Manila District

Manila District

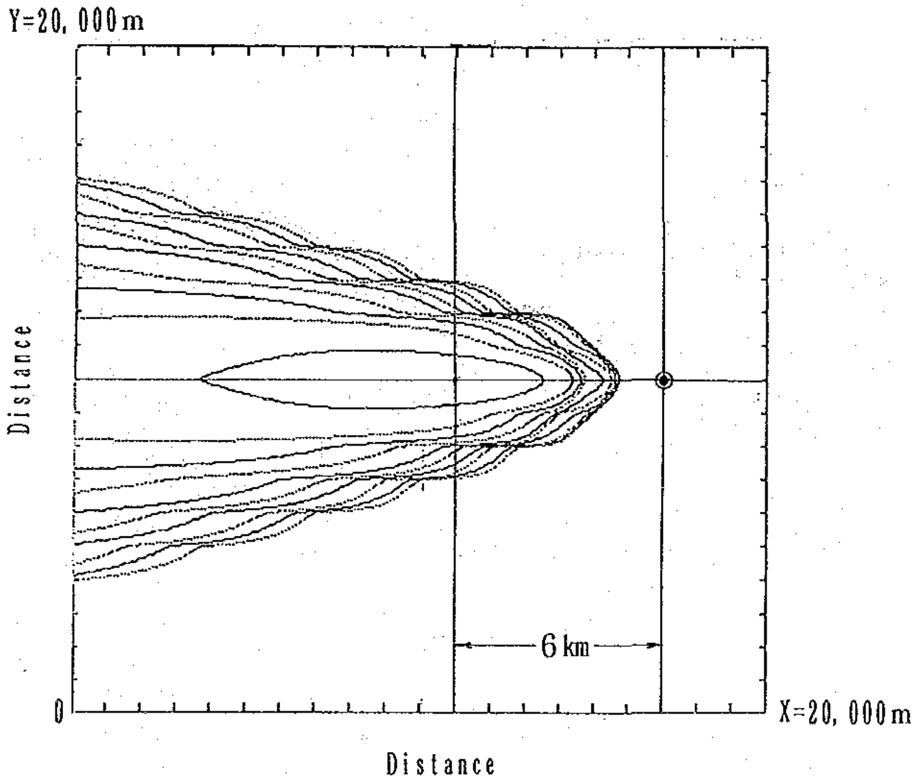
Cmax = 0.094281ppm
i = 11 j = 10

Wind direction	90.0 deg.
Wind speed	6.0 m/s
Temperature gradient	0.00330°C/m
Exhaust gas rise formula	Bosanquet-1
Diffusion formula	Sutton
Number of stacks	2
Mean time min	3.00

Cy = 0.467 Cz = 0.070 n = 0.250

Concentration ratio against Cmax

-- 5.00E-01 -- 2.00E-01
-- 1.00E-01 -- 5.00E-02
-- 2.00E-02 -- 1.00E-02
-- 5.00E-03 -- 2.00E-03
-- 1.00E-03 -- 5.00E-04

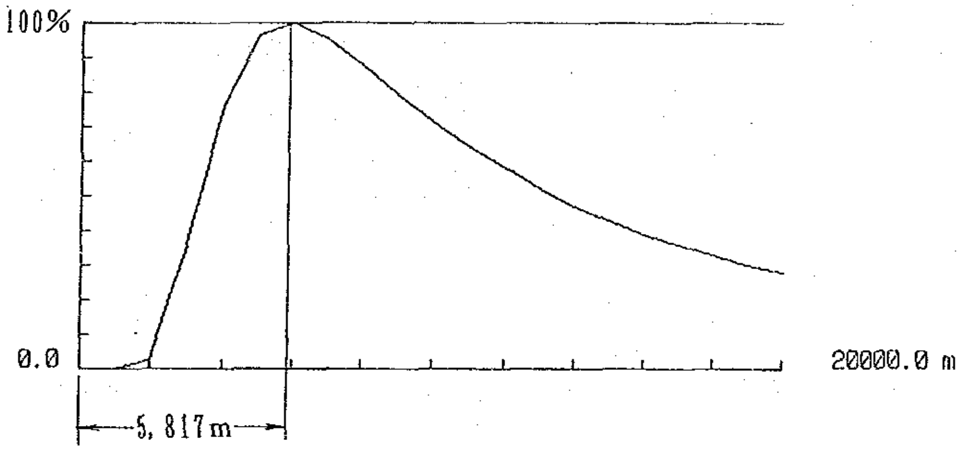


Manila District

Stack No.1

Rise formula by Bosanquet-1, Diffusion formula by Sutton

Wind direction	90.0 deg
Wind speed	6.0 m/s
Temperature gradient	0.00330°C/m
Effective stack height	137.8 m
Max. ground concentration	0.04722 ppm
Distance of occurrence	5,817.8 m



Stack No.2

Rise formula by Bosanquet-1, Diffusion formula by Sutton

Wind direction	90.0 deg
Wind speed	6.0 m/s
Temperature gradient	0.00330°C/m
Effective stack height	137.8 m
Max. ground concentration	0.04722 ppm
Distance of occurrence	5,817.8 m

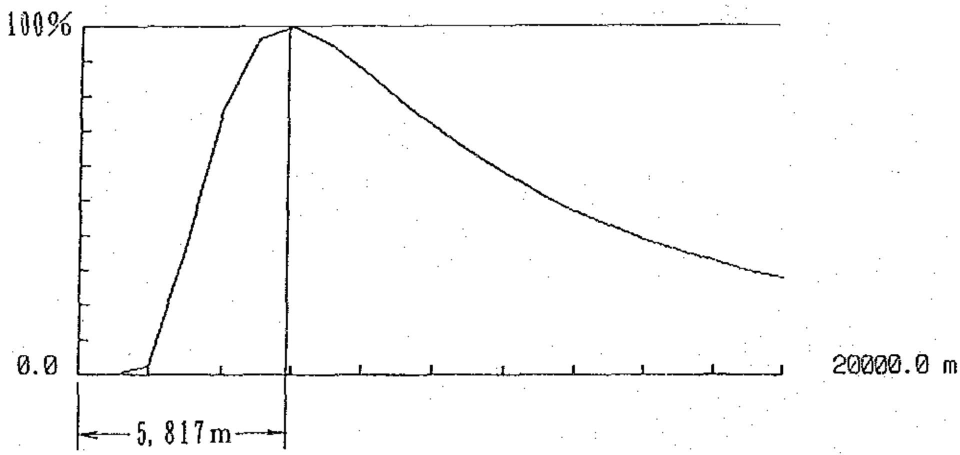


Table 8-2-6 Bataan Power Plant

Boiler		No.1	No.2
Load	MW	75	150
Exhaust gas volume	Nm^3/h	192,195	384,390
Gas temperature	°C	152	152
Sulfur content in fuel	wt%	4.07	4.07
Fuel consumption	kg/h	16,462	32,924
SO_2 emission	Nm^3/h	469	938
SO_2	ppm	2,440	2,440
Stack height	m	75	75
Stack inner diameter	m	2.391	3.0

Meteorology (assumed)

Wind speed 6 m/s

Stability Given the neutral value (D)

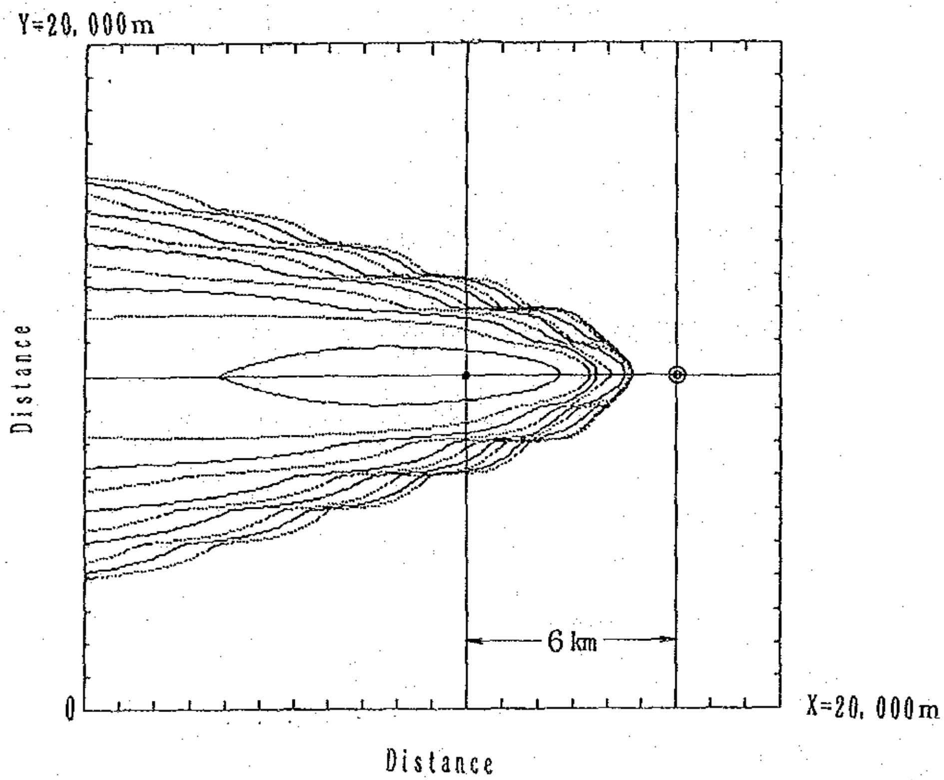
Predictive results of short-term diffusion

Unit	Max. ground concentration Cmax	Distance Xmax
No.1	0.0576 ppm	4,879.4 m
No.2	0.0745 ppm	6,261.2 m
No. 1 + No. 2	0.1285 ppm	6 km point

Fig. 8-2-4 Predictive Results in Bataan District

<u>Bataan District</u>

Cmax = 0.12857 ppm
i = 11 j = 10
Wind direction 90.0 deg.
Wind speed 6.0 m/s
Temperature gradient 0.00330°C/m
Exhaust gas rise formula Bosanquet-1
Diffusion formula Sutton
Number of stacks 2
Mean time min 3.00
Cy = 0.467 Cz = 0.070 n = 0.250
Concentration ratio against Cmax
-- 5.00E-01 -- 2.00E-01
-- 1.00E-01 -- 5.00E-02
-- 2.00E-02 -- 1.00E-02
-- 5.00E-03 -- 2.00E-03
-- 1.00E-03 -- 5.00E-04

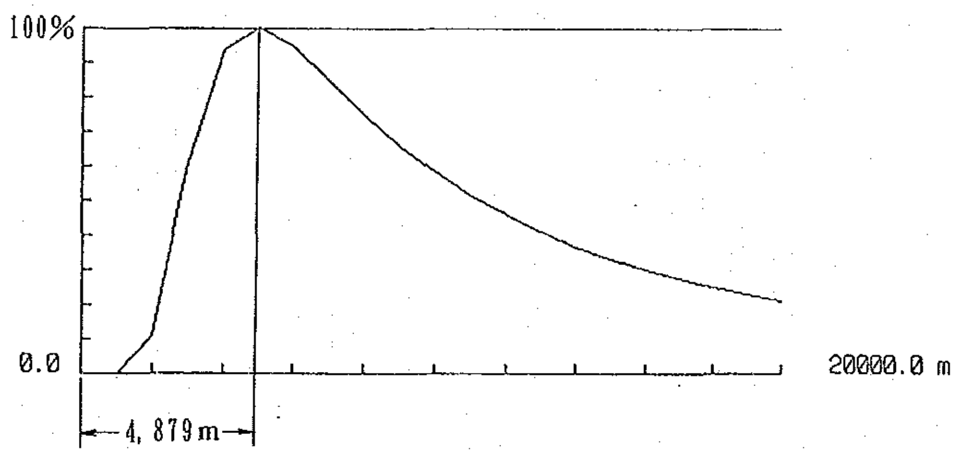


Bataan District

Stack No.1

Rise formula by Bosanquet-1, Diffusion formula by Sutton

Wind direction	90.0 deg
Wind speed	6.0 m/s
Temperature gradient	0.00330°C/m
Effective stack height	118.1 m
Max. ground concentration	0.05761 ppm
Distance of occurrence	4,879.4 m



Stack No.2

Rise formula by Bosanquet-1, Diffusion formula by Sutton

Wind direction	90.0 deg
Wind speed	6.0 m/s
Temperature gradient	0.00330°C/m
Effective stack height	147.0 m
Max. ground concentration	0.07447 ppm
Distance of occurrence	6,261.2 m

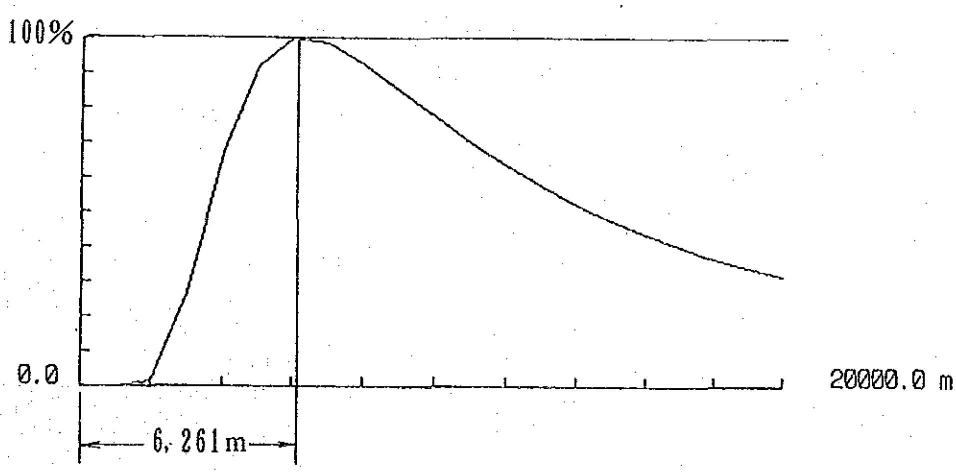


Table 8-2-7 Batangas Power Plant

Boiler		No. 1
Load	MW	300
Exhaust gas volume	Nm^3/h	988,721
Gas temperature	°C	128
Sulfur content in fuel	wt%	Wet coal 0.47 Dry coal 0.58
Fuel consumption	t/h	141.6
SO_2 emission	Nm^3/h	987.5
SO_2	ppm	581
Stack height	m	120
Stack inner diameter	m	5.74

Meteorology

Wind direction & speed

Data from the plant weather observatory

Assumed stability

Neutral value (D)

Predictive results of long-term diffusion

Unit	Max. ground concentration Cmax	Distance Xmax
No. 1	0.00451 ppm	8 km point

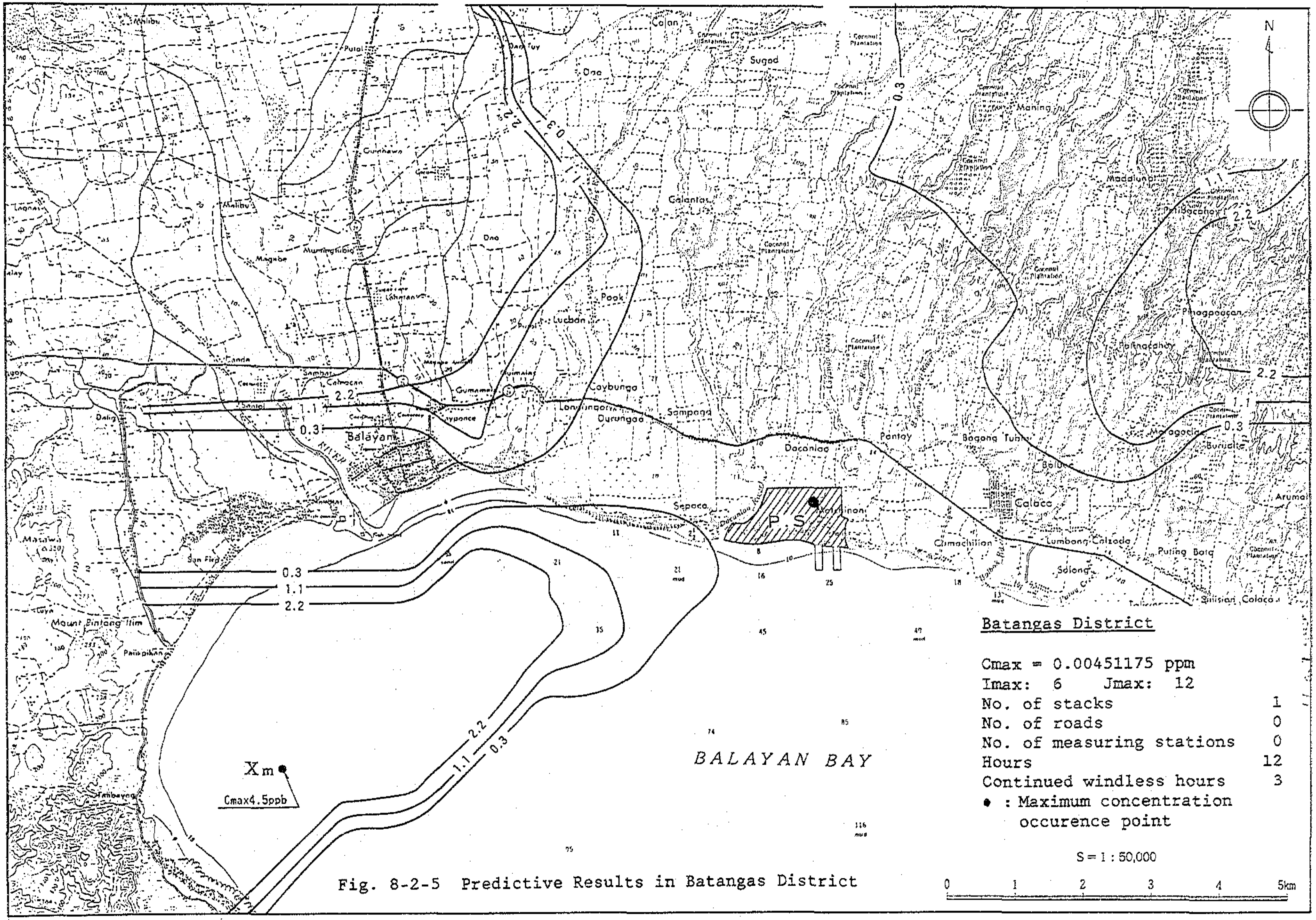


Fig. 8-2-5 Predictive Results in Batangas District