5.3.3 Phase III

Entry into Phase III is recommended after MEPA has consolidated its basic capabilities in water quality monitoring, planning and execution by successfully undertaking the various Phase II activities. As with Phase II, Phase III is expected to require two years.

(1) Goal and Strategy

The main theme of this Phase is an expansion and a reinforcement of the basic monitoring system to be developed in Phase II. An increase in the number of staffs for monitoring and an installation of precious analytical instruments shall be considered in parallel with a development of monitoring system that is applicable to the investigation of pollution mechanism and statistical analysis. Further, reliability of monitoring data should be increased by creating QA and QC systems including the cooperation with outside laboratories. Based on the results of monitoring, suitable coastal area management plan should be established and executed. Since high level technology is required for the realization of the above objectives, MEPA must acquire the basic technologies for monitoring by the end of phases II. Further technology transfer and installation of precious analytical instruments under the assistance of foreign countries are also required.

(2) Phase III Monitoring Tasks

The following monitoring tasks recommended for Phase III are shown in Table 5.3.2, together with the associated laboratory and management activities. Details are given in the following sub-sections.

- Continue the Regional Baseline Monitoring Program, including implementation of quantitative (replicate) sampling designs and statistical analyses of the data.

- Complete the sampling, analysis and interpretation steps of the Specific Monitoring Tasks that were planned and implemented during Phase II.

- Continue archiving field notes, photographs and GPS data to assist ground-truthing the Satellite-GIS mapping study.

The main in Phase III will be to undertake spatial and temporal gap-filling sampling, based on the results obtained from Phase II. This includes prioritized follow-up of

'hot-spot' areas discovered in Phase II. A key feature of Phase III should be the implementation of fully replicated sampling designs to determine spatial and temporal variations in key contaminants, particularly in the 'problem areas' or 'hot spots' that are prioritized for follow-up sampling.

(3) Sampling Design and Survey Planning/Logistics

Without replicate sampling, it is not possible to ascertain with sufficient scientific certainty, whether the average level of a particular contaminant in water or sediment at particular locations is actually above permitted discharge standards or published 'No Environmental Effects' guidelines and criteria. This is because single samples provide no information of the level of variation occurring naturally over distance and time, and they also provide no information of the precision of the sampling device and laboratory procedures.

It is recommended that the best way for MEPA personnel to achieve knowledge and understanding in the design and statistical interpretation of replicated sampling is to:

(a) secure collaborative agreement with at least one environmental statistician familiar with 'Before-After-Control-Impact' sampling designs (BACI), repeated measures univariate and multivariate analysis of variance (ANOVAR/MANOVA), correlation analyses (ANCOVA/MANCOVA) and community analyses by clustering and ordination methods; and/or

(b) appoint such a statistician to train and assist all MEPA staff responsible for implementing robust environmental monitoring using statistical sampling regimes and data analysis techniques (preferable).

(4) Monitoring Parameters

Phase III monitoring should include the ability to investigate the behavior of nutrients in the water column and sediments. Sampling and analytical capabilities should therefore be increased so that the major species of nitrogen and phosphorous can be determined to appropriate limits of detection (i.e. organic and inorganic species including nitrate-nitrite, orthophosphate, etc.)

(5) Field and Laboratory Equipment

1) Field Equipment

The follow-up sampling work for Phase III will benefit from the use of a Vertical Drop Core sampler and a Dredge sampler. A relatively cheap sedimentation sampler (an array of six sediment cup collectors) is useful to determine the level of nutrients in sediments settling to the seafloor at particular places of interest or concern.

The water movement studies commenced in Phase II will require calibration and verification by taking time averaged measurements at key locations. Purchase or hire of at least two time-averaging programmable data loggers (e.g. S4 buoy, Anderaa type current meters, etc) is therefore recommended, together with a portable tide gauge.

2) Laboratory Equipment

Installation of more advanced equipment may need to be installed to permit accurate measurement of important nutrient species and trace substances which occur at very low but environmentally significant concentrations (parts per billion; ug/L).
Following equipment may be needed in this phase.

- Autoanalyser for rapid nitrate-nitrite determinations.
- Electron Capture Detector for Gas Chromatography Unit (GC-ECD)
- Flameless Atomic Absorption Spectrometer (FL-AAS)
- Ion Chromatography (IC)
- A Clean Bench to improve speed and reliability of bacteria colony media preparation and culture.

(6) Internal Organisation and External Collaboration

The follow-up work identified by the Phase II studies and review, together with the initial Phase III equipment purchases, will highlight the specific training and operational budget requirements for Phase III.
During Phase III MEPA Eastern Province should be implementing a schedule for a coordinated program of Coastal Zone Management, with a policy for achieving priority action at key areas (e.g. inside Tarut Bay) to prevent further water quality deterioration. Such actions will require MEPA to seek support from all relevant government agencies, municipalities, factories and other commercial organisations, and to encourage them to play active roles in the Coastal Zone Management Program.

5.3.4 Phase IV

Entry into Phase IV is recommended after MEPA has consolidated its basic capabilities in water quality monitoring, planning and execution by successfully undertaking the various Phase III activities.

(1) Goal and Strategy

In this phase, comprehensive monitoring system closely connected with coastal area management should be established. In this phase, monitoring survey including technically difficult and/or complicated programs such as an investigation of pollutions by highly toxic substances such as POPs and dioxin, and clarification of circulation and accumulation mechanisms of pollutants in ecosystem should be executed. MEPA should conduct the monitoring surveys for the above purposes in cooperation with outside research institutes such as universities, because these surveys are very complicated. On the other hands, database system incorporated with GIS and/or monitoring network with relevant organization should be created, because various kinds and large numbers of data must be handled in this phase.

(2) Phase IV Monitoring Tasks

It is likely that one or more highly focused investigative studies may be required in Phase IV. These should be undertaken in close collaboration with pertinent agencies and organizations, or even contracted out to specialist research groups based on the nature and duration of the tasks. Sampling design and survey planning/logistics and monitoring parameters depend on the theme of each task. Regional baseline/surveillance monitoring program should also be continued. However, the program should be modified and/or optimized in accordance with the recommendations from the "End of Phase III" Review.

(3) Field and Laboratory Equipment

1) Field Equipment

Field equipment needed to Phase IV monitoring activity will be change according to the monitoring tasks. Nevertheless, trailer 6-7 m inshore vessel and DGPS system will be needed for MEPA's sampling and research tasks. Other field equipment should be

prepared depend on the directions/needs of coastal monitoring program.

2) Laboratory Equipment

Advanced equipment enabling adequate resolution of trace toxic substances (e.g. POPs, dioxins, etc.) may need to be installed, unless satisfactory arrangements with one or more commercial laboratories can be secured. Depending on outcome of Review of Future Direction/Specialization of MEPA Laboratory, one or more the following equipment items may be required:

- High Performance Liquid Chromatography (HPLC)
- Gas Chromatographic - Mass Spectrometer (GC-MS)
- Inductively Coupled Plasma Mass Spectrometer (ICP-MS)
- Clean Room for assays of low level trace substances

(4) Internal Organization and External Collaboration

MEPA has sufficient skilled personnel with technical know-how to identify and organize its own training requirements, as well as swapping skills and training advice with other organizations and laboratories. MEPA receives additional regulatory powers to develop and implement, in collaboration with other agencies, factory and municipal outfall licenses, plus appropriate self-monitoring by the operators to confirm that discharges meet the specific license conditions set for each outfall, encourage them to play active roles in the Coastal Zone Management Program.

MEPA utilizes outside institute and laboratories for specific purposes such as QA/QC, staff training, and/or for answering specific questions that require specialist research or modeling. This strategy allows MEPA to deal with a wide range of monitoring and analysis requirements.

Future monitoring plan, its proposed development and estimated funding requirement is summarized in Table 5.3.2(1) and (2).

Table5.3.2(1) Proposed Development of Gulf Coastal Water Management and Monitoring Plan

Indicative Period	1999-2000	2001-2002		2003-2004		2005-2006
Phase of Development	**Phase I** **Implementation and Planning (Completed)**	**Phase II** **Consolidation**	**Chk**	**Phase III** **Growth and Enhancement**	**?**	**Phase IV** **Maturation and Focus**
Aims of Phase	JICA assisted upgrade of MEPA Laboratory sampling and analytical equipment at the Eastern Province Office (Damman). Upgrade includes marine monitoring technology transfer and training via implementation of: Baseline Regional Water Monitoring Program, including analyses by MEPA Laboratory of water and sediment samples.	Consolidate Basic Water Quality Monitoring, Planning and Execution Capability by: - Completion of Laboratory staffing and training program - Organisation of Laboratory and Field Monitoring Task Teams - Development and MEPA HQ approval of annual budgets for Laboratory and Field Sampling Operations. - Demonstrated regular use and maintenance of laboratory equipment - Expansion of Regional Baseline Water Quality Monitoring Program - Commencement of Specific Monitoring Tasks (Planning & Implementation)	AUDIT OF PROGRESS	Grow and strengthen coastal water monitoring and management capabilities by: - Undertaking Collaborative Monitoring Tasks with External Agencies. - Introducing quantitative monitoring designs with statistical power and hypothesis testing. - Enhancing MEPA Laboratory's Analytical Capabilities. - Confirming Laboratory Quality Assurance/Quality Control by Independent (External) Checks - Prioritising and Contracting Investigative/Research Tasks to External Specialist Groups.	REVIEW RESULTS, TRENDS AND NEEDS	Depending on the Review's Conclusions and Recommendations and calibre/expertise of staff, Phase IV Aims could include: - Laboratory specialisation. For example, to be a Gulf 'Centre of Excellence' for: * analyses and modelling of nutrient species/biostimulants; * sediment/water partioniring and bioavailability of metal species (Vn, Ni, etc) * ecotoxicity testing; * extraction and assay of contaminants from marine plant and animal tissues * marine bacteria culture, assay and disease identification * phytoplankton taxonomy, growth conditions and red-tide toxicity studies.
Monitoring Activity	Basics of monitoring design, planning, safety, navigation, sampling and sample handling and transport - via 'hands-on' training and background theory. Implementation of Regional Baseline Monitoring in the Central Zone (= 'Intensive Study Area'; Half Moon Bay to Abu Ali). Two water and sediment quality monitoring sampling and analysis exercises conducted (October 1999/June 2000), with most samples analysed at MEPA Laboratory (OCL-POPS and metals in water samples contracted to external laboratory).	Extend Baseline Regional Monitoring Program to determine basline trends and 'hot spot' areas in the North (Abu ali - Kafji) and South (Gulf of Salwhat) sectors of KSA Gulf Coast. Complete seasonal monitoring surveys in Central Zone KSA. Plan and implement following Specific Monitoring Tasks: - Characterise dispersal, fate and effects of nutrients from fertiliser factory outfall. - Characterise amount, dispersal and fate of organic matter and nutrients discharged by Al Khobar STP (collaborate with external biostatisticians on sampling design) - Identify and characterise all point source inputs of nutrients into environmentally significant areas of Tarut Bay. - Photographically document types and distribution of Shoreline Marine Litter and Rubbish. Archive material for use in public awareness/education campaign. (e.g. schools in coastal towns to be part of national coastline survey of beach litter). - Ground-truthing for the satellite-based fine-scale mapping of sabkah, mangroves, seagrass bed, coral reef and artificial/deepened/modified shorelines - for long term coastal habitat status monitoring in Central, North and South regions of KSA Gulf.	ALL PHASE II MONITORING TASKS AND ACTIVITIES IMPLEMENTED?	Continue Regional Baseline Monitoring Program (e.g. spatial and temporal gap-filling, and prioritised follow-up on any hot-spot areas discovered in Phase II). Implement Quantitative Sampling Designs and Statistical Data Analyses. Achieve by (a) securing collaborative agreement with biostatistician familiar with analysis of repeated measures, multiple control BACI designs by ANOVAR/MANOVA and MDS methods; and/or (b) appointing a biostatistician to assist and help train all MEPA staff responsible for robust environmental monitoring using statistical design and analysis techniques (preferable). Complete the sampling, analysis and interpretation steps of the Specific Monitoring Tasks that were planned and implemented during Phase II. Continued ground-truthing for satellite mapping study.	IDENTIFY NEEDS AND FUTURE DIRECTION	Regional Baseline / Surveillance monitoring Program continues - but modified/optimised in accordance with recommendations by the "End of Phase III" Review. It is likely that one or more highly-focussed investigative studies may be required. These should be undertaken in close collobaration with pertinent agencies and organisations, or even contracted out to specialist research groups depending the nature and duration of the task/s.
Monitoring Program — Sampling Equipment	Supply, training and use of: GPS units (2), portable electromagnetic water current meters (2), Hydrolab Multiprobe (1), Van Dorn water samplers (3), Eckman grabs (3), Van-Veen grab (1), polycarbonate soil corers (5), plankton nets (2), secchi discs (2), sounding leads (2).	Field sampling equipment at MEPA Dammam is sufficient for Phase II work		Sediments: Vertical Drop Core sampler; Dredge sampler. Sedimentation sampler (sediment trap/collector). Water current velocity/direction: Purchase or hire of two time-averaging programmable data loggers (e.g. S4 buoy, Anderaa type current meter). Portable tide gauge.		Trailerable 6-7 m inshore vessel for MEPA's Sampling and Research tasks. DGPS system. Other field equipment depends on direction/needs of coastal monitoring program.
Numerical Modelling	None.	Specific Tasks require development of 2D/quasi-3D Hydrodynamic Model of water movement and flushing rate for the coastal sectors at Al Khobar-south Dammam and Tarut Bay to determine dispersal patterns (grid resolution no more than 500 m). This modelling needs to be subcontracted to specialist firm/group.		Completion of field calibrated 2D/3D Models for Al Khobar and Tarut Bay-Dammam. Contracted supplier provides training in the understanding, interpretation, application and constraints of model results.		Modelling requirements will depend on level of convenient external support (e.g. KFUPM) versus in-house requirements and desirable project time-lines.
Satellite Image Analysis	Basic techniques and information from Satellite Image Analysis conducted of Central Zone (ISA) transferred to MEPA.	Obtain images for North and South sectors of KSA Gulf coast. Development of GIS database system in combination with the above satellite image and monitoring results.		Commence detailed GIS-based 'Coastal Habitat Distribution Map' showing present distribution of key habitat types (see above). Further development of GIS database system.		Continued development of GIS database system; Obtain and process 2nd round of satellite images for long term coastal habitat monitoring.
MEPA Laboratory — Staff	Four MEPA staff assigned (laboratory chemist and three laboratory assistants). Four more staff with good chemistry background required.	Appointment of Laboratory Manager and two more laboratory technicians with suitable chemistry background. These are required as soon as possible for consolidation of laboratory operations via training for routine analysis work. Advisors from outside organization will be required.	STAFFING AND TRAINING ACHIEVED?	MEPA appointment of one deputy laboratory manager (a chemistry technician responsible for QA/QC control) and 1 more technician with chemistry background. This will meet Phase III requirements (i.e. four technician specialists for inorganic analyses (1), nutrient analyses (1), other organic analyses (1) and bacteriological (1), under one Laboratory Manager).	REVIEW FUTURE NEEDS / DIRECTION	Same as Phase II, except possibly one more laboratory technician for specialist preparative work of samples (depending on future analytical needs and direction of MEPA coastal water monitoring requirements).
Equipment	Laboratory Facilities Audit and Upgrade (including fridge and fume cupboard) Installation and initial training on use and maintenance of: Gas Chromatography Unit (GC-FID) Atomic Absorption Spectrometer (AAS) Total Organic Carbon meter (TOC) Distillation Apparatus (several) and spectrophotometer for sample preparation Oil Content Meter	No major new equipment items required <u>Minor equipment:</u> Microwave for sample treatment and teflon containers for acid digestion Camera adapter and 1 Low-power widefield stereomicroscope for macroplankton ID and counting Hollow Cathode Lamp (for Varian AAS)		Installation of: Nitrate-nitrite Autoanalyser Electron Capture Detector for Gas Chromatography Unit (GC-ECD) Flameless Atomic Absorption Spectrometer (FL-AAS) Ion Chromatography (IC) Clean Bench to improve speed and reliability of bacteria colony media preparation and culture		Depending on outcome of Review of Future Direction/Specialisation of MEPA Laboratory, one or more the following equipment items may be required: High Performance Liquid Chromatography (HPLC) Gas Chromatographic - Mass Spectrometer (GC-MS) Inductively Coupled Plasma Mass Spectrometer (ICP-MS) Clean Room for assays of low level trace substances
Comment	Equipment sufficient to sample and analyse key sea water/effluent quality parameters, including CTD, DO, pH, TSS, nutrients, organic content, sediment metal levels, TPH, bacterial coliforms, plankton.	Analyses for metals in water samples and for POPS (persistent organic pollutants such as PAH, PCB and organo-halides) to continue to be subcontracted to external laboratory.		Installation of the above advanced equipment will permit accurate measurement of important nutrient species and trace substances which occur at very low but environmentally significant concentrations (parts per billion; ug/L).		Advanced equipment enabling adequate resolution of trace toxic substances (eg. POPs, dioxins, etc) may need to be installed, unless satisfactory arrangements with one or more commercial laboratories can be secured.
Estimated Funding Requirements	COMPLETED	**MEPA Laboratory oerations: SR 45,000** **MEPA Laboratory Minor Equipment: SR 10,000** **Field Sampling Logistics: SR 8,000** **Hydrodynamic Modelling Study (part 1): SR 15,000** **Satellite Image Purchase (north and south regions): SR 3,000**		**MEPA Laboratory oerations: SR 90,000(for Baseline monitoring)** **Field Sampling Logistics: SR 24,000** (for Baseline monitoring) **MEPA Laboratory Equipment: SR 700,000**		**MEPA Laboratory oerations: SR 90,000 (for Baseline monitoring)** **Field Sampling Logistics: SR 24,000 (for Baseline monitoring)** **MEPA Laboratory Equipment: SR 1,900,000**

Table 5.3.2 (2) Proposed Development of Gulf Coastal Water Management and Monitoring Plan (Continue)

Indicative Period		1999-2000	2001-2002	Chk	2003-2004	?	2005-2006
Phase of Development		Phase I Implementation and Planning (Completed)	Phase II Consolidation	Good Organisational Support & Database?	Phase III Growth and Enhancement	REVIEW ORGANISATIONAL NEEDS	Phase IV Maturation and Focus
Organization Structure	Technical training/ education system	Three staff and two managers from MEPA Eastern Province receive training in Japan. JICA Study Team completed technology transfer with on-job training, seminars, preparation of field and laboratory manuals, and documentation.	MEPA staff develop self-training system. Advisors from outside organizaitons will be needed to provide further training to ensure MEPA personnel can fulfil sampling and analysis requirements of water quality monitoring program.		The Phase II review and initial Phase III equipment purchases will highlight the specific training requirements for this Phase.		MEPA has sufficient skilled personnel with technical know-how to identify and organise its own training requirements, as well as swopping skills and training advice with other organizations and laboratories.
	Information	Basic monitoring database system established by using Microsoft-Excel. Procedures and technical reference books were provided. Information on local suppliers and prices of chemicals and consumables gathered.	Accummulation of spatial and seasonal data. Commence obtaining computer file copies of relevant marine monitoring data from Royal Commission of Jubayl, ARAMCO and Regional Organisations (ROPME, etc) for entry on database, so MEPA can become a regional data centre and repositry of historical water quality information.		Continue collation and archiving of spatial and temporal monitoring data. Synthesise and plot data to identify general spatial and seasonal trends, and to identify areas requiring more intensive sampling to elucidate apparent pollutant 'hot spots' and/or previously unknown important point source inputs.		Monitoring results are synthesised into 'State of Coastal Environment Reports' supplied to Government, coastal stakeholders and general public to help gain support for policy development, decision-making and future funding. MEPA strives to ensure all monitoring results collected are reliable and used to provide robust, scientifically-sound advice, including feedback on success of the Coastal Zone Management Plan.
	MEPA organizaion	MEPA managers started planning a new organization for the work. MEPA assigned 5 specialists. MEPA Head Office finished financial arrangement for 2 new chemists. MEPA H.O and E P started discussion for the goal.	Apply organisational framework at MEPA Eastern Province for management of field monitoring and laboratory teams, and progress in MEPA's water quality monitoring system and capabilities. Secure adequate annual budgets for laboratory operations, field monitoring logistics and assignment of specialists. MEPA may request to obtain advice and support by dispatching an advisor from outside organizations including JICA.		MEPA implements schedule for the Coordinated Coastal Zone Management Program, with a policy for achieving urgent action at key areas (e.g. inside Tarut Bay) to prevent further water quality deterioration.		MEPA receives additional regulatory powers to develop and implement, in collaboration with other agencies, factory and municipal outfall licences, plus appropriate self-monitoring by the operators to confirm that discharges meet the specific licence conditions set for each outfall.
	Co-operation with other organization	MEPA started communications with relevant outside agencies and third parties by meetings and workshops. Capability of universities, private institutes and other laboratories in Eastern Province determined.	Maximise collaboration opportunities with other agencies, municipalities and third parties during the various data collation and liaison tasks that form part of the Phase II marine monitoring tasks.		MEPA Eastern Province seeks support from all relevant government agencies, municipalities, factories and other commercial organisations, and encourages them to play active roles in the Coordinated Coastal Zone Management Program for protecting coastal waters and resources.		MEPA utilizes outside institute and laboratories for specific purposes such as QA/QC, staff training, and/or for answering specific questions that require specialist research or modelling. This strategy allows MEPA to deal with a wide range of monitoring and analysis requirements.

References

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Chapter 6

Laboratory Conditions and Future Plan

Chapter 6 Laboratory Conditions and Future Plan

6.1 Background

During the first work stage in KSA in March 1999, the JICA Study Team reviewed the status and capabilities of the laboratory in MEPA Eastern Province and indicated following matters to be improved in advance of the project proceeding based on the observation of the concerned laboratory that few actual operation had been implemented by a few staffs with a few equipment.

- To remove the unnecessary equipment from the laboratory,
- To repair the existing fume hoods (at least 2 among 5 hoods),
- To prepare the water supply for each small room,
- To exchange existing water sinks wider size (at least 2 sinks),

the size of its should be 80cm x 40cm x 25cm (depth)

- To check the voltage fluctuation in the laboratory,
- To install an exhaust system for AAS room,
- To install the gas cylinders with regulator which is required for the analysis,
- To arrange hazardous wastes disposal.

The Study Team also recognized following two important matters to make the laboratory activities be stable in the future.

- Enough number of staff should be assigned, and
- Enough budget for laboratory activities should be allocated.

Based on the discussions between MEPA and the Study Team about various things including the above issues, the parameters to be analyzed and the equipment necessary for analyses were selected. The parameters were selected from the following standpoint.

1) Parameters of MEPA's Water Quality Standard (H1401-01)
2) Spilled oil index (BTEX; Benzene, Toluene, Ethylbenzene and Xylene)
3) Eutrophication index (Chlorophyll a)
4) Confirmation of traces from past accident (PCB)

Table 6.1.1 and Table 6.1.2 show the list of parameters and equipment selected, respectively.

In this chapter, a plan of possible step-wise development of the laboratory in MEPA EP in accordance with the frame work described in the previous chapter.

Table 6.1.1 Analysis Parameter and Methodology

Analysis Parameter	Methodology
Water Analysis	
Residual Chlorine	Titrimetric/Colorimetric
TOC	Combustion/IR-Spectroscopy
TSS	Gravimetric
NH_3	Distillation/Spectrophotometric
TKN	Macro-Kjeldahl/Spectrophotometric
Total Phosphorus	Distillation/Spectrophotometric
Cyanogen	Distillation/Spectrophotometric
Magnesium	Flame AAS
Cd, Pb, Zn, Cu, Co, Ni, Cr	Extraction/Flame AAS
Mercury	Cold-vapor/AAS
Arsenic	Hydride generation/AAS
Phenols	Distillation/Spectrophotometric
Oil & Grease	Spectrophotometric
TPH	Extraction/Spectrophotometric
BTEX	Equilibrium Headspace/GC-FID
Chlorophyll	Spectrophotometric
Total Coliform	Membrane filter procedure
Sediment Analysis	
Ignition Loss	Loss on Ignition at 550C
TOC	Titrimetric
Cr, Cd, Pb, Zn, Cu, Co, Ni, V	Acid digestion/Flame AAS
Hg	Cold-vapor/AAS
As	Hydride generation/AAS
TPH	Ultrasonic extraction/SP
BTEX	Equilibrium Headspace/GC-FID

Table 6.1.2 Equipment list provided by JICA

Equipment	Maker/Model	Q'ty	Notes
Analyzer			
Gas Chromatograph	Shimadzu GC17A	1	FID, Headspace auto-sampler
Atomic Absorption Spectrometer	Varian Spectra 220	1	flame atomizer, vapor generator
Spectrophotometer	Shimadzu UV1240	1	UV, visible
Benchtop pH meter	Metrohm 744	1	
Benchtop EC meter	Entech CON-500	1	
TOC analyzer	Shimadzu TOC5000A	1	with SSM5000A
Oil Content meter	Horiba OCMA300	1	oil & grease analysis
Microbiological System	Millipore Milliflex	1	total coliform analysis
Microscope	Nikon Alphaphot 2	1	plankton determination
Sample treatment			
Microkjeldahl assebly	Fisher Scientific	5	digestion for TKN
Cyanide Distill assembly	Wilkens-Anderson	3	distillation system
Phenol Distill assembly	Wilkens-Anderson	3	distillation system
Autoclave	ALP Japan KI 30S	1	sterilization, decomposition
Shaker	SGM-200-010F	1	solvent extraction
Centrifuge	Clifton NE010G	1	chlorophyll analysis
COD digestion vessel	Fisher Scientific	1	
Hotplate	SD3DI	1	acid digestion
Ultrasonic cleaner	Neytech 19B	1	sediment extraction
Fume hood	Nuaire NU164-424G	1	sample treatment with acid
Water Purification	Milli-Q"Academic"	1	blank water making
Refrigerator	Thermolyne	1	sample storage

6.2 Recommended Laboratory Plan in the Future

6.2.1 Phase I (Present Condition)

(1) Objective

As mentioned in Chapter 5, Phase I represents the present project.
One of the most important objects of Phase I, which is understood to be just the start-up operation for the laboratory in MEPA EP, is to establish the foundation of MEPA laboratory system to conduct the water quality monitoring among the Arabian coast of the Gulf. To achieve this object, analytical equipment and/or instruments had to be upgraded in MEPA laboratory.
Also, basic technology for chemical analysis and laboratory management were transferred from JICA to staff of MEPA concerned.

(2) Analysis Parameter

Parameters, which are possible to be analyzed at this stage, are listed in Table 6.2.1. All of the parameters are listed in Table 6.1.1, indicating possible pollutants suspected by industrial activities along Arabian Coast in KSA.

Table 6.2.1 Sample of Analysis Parameter in Phase I

Sample	Parameter
Sea Water	TSS, TOC, TKN, NH3, T-P, Oil & Grease, Total/Fecal Coliform, Chlorophyll a, Plankton
Sediment	Particle Size, TOC, TPH, Metals
Waste water	TSS, COD, TOC, TKN, NH3, T-P, Oil & Grease, CN, Total/Fecal Coliform, Phenol, BTEX, Metals

(3) Equipment

JICA provided the equipment as per Table 6.1.2. In order to install all equipment correctly, the Study Team was present during the installation and provided advice and support. JICA representatives inspected the condition of installation on November 17 and 18, 1999.

(4) Laboratory Staff

As laboratory staff, four MEPA (one analytical chemist and three laboratory assistants) personnel have been assigned at laboratory of MEPA Eastern Province. They have carried out the chemical analysis of the samples obtained during two round monitoring investigations. Detailed technology transfer from the JICA Study Team to them are described in the separate volume.
Assignment of junior scientists having chemistry background was strongly required.

(5) Laboratory Management

The Study Team has prepared the prototype of check-list for chemicals, maintenance of equipment and equipment management manual. Periodically review and revision of these documents are strongly expected to be continued by MEPA itself.

The following documents are made for the laboratory work:

1) Standard operation procedures of chemical analyses,
2) Chain-of-custody sheet,
3) Sample management procedure,
4) Instrument operation/calibration manual,
5) Field data record,
6) Data reporting format,
7) Laboratory health and safety plan,
8) Waste management plan.

Among the above various management standards, the Team has prepared fundamental schemes of; a) Management standard for facility and equipment, b) Storage and maintenance standard for the instruments and chemicals, c) Health and safety standard and e) Standard operation procedure.

Purchase of the laboratory equipment and chemicals is used to take long time in Saudi Arabia in accordance with its own business manner. For example, some chemicals are required to be delivered at least for a couple of months after since they are ordered. Lack of chemicals and trouble in equipment has always a cause of serious risk to stop conducting practical monitoring program. Therefore, it is necessary that management

systems of chemical stock and equipment maintenance should be fully planned systematically.

6.2.2 Phase II (Consolidation Period)

(1) Objective

The objective of Phase II is to establish a solid foundation for future monitoring system as well as to consolidate the system of basic laboratory staffing and organizational capabilities.

To consolidate the capability, planning and execution of basic coastal water quality monitoring, following four items will be highlighted.

- Completion of laboratory staffing and training program,
- Organization of laboratory staff,
- Development of annual budgets to be approved by MEPA HQ for laboratory operations, and
- Regular use and maintenance of laboratory equipment installed.

Based on the present situation that laboratory of MEPA, following three assistant activities will be necessary for MEPA to fulfil the above requirements.

- Application of outside laboratories,
- Training of laboratory personnel on environmental analysis,
- Implementation of quality assurance and quality control (QA/QC).

(2) Parameters to be selected

The parameters to be analyzed in MEPA laboratory will have to be the same as these selected in the phase I.

According to the information obtained, the concentration levels of Barium as well as Nickel and Vanadium may be elevated in the sediment due to the impact of oil production facility and tanker terminal/navigation lane. Therefore, Barium is to be selected as one of parameters.

It is recommended that, at the beginning stage of laboratory operation, selected number of parameters should not be large but limited as small as possible because of the technology level of laboratory.

For example, as described in the previous chapter, since contamination by Cyanide, Phenol and BTEX, which may not be important in this concerned area, laboratory analyses of them will not be urgently necessary.

To detect Fecal Coliform in water sample, culture media (m-FC Broth; M000-00P 2F) for Milliflex microbiological system is recommended to enable us to analyze in detail, as described in the chapter of monitoring plan shall be purchased.

Table 6.2.2 Sample of Analysis Parameter in Phase II

Sample	Parameter
Sea Water	TSS, TOC, TKN, NH3, T-P, Oil & Grease, Total/Fecal Coliform, Chlorophyll a, Plankton
Sediment	Particle Size, TOC, TPH, Metals (including Barium)
Waste water	TSS, COD, TOC, TKN, NH3, T-P, Oil & Grease, CN, Total/Fecal Coliform, Phenol, BTEX, Metals

Analyses for metals in seawater samples and for POPs (persistent organic pollutants such as PCB and Chlorinated hydrocarbons) may have to be analyzed by outside laboratory in the similar way of Phase I.

Table6.2.2 indicate the parameters to be selected in PhaseII.

(3) Equipment

[Equipment/Apparatus]

No major new equipment items are required in this phase. However, to detect Barium in the sediment sample, a Hollow Cathode Lamp shall be installed for AAS system in the laboratory. Further, following equipment installation will help some part of laboratory operation effectively and safely:

- a microwave digester with decomposition vessels (Teflon vials) for sediment treatment; the detailed operation procedure shall be applied from:
- 'Standard Methods' 3030-K Microwave-Assisted Digestion, and
- US.EPA SW-846 Method 3052 Microwave Assisted Acid Digestion of Sediments, Sludges, Soils, and Oils.
- a camera adapter and a low power, wide-field stereomicroscope for plankton identification and counting; the operation procedure shall be applied from: 'Standard Methods' 10200 Plankton.

All equipment should be properly maintained. Periodical maintenance shall be executed based on the maintenance manual supplied by manufactures. In case that instrument would be broken or suspected to be broken, the reason of the trouble (e.g. overloading or miss-operation) shall be clearly identified.

[Facility and Utility]

To assure the precise and proper works in the laboratory, MEPA should implement the following modifications and improvements of the facilities and utilities.

a) Water supply

The water quality of which supplied to the laboratory should be kept at good enough for analysis work. High contents of minerals in the ground water (maximum 1,700 ppm as TDS) affect to spoil the water purify system in the laboratory. MEPA should improve their treatment facility of ground water to keep good quality (less than 500 ppm as TDS).

b) Improvement of sink

The sink of laboratory table is too small (approx. 40cm x 30cm) to wash glassware and apparatus, especially to wash glassware with long size such as pipettes. In order to minimize the breakage of glassware at washing and make sufficient washing, a few sinks should be modified to larger size (ex. 80cm x 40cm).

c) Air conditioning

The inflow of dusts to laboratory and the heat atmosphere are used to cause

various troubles in instruments. To prevent such troubles, air-conditioning system of laboratory and control of dusts invasion shall be improved.

d) Increase the capacity of electricity

Many laboratory equipment such as heating mantle, autoclave and hot plate require a large amount of electricity for their operation. Even now, if such equipment are used at the same, capacity of electricity is not sufficient. Therefore, capacity of electricity should be increased, if MEPA has an intention to install additional instruments.

(4) Laboratory Staff

To assign the competent personnel as well as to install the suitable facilities are understood to be the most essential requirement to provide accurate and reliable test results in the laboratory.

To consolidate the laboratory operations via training for routine analysis work, assignments of laboratory manager and four MEPA staff with chemistry background are required. Specification and documentation of authority, responsibility and interrelation of all laboratory personnel are very important to assure the quality of chemical analysis.

Table 6.2.3 show the roles of laboratory staff recommended.

To learn and maintain the up-to-date technologies for chemical analysis, laboratory management, and data quality control, MEPA should provide opportunities to attend the education and training programs for laboratory personnel which should be held by proper organization (e.g. ROPME, RCJY, SWCC and JICA). Laboratory manager should prepare the schedule of education and training of laboratory staff. Close relationship with other reliable laboratories and university is also important.

Table 6.2.3 Proposed organization structure in Phase II

Sections	Number of personnel		Roles
	Experts	Assistants	
Laboratory Manager	1		Overall management of the laboratory, Analysis planning, Data management and Quality control for lab works
Staff 1 (Wet Chemistry)	1	(1)	Responsible for analyses TSS, NH3, TKN, T-P, CN, Phenol and others
Staff 2 (Trace Metals)	1	(1)	Responsible for analyses Metals and others
Staff 3 (Organic Analysis)	1	(1)	Responsible for analyses TOC, Oil & Grease, BTEX and others
Microbiological	1	(1)	Responsible for analyses Coliform, Chlorophyll, Plankton and others

(5) Laboratory management

[Management Standards for the Laboratory Operation]

In order to operate the chemical laboratory safely and smoothly, various types of internal management standard are required. Some of important standards can be listed below.

a. Management standard for facility and equipment
   To arrange the utility (air conditioner, water supply etc.) and manage/arrange the equipment for sampling and analysis
b. Storage and maintenance standard for the instruments and chemicals
   To store/manage the instruments and chemicals appropriately used for analysis
c. Health and safety standard
   To manage the health in the laboratory including maintenance and cleaning and to keep the workers ' safety
d. Standard for waste management
   To manage waste treatment including emission gas and waste water for the purpose of preventing secondarily environmental pollution from the laboratory.

e. Standard operation procedure

Operation manual for the unit procedure to adjust/standardize the analytical methods.

f. QA/QC

QA/QC for the measurement data includes assurance with outside lab data.

Among the above various management standards, the Team has prepared fundamental schemes of; a. Management standard for facility and equipment, b. Storage and maintenance standard for the instruments and chemicals, c. Health and safety standard and e. Standard operation procedures (SOPs). Others are required to be established at the earliest opportunity.

[Quality Assurance and Quality Control (QA/QC)]

Quality assurance refers to the activities which allow us to demonstrate that a certain quality standard has been met at a stated confidence level. Quality control refers to procedures that lead to statistical control of the measurement of specific technical process and provide the desired accuracy of the measurement. So, QC consists of specific technical procedures such as the running of blanks or spiked samples to assess and control the measurement process, and QA refers to the management process which implements and documents effective QC.

Some basic requirements of QC system are shown in Figure 6.2.1

As QC procedure, following items were resolved during the present monitoring study.

1) Preparation of SOPs
2) Preparation of Instrument/operation/calibration manual
3) Analyses for blank samples (system, instrument, solvent and method)
4) Implementation of Spike Test
5) Reproductive Test

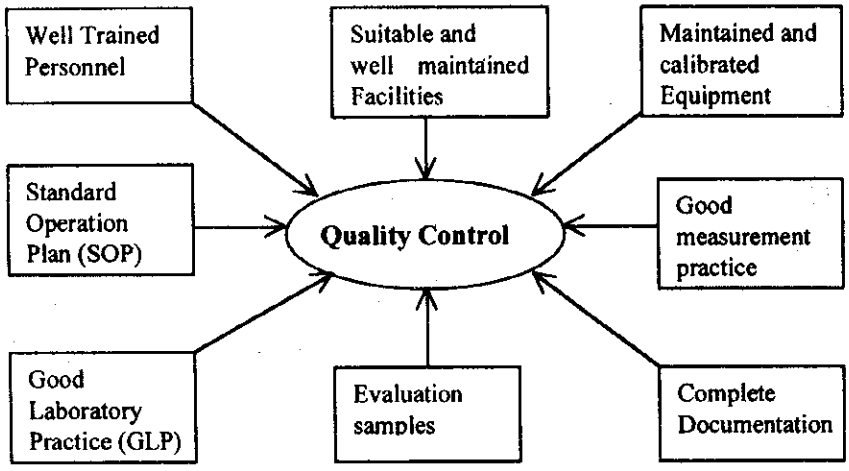


Figure 6.2.1 Components of QC program

MEPA should provide the overall management plan of the laboratory and SOPs for each work, and execute the reliable operation including the quality control based on the management plan.

Besides the above, MEPA should establish the standard analysis method in KSA under the full cooperation of other laboratories. Preparatory works for the institution of SOP for the quality control is also important work for MEPA. In creating the SOP for quality control system, following procedure is used to be implemented;

1) To split a sample into two,
2) To analyze them at different laboratory but by the identical procedure with each other, and
3) To compare the results of them

In considering the above, closer relationships with outside laboratories must be very important for QA procedure of MEPA.

To establish MEPA's credit as a reliable laboratory, following procedures shall be

arranged and maintained:

a) Maintenance and evaluation of instrument:
   - Standard solution to be used for preparation of calibration curve
   - Adjustment of analytical equipment.

b) Evaluation of credibility for measurement result:
   - Detection limit
   - Check on sensitivity of measuring instruments
   - Blank test
   - Repeat measurement
   - Spike and recovery test
   - Cross-checking.

c) Data control and evaluation:
   - Reliability of samples
   - Treatment of abnormal data and lack of data
   - Recording of measurement operation.

6.2.3 Phase III (Growth and Enhancement Phase)

(1) Objective

On Phase III, the following step-up should be considered in the laboratory.
- Enhancing measurement/analysis capacity, and
- Confirming laboratory quality assurance/quality control procedures.

(2) Analysis Parameter

The analysis capability should be improved on the following items:

a) Detection of trace metals in ppb level for seawater sample,
b) Detection of PCB, Chlorinated Hydrocarbons and Organic halides,
c) Analysis of inorganic nutrient (Nitrate and Nitrite) for the investigation of eutrophication mechanism at Tarut bay and so on.

Assumed analysis methods for these new parameters are listed below:

1) 'Standard Methods' 3113 Metals by Electrothermal AAS,
US.EPA Method 200.9 Determination of Trace Elements by Stabilized Temperature Graphite Furnace AAS,
US.EPA Guideline on Establishing Trace Metal Clean Rooms in Existing Facilities EPA/821/B-96-001.

2) US.EPA Method 608 Organochlorine Pesticides & PCBs,
US.EPA Method 612 Chlorinated Hydrocarbons,
US.EPA Method 617 Organohalide Pesticides & PCBs,
US.EPA SW-846 Method 8082 PCBs by GC (for sediments).

3) 'Standard Methods' 4500 NO_3-N Automated Hydrazine Reduction,
US.EPA Method 353.1 Colorimetric Automated, Hydrazine Reduction,
'Standard Methods' 4110 Determination of Anions by IC.

4) 'Standard Methods' 9221 Multiple-Tube Fermentation Technique for Members of the Coliform Group

(3) Equipment / Instruments

In order to conduct the above-mentioned works, installation of new instruments and modification of existing instruments are required.
Examples of instruments to be required are shown in below.

a) Attach a graphite furnace to AAS with clean bench system, and install exclusive Mercury analyzer,

b) Attach a Purge & Trap system and Electron Capture Detector (ECD)* to GC unit

c) Install a Flow Injection Analyzer (FID) for nitrate-nitrite analysis; and
a Ion Chromatography (IC) for inorganic anion such as F^-, Cl^-, I^-, SO_4^{2-}, PO_4^{3-},

d) Install clean bench for microbiological examination, Coliform fermentation technique.

*: such as ^{63}Ni radioisotope detector cell (sealed) is used in ECD, thus appropriate supervision is required to install ECD in the laboratory.

(4) Laboratory Staff / Organization

One deputy laboratory manager, a chemistry technician responsible for QA/QC management, and a few more technicians with experience of FL-AAS and GC-ECD should be appointed.

(5) Laboratory Management

To confirm the QA/QC procedures, the below guideline shall refer:
'Standard Methods' Part 1000 Introduction,
US.EPA SW-846 Chapter 1 Quality Control.

In practice, the quality systems applied to the analytical laboratory can be approached in different manners adherence to standards and compliance with legislation. The International Standards Organization (ISO) has issued a variety of standards and guides that are relevant to the implementation of quality in the analytical laboratory. ISO 17025, entitled "General Requirement for Competence of Calibration and Testing Laboratories", provides us with useful information to establish a laboratory management procedure. The European Centre for Standardization (CEN) has also developed a series of standards for implementation of quality; the EN-4500 series.

Good Laboratory Practices (GLPs) constitute an alternative to the standards derived from ISO Guide 25. They have been established worldwide by institutions such as the OECD. GLPs can be defined as "a body of rules, operating procedures and practices established by a given organization that are considered to be mandatory with a view to ensuring quality and correctness in the results produced by a laboratory."

6.2.4 Phase IV (Maturation and Focus)

(1) Objective

Phase IV aims could include the specialization of MEPA laboratory to be the Gulf reference laboratory for:

- Manage and publish of every monitoring data,
- Carry out ecotoxicity, bio-hazard, POPs testing by themselves or outside laboratories,
- Conduct research work for eutrophication mechanism and red-tide studies,
- Hold training and education program of laboratory analysis and environmental problems,
- Direct quality management system for environmental laboratories in KSA.

(2) Analysis Parameter

The following methods shall be applied to conduct the analyses above-mentioned:

'Standard Methods' Part 8000 TOXICITY,
'Standard Methods' 3130 Metals by Plasma Emission Spectroscopy,
'Standard Methods' 6210 Volatile Organic Compounds,
'Standard Methods' 6220 Volatile Aromatic Organic Compounds,
'Standard Methods' 6431 PCBs,
'Standard Methods' 6630 Organochlorine Pesticides,
US.EPA Method 610 Polynuclear Aromatic Hydrocarbons,
US.EPA Method 200.7 ICP-AES Method for Trace Element Analysis,
US.EPA Method 1638 Determination of Trace Elements in Ambient Waters by ICP-MS,
US.EPA SW-846 Method 6020 ICP-MS (for sediments),
US.EPA SW-846 Method 8081A Organochlorine Pesticides by GC (for sediments),
US.EPA SW-846 Method 8275A Semivolatile Organic Compounds (PAHs and PCBs) in Soils/Sludges and Solid Wastes using Thermal Extraction-GC-MS.

(3) Equipment / Instruments

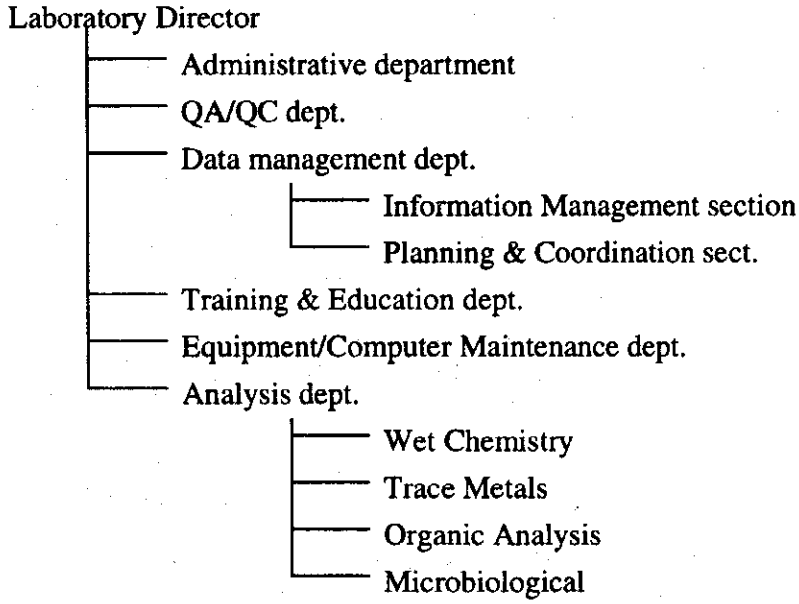
Advanced equipment enabling adequate resolution of trace toxic substances (eg. Pesticides, PAH etc,) may need to be installed, unless satisfactory arrangements with one or more outside laboratory can be secured.

- Gas Chromatograph- Mass Spectrometer (GC-MS),
- Inductively Coupled Plasma- Atomic Emission Spectrometer (ICP-AES) or Inductively Coupled Plasma- Mass Spectrometer (ICP-MS),
- High Performance Liquid Chromatography (HPLC) with UV-fluorescence detector.

As for the facilities of the laboratory, works to supply electricity and gas for the above instruments are required. Further, well-trained personnel are additionally required for the operation of these instruments.

(4) Laboratory staff / Organization

To accomplish the above works, adequate laboratory organization is required.



To aim for a reference laboratory of KSA, MEPA should continuously control the quality of analysis in its own laboratory and institute the standard quality systems of KSA in cooperation with other laboratories.

In general, the reliability of analysis results is based on the followings:

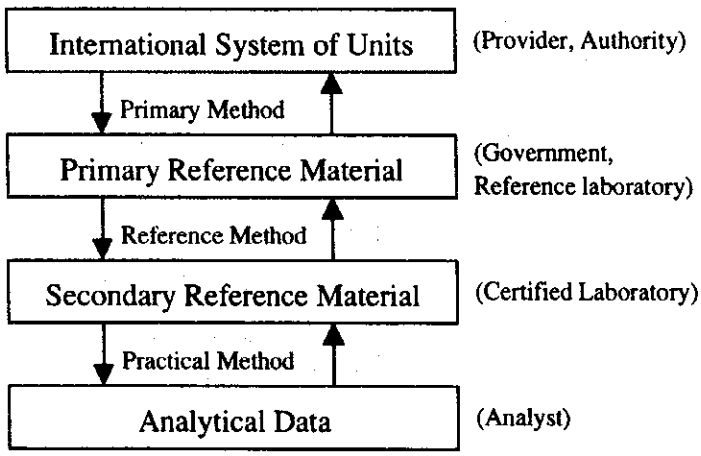
- appropriate sampling procedures,
- quality of analysts, how much experience they have,

- accuracy and sensitivity of analytical instrument, and
- traceable reference materials to be used for methods and instrument validation .

(5) Nationwide QA/QC System

To support the reliable data in the laboratory, MEPA should provide the certified reference materials (CRMs) not only for their laboratory but also for the outside laboratories in KSA. The nation-wide quality control shall be established upon this procedure. CRMs are available prepared and certified by several non-commercial sources such as the National Institute of Standards and Technology (NIST) in USA, the Community Bureau of reference (BCR) of Communication of EC and the Laboratory of Government Chemist (LGC) in UK. There are also commercial sources for CRMs.

The traceability concept has been required in instituting quality systems in analytical laboratories and the expansion of international trade/research. In the analytical chemical field, traceability is realized as the history of the production of result of the performance of system (a laboratory, instrument, apparatus, reference materials, etc.), which should be clearly, comprehensively documented by qualified personnel under internal supervision of external control of national/international organizations.



The methods used by an analytical laboratory subject to a quality control system can be ranked according to accuracy and precision. MEPA should provide the standard methods for environmental analyses under conducting the comparison test using CRMs in unison of all certified laboratories in KSA.

6.3 Cost for Laboratory Equipment

A rough estimate for laboratory equipment and apparatus is shown in Table 6.3.1

Table 6.3.1 Cost Estimated for Laboratory Equipment

[Phase II]

Equipment/apparatus	Purpose	Cost estimated (SR)	Note
Hollow Cathode Lamp for Barium	Barium measurement	700	(addition to AAS system) Varian 56-101004-Ba
Microwave Digester with Teflon vials	Digestion of sediment sample	100,000	(newly install) Wave power 1000W, 300 C 10 TFM vessels on rotor
Microscope with Camera adapter	Plankton identification and counting	15,000	(newly install) wide-field, stereo-type x 400

[Phase III]

Equipment	Purpose	Cost estimated (SR)	Note
Electron Capture Detector (ECD)	Chlorine compounds such as PCB	30,000	(addition to GC system) Shimadzu Constant-current system with 370 MBq ^{63}Ni
Purge & Trap system	High sensitive analysis for organic compounds	30,000	(addition to GC system) hexagonal valve
Graphite Furnace	High sensitive analysis of trace metals	90,000	(addition to AAS system) Varian GTA-110, PSD-100
Mercury Analyzer	High sensitive analysis of mercury	150,000	(newly install) nondispersive double beam cold vapor-AAS
Flow Injection Analyzer	Nitrate and nitrite	150,000	(newly install) Spectrophotometric
Ion Chromatography	Inorganic anion and cation	150,000	(newly install) 2 channels, EC detector
Clean Room	Trace metals analyses	100,000	(newly install) prefabrication type, 5 m^2
Clean Bench	Microbiological examination	10,000	(newly install) bench-top, sterilizing light

[Phase IV]

Equipment	Purpose	Cost estimated (SR)	
Gas Chromatography - Mass Spectrometly (GC-MS)	Simultaneous analysis of organic compounds	600,000	(newly install) 2 - 1000 amu, 6000 u/s with EI & work station
Inductively Coupled Plasma - Mass Spectrometly (ICP-MS)	Simultaneous analysis of trace metals	1,000,000	(newly install) wave length: 160-800 nm
High Performance Liquid Chromatography (HPLC)	Pesticides and PAHs	300,000	(newly install) UV-Vis detector; 190-700nm

Chapter 7

Recommendation for Management and Administration

Chapter 7 Recommendation for Management and Administration in MEPA

7.1 Preface

MEPA counterparts and JICA Team have successfully completed the project in the most collaborative manner, and attained the objectives targeted at the beginning of the project without involving in serious accidents.

However this does not necessarily guarantee the continuation or self-development of the work by the MEPA Eastern Province staff in the future, because there remain several issues are remained to be resolved. During the period of the project implementation, on the other hand, the Team learned much about the actual situation of the Saudi Arabian environmental protection system, including its policy, laws and regulations, international relationships, related government agencies, and the organization, responsibilities and work conditions of MEPA, particularly at its Eastern Province office.

Based on the study experience, recommendations are proposed for operation in the future for the monitoring and analytical work, including suggestions for enhancing of the overall environmental protection system.

Since the recommendations directly related with water quality monitoring and analytical work at the laboratory have been made at Chapter 5 and 6, this chapter will address the issues related with management and administration of MEPA Eastern Province.

Most of the recommendations will not be able to be fulfilled without support and appropriate actions, as and where necessary, by top management authorities of MEPA Eastern Province and Jeddah Head office.

7.2 Management and Administration in General

7.2.1 General

The monitoring results of this study has shown that it is now the time for MEPA to take real actions to implement marine environmental protection management, with respect to coastal water quality.

MEPA E. P. should continue the water quality monitoring in the Gulf. Also, different kinds of environmental management activities, which includes accumulation of data and analysis, identification of problems and the sources, stop or protection from degradation of environment, establishment of counter measures against pollution, recommendation of revision of standards or specifications, coordination with its Head Office and other agencies etc., should be followed in parallel.

In order to implement these activities, it is indispensable to enhance the capability of MEPA E. P. in general.

The capability of MEPA E. P. is closely related with structure of organizations, policy of its Head Quarter in Jeddah, and even reinforcement of laws and regulations. Assignment of qualified human resource and necessary budget is also essential and indispensable. The enhancement measures of the capability of MEPA E. P. should be discussed and recommended from these multifarious viewpoints.

7.2.2 Clear Administrative and Operational Objectives of MEPA Eastern Province

There are significant landbased-sources in the Eastern Province, which includes industrial plant, oil terminal, sewage treatment plant and so on. Ship activity and Port are also possible pollution sources. It is not too much to say that the Eastern Province is the most important region in KSA from the viewpoint of environmental protection. Therefore, the role of MEPA E. P. as the environmental management organization is also very important.
In spite of its importance, the formal position of the Eastern Province office is not necessarily clear.

As far as the Team knows, MEPA, Eastern Province office is situated under the National Meteorology and Environment Center, Regional Affairs Section, and not under Environmental Protection General Directorate (EPGD) which deals the environmental issues. If it is true, the part of environmental protection issues at Eastern Province office can be hardly communicated with EPGD Head Office.

Historically, the Environment Protection Division was merged to the Meteorology Branch office in the Eastern Province in 1981, but it seems that the Eastern Province office has been maintaining the original position as it was, though the Eastern Province office has conspicuously functioned as the oil spill fighting center at the time of Gulf War and subsequent oil spills in the Gulf. This function was apparently set up by the emergent and impending needs in the Eastern Province.

Presently, the Eastern Province office seems to try to function as a "mini MEPA" in the Eastern Province, to cover all aspects similar to MEPA Head office with a few exceptions. Let it be reminded that MEPA has originally the following principal responsibilities which were determined by Royal Decree No. 7/M/8903:

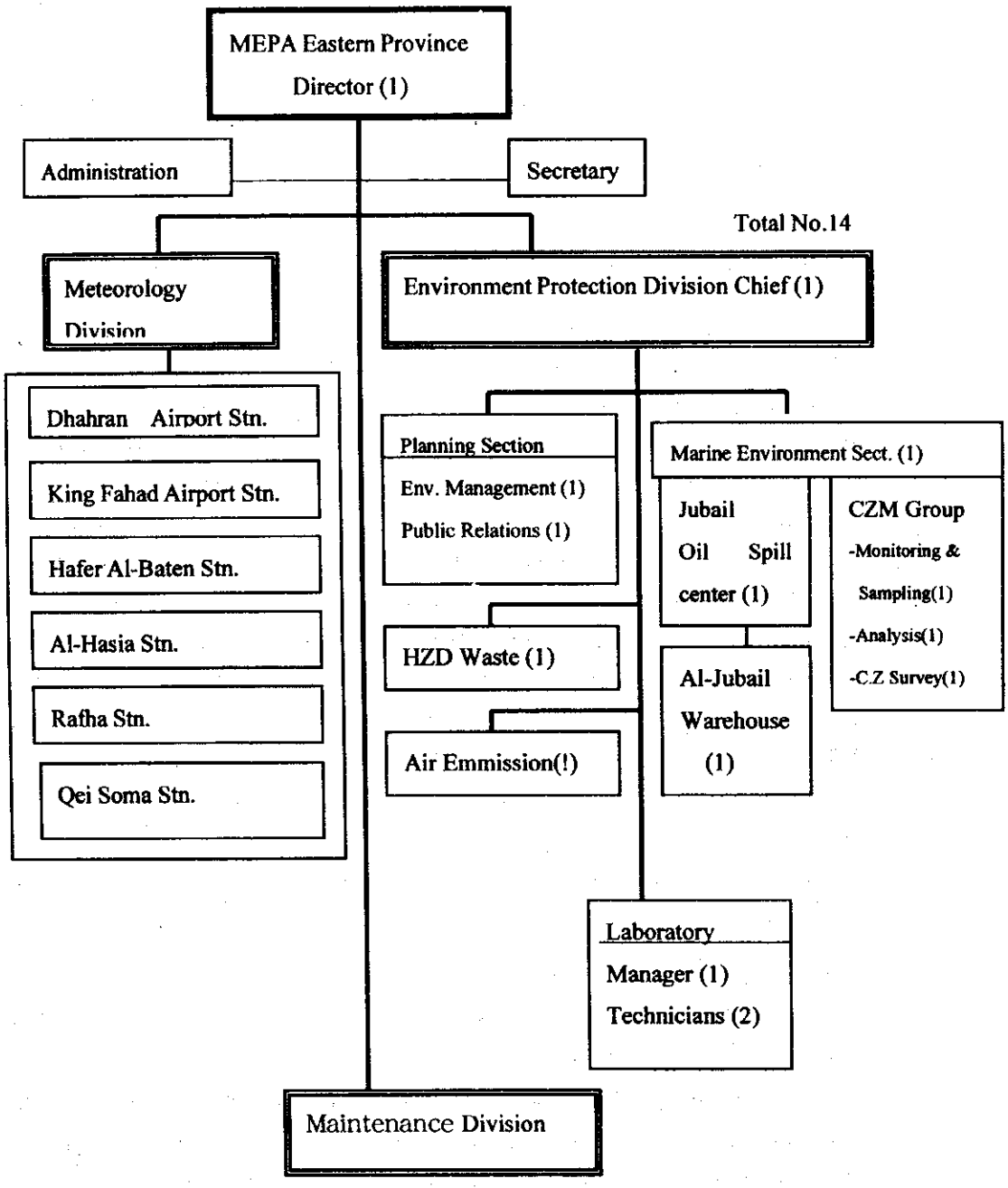
1) Conduct environmental surveys to define problems and recommend environment standards and measures.
2) Recommend practical measures necessary to deal with emergency situations affecting the environment.
3) Recommend protection regulations and measures dealing with environmental problems.
4) Assess existing environmental pollution levels and future variations.
5) Keep abreast with development in the field of environmental protection on the regional and international levels.
6) Establish environmental standards and specifications for pollution control and environmental protection in a definite and stable form to be considered by the

appropriate authorities when issuing permits for industrial and agricultural projects.

However, it may not be possible to cover all areas of the MEPA's responsibilities with the current limited human resources (for example, the Environmental Protection division of Eastern Province has only 8 staff and few of these are specialists having Master's degree).

In order to improve present situation following actions are recommended.

1) Establishment of formal position of Eastern Province Office in relation with EPGD Jeddah Head Quarter. Affiliation to EPGD may worth to be discussed.
2) A wide responsibility and authority to the Eastern Province office as to functions of an environmental protection MANAGEMENT station in addition to the function of the problem/accident solving TASKFORCE station should be assigned.
3) A scope of work for coverage by the Eastern Province office and MEPA Head office in the Eastern region, especially referring to the human resources (number and qualification) should be defined clearly in the Eastern Province.
4) Manpower reinforcement of environmental MANAGEMENT staff as well as field monitoring and laboratory specialists should be realized.
5) Based upon the above conditions, the Organization of MEPA E. P. will be recommended to re-arrange as per Figure 7.2.1, in which the following effects and intents are included.
   i) Each section has its own responsibility and scope of work
   ii) Create Coastal Zone Management (CZM) section
   iii) Reinforce laboratory section with specialists
   iv) Al-Jubail Oil Spill Center and Al-Jubail warehouse are closely connected with Marine Environment section.
   v) Create Planning Department for environment protection management and administration. (The results of water quality monitoring and analytical work should be ultimately reflected for the reinforcement of laws and regulations including revision of standards and specifications at Head office. Coordination with Head Office in this sense is becoming more important. Establishment with good collaboration with government agencies, guidance to factories, promotion of public awareness, etc., should be also inevitably promoted.)
   vi) Delegation of power to each section
   vii) Environment Protection Division of MEPA Eastern Province is expected to have at least 14 staff in total to fulfill their responsibilities.



Notes: 1.Recommendation is only on Environment Protection Division.
2.The figure in bracket ( ) shows the minimum required staff number.
3. Depending upon the requirement or emergency case, the assigned personnel should be flexible in helping each other by the request of the Chief.

Figure 7.2.1 Recommendation on Organization Structure of MEPA Eastern Province

7.2.3 Flexible Budgeting System of Eastern Province

The Eastern province has little autonomy in its expenditure. Salaries of employees are determined by MEPA Head Office depending upon the rating of employees, and the contracts for maintenance services for the building and facilities are concluded between the contractor and MEPA head office.

Extra- expenses for overtime work and ad-hoc travel expenses are examined and reimbursed by the head office. This makes it difficult for the Eastern Province office to take a quick and spontaneous action. Specially in such a case as it accommodated the JICA Team to implement the project, it required some extra budget to undertake its own part including recruitment of specialists for the laboratory, repair of the facility and purchase of consumables.

In order to continue and further develop water quality monitoring and analytical work at the laboratory, increase of budget for new expenditures is essential and at the same time, flexible execution of the budget is also desirable. Under these circumstances, it is recommended that:

1) Establishment of Budgeting System for the Eastern Province

The JICA Team regards the Eastern Province is the most prioritized area for which MEPA should prepare arrangement for anti-pollution and environment protection. MEPA Head Office is expected to support its Eastern Province to self-develop the activities as much as possible from view-point of the expenditures and operation. Following is a flow of budgeting system from planning to execution.

Plan of Annual Activities by Eastern Province (E.P)→Estimate of Annual Expenditure by EP→Request for Budget by EP to Head Office (H.F)→ Examination by H. O→Approval of Budget by H.O→Execution by E.P

2) Flexible Budget

Within the approved budget, the Eastern Province office may shift the expense items among them to a certain extent in order to comply with the actual requirement.

7.2.4 Collaboration and Integration for Environmental Protection Management.

As already mentioned above, it may not be possible for Eastern Province Office to cover all areas of the MEPA's responsibilities with the current limited resource.
Therefore, MEPA and related governmental agencies are expected to cooperate to protect the Gulf environment.

Besides MEPA, there are many public agencies involved in the environmental

protection activities, such as Ministries, Aramco, Royal Commission, Fishery Department, Sewage Department, Municipality, Police Office, Coast Guard, and other related agencies in Eastern Province.

The Team noticed dumping of untreated sewage and industrial waste along the coast, uncontrolled development of land and reclaiming/ dredging of the sea bed. On the other hand, the Team recognized various marine surveys conducted by Aramco and KFUPM Research Institute, self-control of the environment protection in the industrial city of Al-Jbail by Royal Commission with a complete set of regulations and procedures.

All these agencies undertake part of the responsibility for environmental protection. But the individual activities are neither necessarily coordinated nor integrated for the effective environment management in the region. It is therefore recommended that:

1) MEPA Eastern Province as a focal place for environmental protection holds leadership to coordinate and integrate the activities of the related agencies in the region, and summons periodical meetings for mutual collaboration and teamwork.
2) MEPA Eastern Province becomes the center of information and communication including collection of all data of surveys conducted by the related agencies. (The data to be accumulated by MEPA through water quality monitoring and scientific analysis will contribute to the most reliable sources for Coastal Zone Management of other agencies)

In order to materialize the above goals, a chart titled " Environment Management - relation with public agencies" is shown in Figure 7.2.2 in which the following effects are intended.

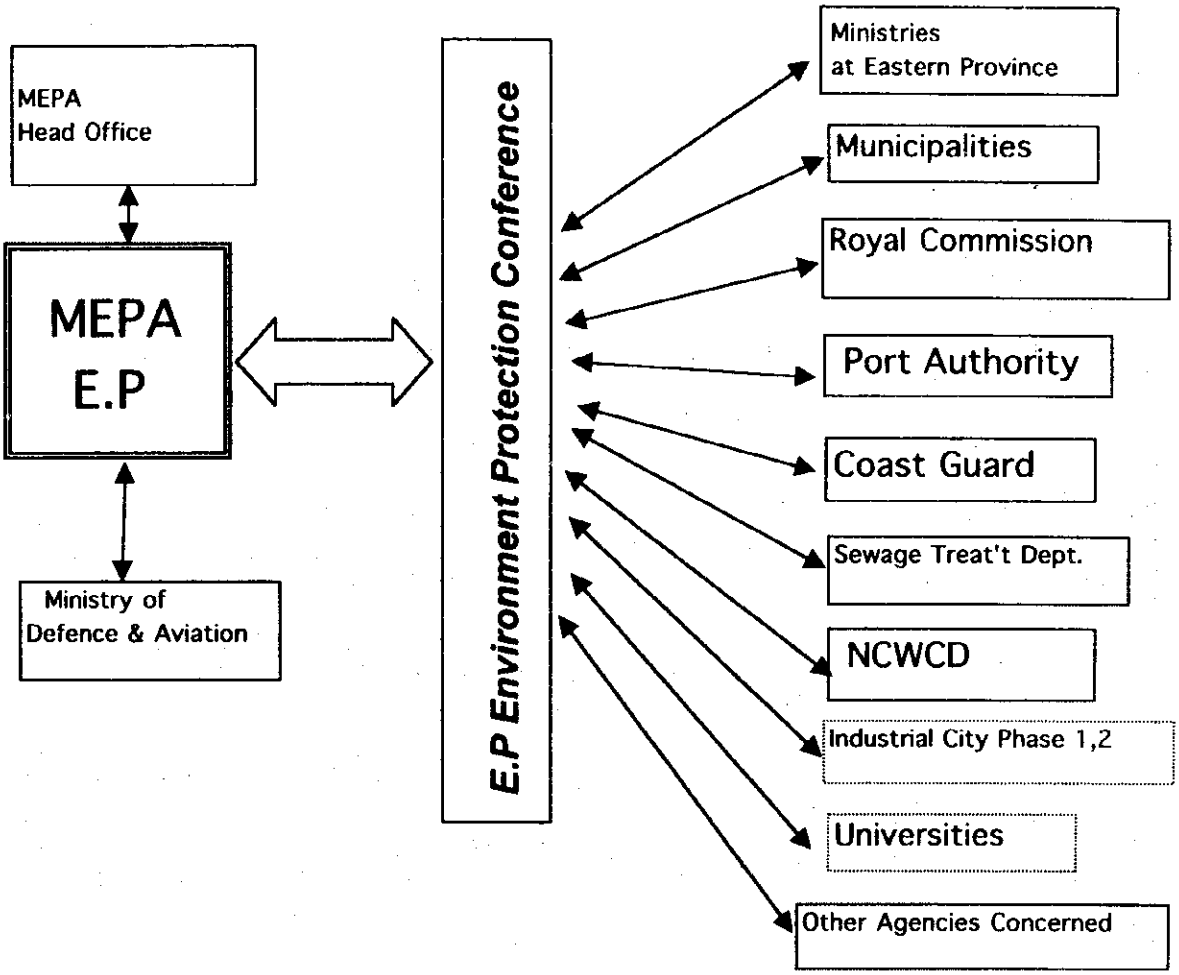
1) Establishing Environment Protection Conference with other agencies and leads the meeting for Coastal Zone Management (CZM).

2) Confirming the responsibilities of each agency for CZM and coordinate among the agencies for integration and linkage of the activities.

3) Accumulating necessary data including MEPA's own and other agencies for CZM and provides them to the related agencies upon request.

4) Guiding the agencies for better environment protection management through discussions about various topics on environment issues, including provision of necessary formats and specifications. (The topics may include issues about actual situation of pollutions along the coast, plans of land development, confirmation of authority and responsibility of the agencies, case study of emergency, public awareness, report of attended international conference etc.,)

The examples of possible cooperation between MEPA E. P. and each organization are shown in Table 7.2.1



Role of MEPA

1) Summon Conference

2) Coordinate Agencies

3) Accumulate Data

4) Guide for Better Environment Management

Topics to discuss

1) General Affairs for Environment Management
2) Dumping of Pollutants
3) Waste Water/Solid Waste/Air Pollutants
4) Dredging/Land Reclamation
5) Large Scale Development
10) Public Awareness
11) Laboratories/Institutes
12) Transport of Hazardous Material
13) Method of Treatment of Waste Disposal
14) Scope of Work among Agencies

Figure 7.2.2 Environment Management-Relation with Public Agencies

Table 7.2.1 Possible Cooperation between MEPA and related organizations

Organization	Possible Cooperation
Ministry of Agriculture & Water	Provide the water quality monitoring results to Ministry of Agriculture & Water Cooperation on the control of the affect of agricultural/fishing activities Conservation of Marine resources
Ministry of Health	Provide the water quality monitoring results to Ministry of Health Reflect the monitoring results to Human Health management
Ministry of Industrial and Electricity	Cooperation on Industrial waste water management/monitoring
Ministry of Interior	Information exchange on Chemical substances
Ministry of Transportation/Port Authority	Cooperation on the Monitoring activities Management/Control of oil spill from ship
Ministry of Planning	Provide the water quality monitoring results to Ministry of Planning
Ministry of Municipal and Rural Affairs	Cooperation on the solid waste/sewage management Pollution prevention
Ministry of Information	Cooperation on the Environmental Education/publicity activities
Royal Commission	Exchange of Water quality information in the Al-Jubail Industrial Area Cooperation on the Monitoring activities /Chemical Analysis Technical Information exchange
NCWCD	Cooperation on the Monitoring activities in the Southern Region of the Gulf
Coast Guard	Cooperation on the Monitoring activities
ARAMCO	Cooperation on the Monitoring activities in the Northern Region of the Gulf
KFUPM	Cooperation on the Monitoring activities /Chemical Analysis Technical Information exchange

7.2.5 Development of Method for Environmental Protection Administration and Management

As seen above, the Eastern Province office (Environmental Protection Division) played an important role as the oil spill fighting center in 1991.

All of the current staff members (except for managers) joined the Eastern Province office just one year before the Gulf War broke out. Their initial and unforgettable experience was to fight with the worst oil spills that ever took place in the world.

Thus their theme and mentality are apt to be of direct-controllers of accidents or problem shooters.

However, according to the MEPA's responsibilities as described at section 7.2.2, it is understood that its principal role is to establish guide lines for environment protection management based on data which are collected through reports, communications, studies, surveys, problems, emergency cases, etc.

MEPA is expected to "establish environmental standards and specifications for pollution control and environmental protection, in a definite and stable form to be considered by the appropriate authorities when issuing permits for industrial and agricultural projects which may have an environmental impact".

In other words, all MEPA staff are expected to have extensive view points of environmental protection management and create environment protection system in various fields. In addition, judging from the indicated responsibilities of MEPA, MEPA has no power to take strong measures such as prosecution against any illegal activities for the environment. It is possible only through collaboration with appropriate authorities that MEPA can stop pollution or other illegal activities. Under the circumstances, it is recommended that:

1) MEPA develops a system and method for indirect control of the environment involving third parties. "Indirect control" includes: i) Promotion of public awareness, ii) Stimulation of activities of the individual authorities concerned, iii) Establishment of report system, iv) Establishment or recommendation of laws and regulations v) Utilization of third parties for part of work (such as, a certain university for remote sensing, an institute for analytical work for a specific objective, etc.)

2) MEPA organizes authorized laboratories or institutes to monitor or audit the level of environmental conditions of the factories on an official basis.

In order to illustrate the above sample case, a chart titled "Environment Management - Relation with Industrial Companies/Factories" is shown in Figure 7.2.3 in which the following effects are intended.

1) Establishment of self-control system for environment protection by companies.
2) Collaboration with an appropriate authority (in this case: MIE)
3) Creation of authorized laboratories that can audit the environment protection system of a company, and undertake monitoring and analytical work and make reports to MIE and MEPA on an official basis on behalf of a company. (This system may encourage laboratories and institutes to be involved in environment protection on a commercial basis.)

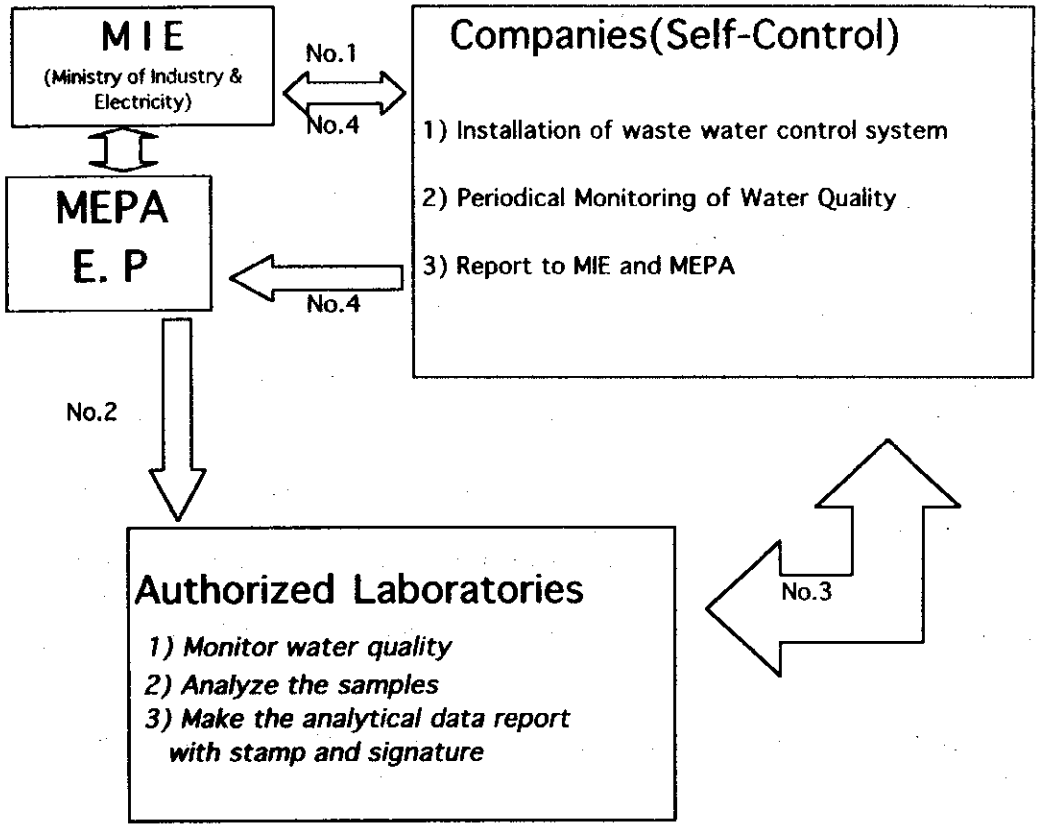
4) Collection of reports on an automatic basis from companies.

5) MEPA can recheck the reports from companies at a selective basis with its own monitoring system.

6) MEPA can shift its effort to more particular and strategic areas.

(This case shows a system of collaboration with MIE. There are many other possibilities of collaboration with the ministries;
to control agricultural water and fishing with Ministry of Agriculture and Water,
to control degraded environment affecting public health with Ministry of Health,
to control oil spillage from ships with Ministry of Transportation and /or Port Authority, etc.,)

(An example: case of waste water control)



Notes:

No.1 MIE orders a comapny to establish self-control system for waste water, and request a report to MIE and MEPA.

No.2 MEPA encourages Saudi laboratories/institutes for monitoring and analytical work for water quality, and authorize them, under a certain condition, to undertake such work for an official report.

No.3 The individual company requests an authorized laboratory/institute to monitor, check and confirm the data on the report to be sent to MIE and MEPA .

No.4 The company/factory send a report periodically to MIE and MEPA of the monitoring result which is confirmed and stamped by the said laboratory or institute.

Figure 7.2.3 Environment Management-Relation with Manufacturing Factories

7.2.6 Office Administration and Personnel Management

The Team noticed the managers of the Eastern Province office are active and always very busy and actively dealing with many tasks. On the other hand, the staff members do not seem to be so active or know what to do, unless specifically directed by the managers.

In general, there seems to be much room for improvement for effectiveness in the office administration and management.

(1) Clear Departmental and Personal Objective and Responsibility

The present organization chart of the Eastern Province office is shown in Figure 3.2.3. in Chapter 3. The Team observed the actual operation is not complied with this chart.

Most of the staff members are not well aware of the exact objectives of each department or section nor their own duties and responsibilities, because the individual staff members are expected to be open for anything to do, when and where necessary, by the order of the managers. " Everybody is ready for anything" system is quite convenient and practical in a sense under the very limited human resources of MEPA Eastern Province office.

However, this system will not bring up any specialists and self-development of professionalism.

Based on the new organization structure shown in Figure 7.2.1, it is recommended that:

1) Clear Objective of Each Department and Section.

The managers show long term and short term objectives

2) Position Description of Each Member

A sample of position description and responsibility for each member's responsibilities and "what to do", is shown in Table 7.2.2. Figure 7.2.4 shows a spiral relation from a position, clear objective, responsibility, self-training, accumulation of know-how and better work performance. The position description is expected to show each member all items of his responsibility together with the objective. Based upon the position description, the person will grasp what to do, and do his effort even if he is not directed by his superior.

Note: The Team understands that due to the limited number of the staff members it will be difficult to assign one person to one position. But still MEPA should try to assign at least a person as primary responsible man for one specific position which eventually leads to bringing up specialists in MEPA, because unless a person should be given a specific responsibility, he would not be motivated to accumulate the know-how and technology in the particular area.

Table 7.2.2 Position Description and Responsibility

Position Description (sample)

Name	Mohamed Ali
Department	Environment Protection Division –Coastal Zone Management
Title	Coastal Zone Management Supervisor
Report to	Aziz Al-Omary
Supervise	Husein Ali, Muhammed Al-Heil, Faisal Al-Dawish
Objective	Assist Manager in Gulf Sea Water Quality Protection
Responsibility	1. Plan an annual schedule for the group's activities 2. Plan better methods or system to protect sea water quality from pollution. 3. Design and update work-flow charts and procedures for efficient work for the group. 4. Gather as much information as possible of the environment related data including from international sources. 5. Keep updated the data of the Gulf water quality 6. Coordinate with persons in charge of Sewage Department, Fishery Department, Coast Guard and other public Departments for environment protection of the Gulf 7. Plan sea water monitoring program and schedule. 8. Lead monitoring work at sites. 9. Evaluate the result of monitoring in comparison with accumulated data, after receiving the analytical result at lab. 10. Make written reports about the sea water condition, including any accident, problem, pollutants, etc. 11. Guide, train and help subordinates for better group work. 12.Perform other duties than the above to be given by his manager

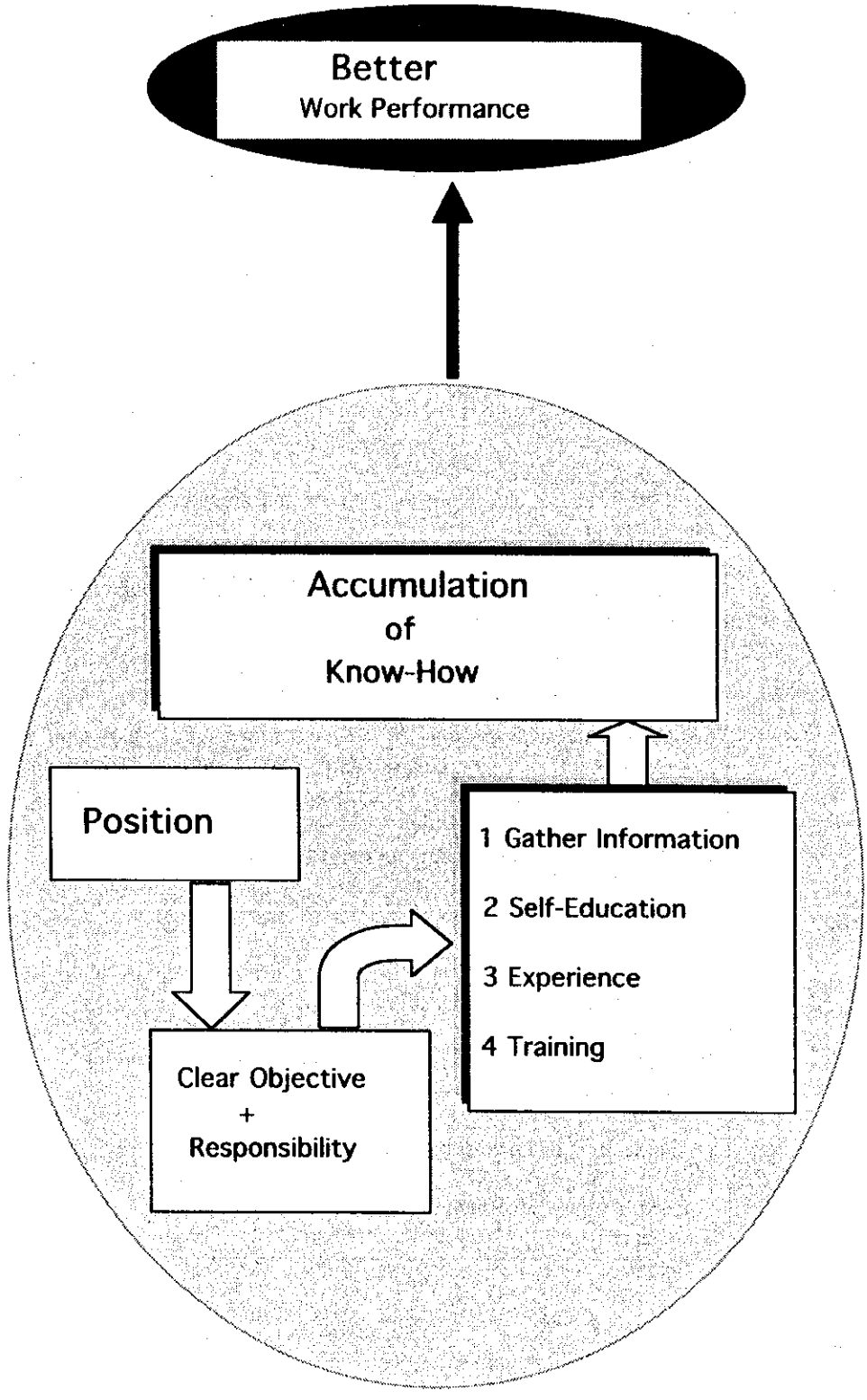


Figure 7.2.4 Objective, Responsibility and Work Performance

3) Creation of Group Leaders.

There is need for two group leaders to assist the chief of Environmental Protection Division, in order to alleviate the administrative burden form the chief.

It is desirable that one leader will undertake marine environment issues and the other will take issues for environment protection management. The chief delegates the leaders his authority for routine work and specific section management as much as possible.

(2) Work-Flows and Procedures

As the general observation, MEPA is expected to accumulate know-how and experience in the form of written documents besides reference books and data (work-flows and procedures are of such a kind).

These documents may also help a newcomer and colleagues to follow the work with continuation on a uniform basis, and revision will be repeatedly made for betterment in accordance with the new or actual requirement and convenience based on experiences. The Team showed the preferable samples for the Gulf water quality monitoring and analytical work at the laboratory. Based on the above observation, it is recommended that:

- Each member drafts work flow and procedure for his own field indicating who, what, how, when to do. MEPA managers reviews and establishes them as formal documents. (such as, Filing Procedure, Oil Spills (or other pollutants) Fighting Procedure, Water Monitoring Procedure, Procedure for Analytical Work, Site Inspection Procedure, Emergency Response Procedure and so on)

(3) Career Development Plan

The Team well understands that the MEPA staff should be given opportunities for training and education, if possible, outside of the Kingdom. However, as seen above (1), unless the staff members are given a clear position description with opportunity, and therefore do not understand what is required for them, it is difficult for them even for self-training. Training and education are supposed to connect closely with the members' work and responsibility. It is recommended that:

- MEPA establishes a career development plan of individual persons in line with MEPA's long term operation plan.

7.2.7 Establishment of Action Plan

All MEPA staff are well aware of the necessity of effective environmental protection measures. All staff members are expected to take actions in line with the plans under strategic objectives. It is recommended that:

1) MEPA establishes an action plan for a short term, yearly and long term which specifies the goal, schedule, person in charge, etc. This action plan is recommended to be in line with " Recommended Phased Approach to Future Monitoring and Laboratory Capability " described at section 5.1.5., Goal (plan) →Action (do)→Check (see) should be repeated as a cycle.

2) All staff members study well the laws and regulations and understand what they should do, can do and can not do from the given authority by the laws. In addition, as seen at section 7.2.2, MEPA's principal role is establishment or recommendation of guidelines (laws, standards, specifications and measures) and therefore all staff members are supposed to be keen about such laws and regulations. In accordance with good understanding of the laws and regulations, good coordination with other agencies and factories/people can be achieved. It should be noted that in creating an action plan, most of the actions would be connected with the laws and the objectives.

7.2.8 Cooperation with ROPME Countries

Only upon collaboration with GCC countries and Oman (ROPME members), the real protection of the Gulf water quality from degradation can be achieved.

It is recommended to establish the cooperative relationship with these countries.
MEPA should be more active in exchanging information and to make presentation on the condition of the Gulf through ROPME or some other comparable organization.

Also it is suggested for MEPA E. P. to accumulate and analyze the information about the environmental status of Gulf and to educate technical staff with using the Laboratory so that MEPA E. P. can operate as a base of Environmental Management of the Gulf.

The JICA Team hopes that MEPA E, P, becomes a core center for environment management of the Gulf water quality and leads the ROPME members countries providing a training course to the participants from these countries for environment protection management including water quality monitoring and sample analysis, since it is believed that only upon collaboration with these countries, in the near future.

7.2.9 Conclusion

Water Quality monitoring and sample analysis, which is conducted in this study, marks the first step to the full-fledged Coastal Zone Management by MEPA E. P. It is apparent that the project should continue and result in successful achievement of the

objectives.

On the other hand, it is also necessary for the MEPA E. P. to reorganize itself to the environmental Management, to enhance the capability of the staffs and to take an appropriate budget management so that MEPA E. P. can takes a leading role in environment management of the Gulf.

The recommendations addressed in this chapter are summarized as follows.

1) **Clear Administrative and Operational Objectives of MEPA E. P.**
It is suggested that MEPA E. P. be given a clear leading positioning as a center for environmental management in the Eastern Province. It is also suggested that MEPA E. P. be provided an appropriate authority and responsibility as to environment protection management, with a clear definition of scope of work between Head office and Eastern Province.

Furthermore, it is suggested that department in charge of waste management, air quality management, coastal zone management and administration planning are newly installed to clarify the operation system of E. P.

2) **Flexible Budgeting System of Eastern Province**
MEPA Eastern Province should have more flexible budgeting system which allows necessary budget expending with some autonomy at its criteria.

3) **Collaboration and Integration for Environmental Protection Management**
MEPA E. P. should coordinate and integrate environment protection management with other government agencies in the eastern province, so that MEPA Eastern Province had better establish "Environment Protection Conference" with related agencies to discuss various topics related with environment and grasp the actual situation and cooperate each other for protection of the environment.

4) **Development of Method for Environmental Protection Administration and Management**
MEPA Eastern Province should plan and develop environment protection management and administration system with third parties (to control factories with Ministry of Industry and Electricity, to control agricultural water and fishing with Ministry of Agriculture and Water, to control degraded environment affecting public health with Ministry of Health, to control oil spillage from ships with Ministry of Communication and /or Port Authority, etc.,) For this purpose, planning section with appropriate persons should be created in MEPA Eastern Province.

5) **Office Administration and Personnel Management**
For MEPA administration and personal management, the Team recommends:
i) Clarification of objectives and responsibility of department, section and

staff members.

ii) Establishment of work-flow and procedure

iii) Establishment of career development plan and training

iv) Action Plan for long-term and short-term activities.

6) **Establishment of Action Plan**

MEPA establishes an action plan for a short term, yearly and long term which specifies the goal, schedule, person in charge, etc. Also, all staff members are expected to take actions in line with the plans under strategic objectives.

7) **Cooperation with ROPME Countries**

MEPA E. P. should make effort to establish the cooperative relationship with GCC countries and Oman (ROPME members) through the information and technical exchange.

MEPA E. P. is expected to become a core center for environment management of the Gulf water quality and leads the ROPME member countries in the future.